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Remote Control Locomotive Operations: Results of Focus Groups with Remote Control Operators in the United States and Canada

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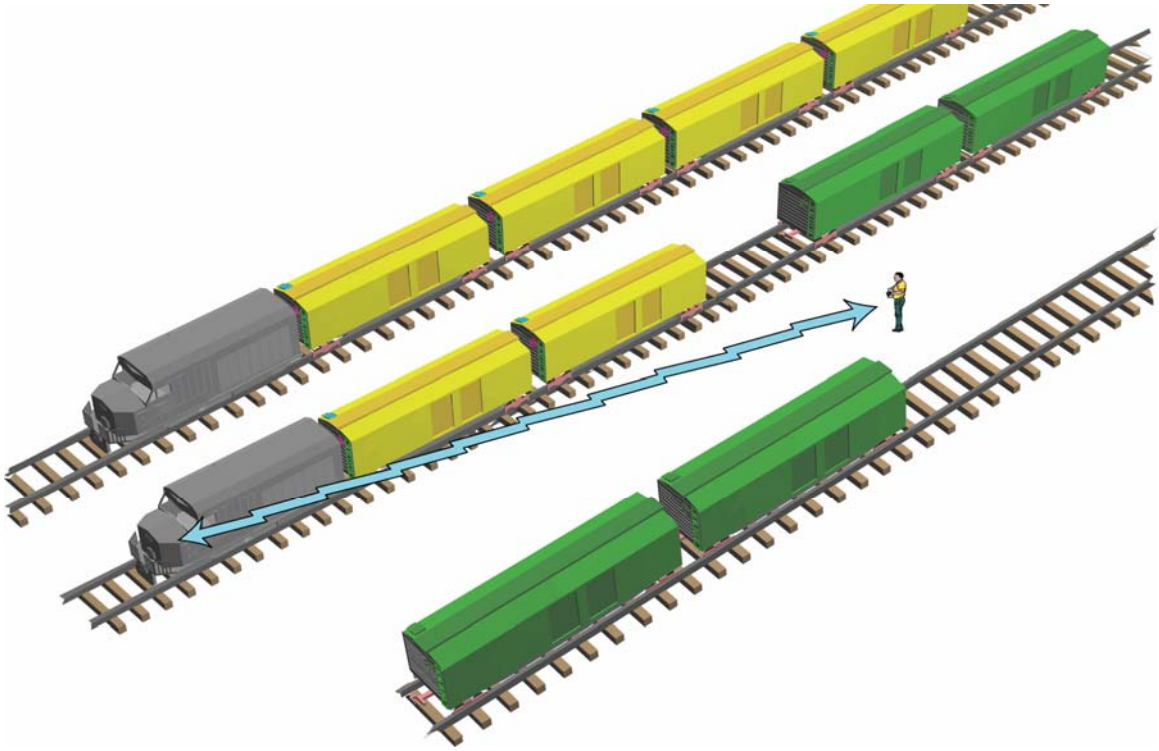

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13. ABSTRACT

This report presents findings from focus groups with remote control operators (RCOs) in the United States and Canada. The purpose was to learn more about remote control locomotive (RCL) operations safety-related issues, lessons learned, and best practices from those most familiar with the equipment and operations. Seventy-eight RCOs participated in 12 focus groups conducted in four cities. Focus groups addressed five themes: RCL implementation, training, current RCL operations, prior operating experience, and future RCL operations. RCOs identified and discussed a number of issues related to each theme and suggested changes for the future. Key themes based on RCO perceptions and experiences include the following: adequacy of RCO training, reliability of RCL equipment, and RCO situation awareness. RCO suggestions addressed these key themes, for example, improve RCO training. RCOs also noted three primary areas where improvements should be made before RCL operations are considered for service outside yards. They are improved training, more reliable equipment, and greater control over the RCL and consist. Lastly, several future studies are proposed to further enhance the Federal Railroad Administration's understanding of RCL operations.

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1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
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1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
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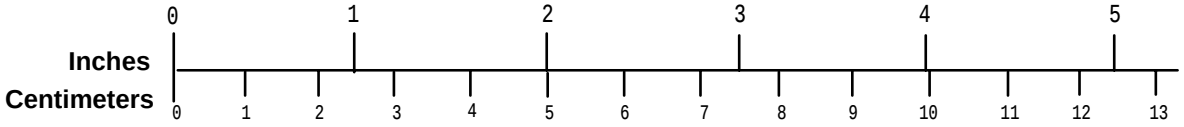

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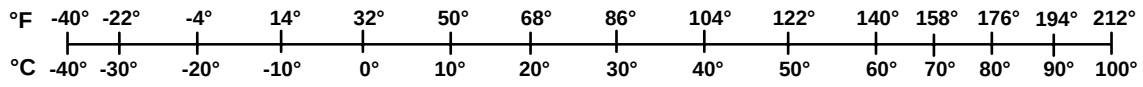

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Preface

U.S. Class I railroads began implementing remote control locomotive (RCL) operations starting in January 2002. Operating environments include yards, industrial spurs and sidings, and some main tracks and sidings/spurs. Remote control operators (RCOs) must adhere to all relevant operating rules in effect during RCL operations and may have additional responsibilities depending on the operating environment. Some of these responsibilities may include communication with a yardmaster or dispatcher, minor train handling on ascending and descending grades, car handling, and communication with other crews operating in the vicinity of the RCL. RCOs on Class I railroads are generally switchmen who receive special training to become RCOs, although a small minority of RCOs are also qualified locomotive engineers who have experience operating a locomotive. Traditionally, switchmen were never trained to operate a locomotive.

The Federal Railroad Administration (FRA) Office of Research and Development Human Factors Program and FRA Office of Safety initiated a multi-study RCL operations research program in early 2002, just as RCL operations began on a large scale in the United States, to ensure RCL operations are as safe as possible. FRA sponsored three separate studies: a comparative risk assessment of RCL and conventional yard switching operations; a root cause analysis (RCA) of RCL-involved train accidents/incidents; and focus groups with RCOs. This report presents a summary of 12 focus groups conducted with RCOs in the United States and Canada between March–May 2003. The FRA Office of Research and Development Human Factors Program and FRA Office of Safety sponsored this research under Contract DTFR53-01-D-00029.

The focus groups were designed to gather information about RCO experiences with RCL operations and equipment; identify some of the safety-related issues, lessons learned, and best practices from those who are most familiar with RCL operations and equipment; and solicit suggestions on how to improve RCL operations. Given the diversity of railroad yard switching operations, the recent and evolving nature of RCL operations, and the number of RCOs that participated, this study undoubtedly does not address all safety-related issues nor lessons learned and best practices that exist for RCL operations. Rather, the focus groups provide a snapshot taken in the very early stages of RCL implementation in the U.S. railroad industry. *No attempt was made to validate any statements made by RCOs. Furthermore, the views, concerns, lessons learned, best practices, and suggested improvements to RCL operations documented in this report are based on the opinions and perceptions of the RCOs who participated in the focus groups and should not be attributed to the FRA or others who aided in the conduct of this research.*

The authors would like to thank a number of individuals who assisted in the conduct of the focus groups. First, the authors would like to express thanks in particular to Dr. Thomas Raslear, FRA Office of Research and Development Human Factors Program, and Mr. John Conklin, FRA Office of Safety, for supporting this research and answering various technical questions throughout the project. Dr. Raslear and Mr. Conklin provided leadership within FRA to make this study successful.

Thanks to Dr. Frederick Gamst for providing invaluable technical and logistical insight throughout the research project. Dr. Gamst provided feedback on an initial set of focus group

questions, reviewed a draft manuscript of this report, answered dozens of RCL operation technical questions during the conduct of the research, and provided various definitions of railroad terms, including dropping and kicking cars.

We would like to give a special thanks to Mr. Richard Marceau and Mr. James Stem, United Transportation Union (UTU), and Mr. Robert Harvey, Brotherhood of Locomotive Engineers and Trainmen (BLET), for facilitating this research by providing union contacts and helping to identify candidate focus group locations. We would also like to thank the many UTU and BLET general and local chairpersons and legislative representatives who helped to identify and recruit RCOs willing to share their views and experiences.

The authors would like to acknowledge and thank several individuals from Foster-Miller, Inc. Thanks to Ms. Judith Gertler for reviewing a draft manuscript and providing important feedback. Thanks to Ms. Susan McDonough for coding focus group participant demographic data and providing program administration support.

Most importantly, we would like to thank all of the RCOs who participated in the focus groups. Their frank, open, and honest opinions provided a rare but very important look into the world of RCL operations in North America.

Executive Summary

In an effort to reduce operating costs and increase safety and efficiency, Class I freight railroads in the United States 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 Federal Railroad Administration (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, and controls the RCL through inputs to the RCD.

Although the technology has been around for decades, the safety implications of using these devices in the U.S. railroad industry and reducing crew size in switching operations remain unknown. FRA has begun to collect RCL operation-related injury and incident data. However, due to the recent implementation of RCL operations on a large scale in the United States (beginning in early 2002), and the more recent FRA requirement for railroads to report the involvement of RCLs and RCOs in train accidents/incidents (effective May 01, 2003), this data collection process will require several years before sufficient data are available to analyze.

To better understand the safety implications of RCL operations, FRA Office of Research and Development Human Factors Program and FRA Office of Safety initiated a multi-study RCL operations research program in early 2002, just as RCL operations began on a large scale in the United States. FRA sponsored three separate studies: a comparative risk assessment of RCL and conventional yard switching operations, a root cause analysis (RCA) of RCL-involved train accidents/incidents, and focus groups with RCOs to identify safety issues and best practices. This report summarizes the results of focus groups that were conducted with RCOs in the United States and Canada between March–May 2003. Focus groups with RCOs provided a forum to gather information about operator experiences with RCL operations and identify potential safety issues, lessons learned, and best practices from those who are most familiar with RCL operations and equipment. Focus groups also provided a means to solicit suggestions on how to improve RCL operations.

The focus groups provide a snapshot taken in the very early stages of RCL implementation in the U.S. railroad industry. As such, undoubtedly some of the issues that have been identified will have already been addressed by the time this report is published. Furthermore, the RCOs who participated in the focus groups were not statistically sampled to be representative of all RCOs in the United States or Canada. Thus, while these RCOs provide significant insights into RCL operations issues, the results may not be representative of all RCL operations or all RCO experiences.

The specific objectives of this research project included the following:

- Gather information on operator experiences with RCL operations.
- Discern RCL operations safety-related issues.
- Identify RCL operations lessons learned and best practices.
- Solicit suggestions for how to improve RCL operations.

To obtain a broad picture of RCL operations, it was important to look at a wide array of RCL operations experiences. Several criteria were established to help tap into a range of RCO experiences across the United States and Canada. These criteria included:

- Identification of focus group locations where RCL operations had been implemented by at least two railroads (and thus, different operational experiences) to enable RCOs from multiple carriers to attend. Since RCL operations were so new, it was not always possible to satisfy this criterion.
- Identification of at least one focus group location east of the Mississippi River and one west of the Mississippi River to account for cultural and operational differences among the different railroads east and west of the Mississippi River.
- Conduct of focus groups with switchmen and locomotive engineers. Both switchmen and locomotive engineers can qualify to become RCOs; however, whereas locomotive engineers have received significant training and experience controlling locomotives, switchmen typically have no training or experience controlling locomotives.
- Conduct of at least one set of focus groups in Canada since Canadian Class I railroads have been using RCL technology for over a decade in some switching yards. It was anticipated that U.S. railroads would benefit from Canadian RCO experiences, especially lessons learned.

These criteria were used to establish the focus groups and enabled researchers to examine a diverse cross section of RCO experiences in the United States and Canada.

Focus groups are a qualitative approach to studying RCL operations. The advantages of focus groups are in the richness, or quality, of information gathered and the broad range and depth of information and insights, sometimes unanticipated, that can be obtained from participants. Focus groups tap participants' experiences, opinions, and attitudes toward a topic and are well-suited to examine RCO experiences and identify industry best practices.

A total of 78 RCOs participated in 12 focus groups. Participating RCOs came from seven different railroads, six Class I railroads, and one regional railroad. Of the 78 RCOs, 4 were women. The average age of participating RCOs was 40 (range 23-58).

Focus group questions concentrated around five major issues:

1. Implementation of RCL operations
2. RCO training
3. Current RCL operations and safety
4. Switchman/engineer experience
5. Other-than-yard RCL operations

For each topic, RCO concerns, lessons learned, best practices, and suggested improvements were identified. *No attempt was made to validate any statements made by RCOs. Furthermore, the views, concerns, lessons learned, best practices, and suggested improvements to RCL operations documented in this report are based on the opinions and perceptions of the RCOs who participated in the focus groups, and these should not be attributed to FRA or others who aided in the conduct of this research.*

Some of the key themes that emerged from the focus groups include:

Adequacy of RCO training. RCOs felt that 2 weeks (wk) of training may be inadequate to fully prepare RCOs, given the added responsibilities and qualitative change to the nature of the job from a switchman or locomotive engineer to an RCO.

Knowledge of RCL operations. RCOs felt that other operating employees and management have a limited understanding of RCL operations, resulting in few rules, little guidance on what to do in unusual circumstances, changing and sometimes problematic procedures, cuts of cars that are as long as the remote control zone (RCZ), poor communications between RCOs and management, and inadequate maintenance of equipment. Separately, RCOs said that they have encountered employees who work in the vicinity of, or with, RCOs who are not familiar with RCL operations and procedures.

Perceived reliability of RCL equipment. RCOs described several types of reliability problems associated with the RCL equipment, including communication failures between the RCD and OCC, frequent error messages, delays in RCL response, and RCL overspeed.

Inadvertent activation of the RCD. RCOs reported frequent problems with inadvertent activation of the RCD. Causes of inadvertent activation include the location of switches, bumping into rail equipment as a result of mounting or dismounting equipment, and use of thick gloves in cold weather.

RCO situation awareness. RCOs report that operating the RCL on the ground away from the locomotive has reduced some of the critical feedback cues (visual and kinesthetic) available to cab-based operators, and this consequently reduces their situation awareness.

Other-than-yard operations. A few RCOs were comfortable with the prospect of taking an RCL out onto the main track. However, a majority of RCOs were not comfortable, citing among their reasons that the equipment is currently unreliable and that they lack the required knowledge and skills to operate on the main track.

RCOs also recommended a number of improvements to RCL operations. Some of these RCO-based suggestions include:

Improve RCO training. Some suggestions were that railroads should employ instructors who have as much experience and knowledge of RCL operations as possible; on-the-job training (OJT) should cover the entire range of locations, operations, and configurations of cuts of cars (one or more cars of any type, with or without the locomotive or RCL) that RCOs will encounter on the job; and training should cover train handling methods and familiarity and knowledge of basic locomotive systems. For the purposes of this report, train handling refers to handling both trains and cuts of cars.

Improve RCL equipment. The most frequently cited suggested improvements include prevention of inadvertent activation of RCD controls; more responsive equipment; and additional control over, and feedback from, the RCL.

Improve RCL procedures. Suggestions include requiring RCOs to protect the point at all times, familiarity training for those who work around RCL operations, and more frequent maintenance of RCL equipment.

Standardize operating practices. There appears to be a need for more standardization of practices and more education to ensure railroad employees are familiar with safe operating practices around RCL equipment.

Improve railroad facilities in support of RCL operations. Suggested improvements include the provision of additional information to an RCO about a cut of cars' proximity to a derail, increased maintenance of switches and switch leads, smaller ballast (crushed rock) to walk on, and more yard lighting.

Make adjustments for other-than-yard operations. RCOs identified three core areas where RCL operations should be improved before any railroad considers taking RCL operations out beyond a railroad yard or surrounding area. The three areas of improvement are: more extensive training (to cover train handling, air brakes, locomotive systems and troubleshooting, communications protocols, and territory familiarization), more reliable and responsive RCL equipment (e.g., the locomotive's brakes must respond immediately to an RCD input), and more information on, and control over, the RCL and consist (e.g., information on air pressure status and access to dynamic brakes). RCOs wanted as much knowledge and control over the locomotive and consist as locomotive engineers have when operating a locomotive conventionally.

Lastly, several future research studies are proposed, based on the focus group research, to further enhance FRA's understanding of RCL operations and RCL operations safety, including the following:

- Conduct a failure modes, effects, and criticality analysis (FMECA) of RCL operations.
- Develop RCL operations training objectives.
- Analyze RCL operations accident/incident data.

1. Introduction

This report summarizes the results of 12 focus groups that were conducted with railroad RCOs in the United States and Canada between March–May 2003. Focus groups provided a forum to gather information about operator experiences with RCL operations and to identify safety-related issues, lessons learned, and best practices from those who are most familiar with RCL operations and equipment. Focus groups also provided a means to solicit suggestions on how to improve RCL operations. For a number of RCL-related topics, RCO concerns, lessons learned, best practices, and suggested improvements were identified. *No attempt was made, however, to validate any statements made by RCOs. Furthermore, the views, concerns, lessons learned, best practices, and suggested improvements to RCL operations documented in this report are based on the opinions and perceptions of the RCOs who participated in the focus groups, and these should not be attributed to FRA or others who aided in the conduct of this research.*

1.1 Background

In an effort to reduce operating costs and increase safety and efficiency, Class I freight railroads in the United States have begun to implement RCL operations in railroad switching yards. RCL operations consist of three components: the locomotive (the RCL), an OCC (see Figure 1) that interfaces with the RCL's controls (and usually mounted somewhere inside or on the RCL), and a portable RCD, also frequently referred to as a belt pack, operator control unit, or box. See examples in Figure 2 and Figure 3. In Figure 4, an RCO wears the RCD harnessed to a vest. In RCL operations, typically only one or two crewmembers (one or both are RCOs) switch cars, commanding the locomotive to move via inputs to the RCD rather than radio or hand signals to the locomotive engineer onboard the locomotive. The RCO in control of the move is often referred to as the A or primary RCO, while the second RCO is referred to as the B or secondary RCO. The A operator has all of the RCL functions available to control the RCL while the B operator has access to a limited set of safety-related redundant functions, such as the locomotive's horn and emergency brake application.

When an RCO wants to send a command to the RCL (e.g., to slow down), the RCO manipulates hand controls on the RCD. The RCD, in turn, transmits these inputs via radio frequency to the OCC. The OCC then actuates locomotive commands by interfacing with the RCL and sending the instructions to the RCL. Figure 5 illustrates the basic concept of RCL operation. An RCO on the ground can now directly control the locomotive rather than communicate movement directions to a locomotive engineer stationed onboard the locomotive. Consequently, RCL operations have led to reduced crew size—typically one to two crewmembers make up an RCO crew compared, generally, to three crewmembers in a conventional yard switching crew.

Proponents of RCL operations suggest that controlling the locomotive from the ground affords the locomotive operator the best vantage point (see Figure 6). Further, proponents argue that these devices reduce or eliminate miscommunication errors that can occur between a locomotive engineer in the locomotive cab and a switchman on the ground. Opponents of the technology have raised a number of safety-related concerns, including inadequately trained operators, the added mental and physical stress of wearing and operating the RCD, and electromagnetic radiation emissions.

Figure 1. OCC

Figure 2. Front view of an RCD
(Courtesy of Cattron-Theimeg, Inc. 2004. Reprinted with permission.)

Figure 3. Top view of an RCD
(Courtesy of Cattron-Theimeg, Inc. 2004. Reprinted with permission.)

Figure 4. RCO

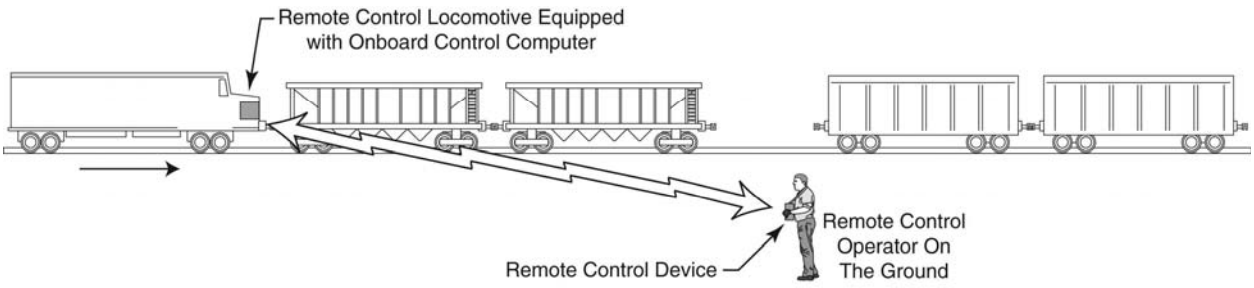

Figure 5. Basic illustration of RCL operation

Figure 6. RCO making coupling

Canadian National Railway, one of two Canadian Class I freight railroads, began implementing RCL operations in North America as early as 1989 (CN, 2000). In addition, a number of regional and short line railroads in the United States experimented with RCL operations in the 1990s. According to FRA, 22 railroads in the United States began using RCL operations between 1995 and 2000 (FRA, 2000). Railroads in other countries, as well as other industries in the United States, such as mining and steel, have also used the technology for a number of years. Despite the varied uses of RCL operations in the United States and Canada since 1989, none of the U.S. Class I freight railroads had implemented RCL operations as of 2000.

In an effort to provide guidance and assist the railroad industry and encourage railroads, RCL suppliers, and labor unions to work cooperatively, FRA held a technical conference in 2000 to discuss RCL operations and safety. Consequently, in February 2001, FRA published RCL operation guidelines (FRA Safety Advisory 2001-01; FRA, 2001). These voluntary guidelines provided general direction in four areas of RCL operations, which were equipment design, operating procedures, operator training, and data collection. These guidelines also clarified which FRA regulations specifically pertain to RCL operations. These include qualification and certification of RCOs (49 CFR § 240), and daily and periodic inspection of RCL equipment (49 CFR § 229), including the RCD.

As a result of these guidelines and a subsequent agreement between the U.S. Class I freight railroads and one of the operating craft unions, U.S. Class I freight railroads began to implement RCL operations beginning in early 2002. Operating environments include yards, industrial spurs and sidings, and, most recently, some main tracks and sidings/spurs. RCOs must adhere to all relevant operating rules in effect during RCL operations and may have additional responsibilities depending on the operating environment. Some of these responsibilities may include communication with a yardmaster or train dispatcher, minor train handling on ascending and descending grades, car handling, and communication with other crews operating in the RCOs' vicinity. A majority of the RCOs on U.S. Class I railroads are switchmen who receive 80 hours (h) of additional training on the RCD and RCL operations to qualify as an RCO, though a small number of RCOs on U.S. Class I and some regional railroads are also qualified locomotive engineers who have experience operating a locomotive. Traditionally, switchmen were not trained to operate a locomotive.

Although the technology has been around for decades, the particular safety implications of using these devices in the U.S. railroad industry and reducing crew size in switching operations remain unknown. Although FRA collects accident/incident data, including those involving RCL operations, it will take several years before adequate RCL-related data are available to analyze since RCL operations began on a large scale in the United States starting in early 2002, and railroads were only required to identify the involvement of RCLs and RCOs in accidents/incidents beginning May 01, 2003 (FRA, 2003).

To better understand the safety implications of RCL operations, 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 United States. FRA sponsored three separate studies: a comparative risk assessment of RCL and yard switching operations, an RCA of RCL-involved train accidents/incidents, and focus groups with RCOs to identify safety-related issues and best practices. This report describes the results of focus groups conducted with RCOs in the United States and Canada. This research was aimed at shedding light on some of the safety-related issues, as well as industry best practices, and complements the other RCL operations studies. FRA is interested in examining the experiences of those who are most familiar with RCL operations. FRA is also interested in helping the railroad industry help itself by facilitating the gathering and sharing of RCL operations best practices among railroads.

1.2 Objectives

The specific objectives of this research project were to:

- Gather information on operator experiences with RCL operations.
- Discern RCL operations safety-related issues.
- Identify RCL operations lessons learned and best practices.
- Solicit suggestions for how to improve RCL operations from those who are most familiar with the equipment and operations.

1.3 Overall Approach

Although each of the U.S. Class I freight railroads has begun to implement RCL operations, differences exist in how these operations are carried out at each railroad. In fact, differences often exist in how RCL operations are performed among different yards within any one railroad. These differences are based on which RCL manufacturer(s) is chosen, what optional and customizable RCL features are selected, and differences in yard configurations, operating rules, cultures, and norms. Thus, a wide range of RCL operating practices exists across the United States.

To obtain a broad picture of RCL operations, it was important to tap into a wide array of RCL operations experiences. Several criteria were established to help examine the range of RCO experiences across the United States and Canada, including the following:

- *Identify focus group locations (cities) where RCL operations had been implemented by at least two railroads*. The purpose of this criterion was to enable researchers to speak with RCOs from multiple carriers (and thus different operational experiences) in each focus group location. Since RCL operations are still relatively new in the United States, it was not always possible to satisfy this criterion.
- *Identify at least one focus group city east of the Mississippi River and one west of the Mississippi River*. Different railroads operate east of the Mississippi than west (the river provides a natural border between some of the Class I railroads). Cultural and operational differences exist among the different railroads east and west of the Mississippi based on their separate corporate histories. This criterion was designed to increase exposure to the range of RCO experiences across the United States.
- *Conduct focus groups with switchmen and engineers*. Both switchmen and locomotive engineers can qualify to become RCOs; however, whereas locomotive engineers have received significant training and experience controlling locomotives, switchmen typically have no training or experience controlling locomotives.
- *Conduct at least one set of focus groups in Canada*. Whereas U.S. Class I freight railroads have only just recently begun to implement RCL operations on a large scale (since early 2002), Canadian railroads have been using RCL operations since 1989. It was expected that differences would exist in experiences between the U.S. RCOs and their Canadian counterparts, given longer Canadian exposure to the technology and cultural and operational differences between U.S. and Canadian railroads. It was

anticipated that U.S. railroads would benefit from Canadian RCO experiences, especially with lessons learned.

These criteria were used to establish the focus groups and enabled researchers to tap into a diverse cross section of RCO experiences in the United States and Canada.

1.4 Organization of the Report

This report is organized into several sections. Section 2 discusses the methods used in conducting the focus groups. Section 3 presents a brief demographic profile of focus group participants. Section 4 presents the results of the focus groups. Section 5 summarizes key RCO themes and RCO recommendations, and provides several suggestions for future research. Lastly, Section 6 presents the references. In addition, this report includes three appendices. Appendix A presents the focus group moderator script that was used as the basis to introduce the focus groups to participants and lay out the ground rules for participation. Appendix B presents the background questionnaire used to obtain focus group participant demographic information. Appendix C presents the focus group questions that were used. Lastly, a list of abbreviations used in the report is provided.

2. Methods

Focus group interviews are a qualitative data collection research method in which 8-10 open-ended questions are posed to a group of 6-9 individuals. Each focus group lasts about 1½ h, is conducted at a neutral, off-site location, such as a hotel conference room, and participants are compensated for their time. Participants are encouraged to answer from their own experience. Group consensus is not sought; rather, individual expression of ideas is encouraged. Results are reported in aggregate, based on the topic being addressed, and are completely anonymous with regard to participants' names, carrier affiliations, and other identifiers. Focus groups are advantageous in that there is no one correct answer, and no attempt is made to quantify the results. The advantages of focus groups are in the richness, or quality, of information gathered and the broad range and depth of information and insights, sometimes unanticipated, that can be obtained from participants. Focus groups tap participants' experiences, opinions, and attitudes toward a topic and are well-suited to examine RCO experiences and identify industry best practices.

Researchers worked with the United Transportation Union (UTU; representing the majority of switchmen) and Brotherhood of Locomotive Engineers and Trainmen (BLET; representing the majority of locomotive engineers and Engine Service Brakemen[1] (ESBs)) to identify cities in which to conduct focus groups using the criteria described in Section 1.3, identify regional union representatives responsible for union members in each city, and identify local union officials representing RCOs at each railroad in each city. Researchers worked with local union officials to identify a hotel to hold the focus groups and recruit RCOs willing to share their RCL operations experiences.

Several criteria were established to assist local union officials in recruiting focus group participants. Participants had to be certified RCOs, have at least 3 months (mo) of RCO experience excluding training, be interested and willing to share their experiences and opinions about RCL operations, and not hold a union position on a committee of adjustment (e.g., local chair) or legislative board (e.g., local legislative representative). Local union officials used these criteria to recruit focus group participants.

Three focus groups were conducted at each of four different locations. Focus group times varied at each location to give RCOs working each shift an opportunity to participate. Although specific focus group times at each location were based on local shift start times, generally one focus group was held in the early afternoon to accommodate RCOs before starting second shift, one was held in the late afternoon to accommodate RCOs coming off first shift, and one was held at night to accommodate RCOs before starting third shift.

Krueger's *Focus Groups: A Practical Guide for Applied Research* (1994) was used to help structure the focus groups. Each focus group lasted 1 ½ h and was led by a moderator and a moderator's assistant. Appendix A shows the moderator script that was used as a guide. Participants were asked to complete a background questionnaire (see Appendix B) before the start of the focus group. Focus groups were guided by a pre-established set of questions (see

[1] ESB is the term used to describe individuals who operate locomotives in Canada, akin to the term locomotive engineer used in the United States.

Appendix C). The same focus group questions were discussed in each focus group at each location. At the completion of each session, participants were compensated and thanked for their time. A total of nine focus groups were conducted in three locations across the United States, and an additional three focus groups were conducted in one Canadian location. A total of 78 RCOs participated in 12 focus groups. The 78 RCOs, however, were not statistically sampled to be representative of all RCOs in the United States or Canada. So, while these 78 RCOs provided significant insights into RCL operations issues, the results may not be representative of all RCL operations or all RCO experiences.

3. Participant Profile

A total of 78 RCOs participated in 12 focus groups conducted between March and May 2003. Participating RCOs came from seven different railroads, six Class I railroads, and one regional railroad. Of the 78 RCOs, 4 were women. Participating RCOs ranged in age from 23 to 58 and had an average age of 40. Table 1 presents railroad operating experience data for participating RCOs. Although the average amount of locomotive engineer experience was 36 mo, a majority of the participants (50 of the 78 RCOs, or 64 percent) had no locomotive engineer experience at all. The average amount of RCO experience, 34 mo, was inflated by the inclusion of Canadian RCOs, all of whom had significantly more RCO experience (average 79 mo) than their U.S. counterparts (average 14 mo) due to the more recent introduction and implementation of RCL operations in the United States.

Table 1. Participating RCO railroad experience

	Average (mo)	Range (mo)	Median (mo)
Railroad experience	174	14-425	143
Yard experience	144	14-425	107.5
Engineer experience	36	0-300	0
RCO experience	34	4-156	13

4. Results

Focus group questions concentrated around five major issues:

1. Implementation of RCL operations
2. RCO training
3. Current RCL operations and safety
4. Switchman/engineer experience
5. Other-than-yard RCL operations

Results are organized according to each major issue. For each issue, 1-4 focus group questions were posed to participants. Appendix C lists the complete set of focus group questions. The nature of focus group research is to rely on participant opinions, attitudes, and experiences. Results are based on what RCOs reported. No attempt was made to validate any statements made by RCOs. The focus groups provide a snapshot taken in the very early stages of RCL implementation in the U.S. railroad industry. As such, undoubtedly some of the issues that are identified below will have already been addressed by the time this report is published.

4.1 Implementation of RCL Operations

The first focus group question asked how local management introduced RCL operations. According to participants, local railroad management at most of the yards where RCOs worked made some type of announcement regarding RCL operations coming to the yard, but management either did not indicate a start date or indicated a start date that was later changed. According to RCOs, rumors circulated about whether or not RCL operations would actually come to a yard, and if so, when. At a later date, a bid sheet or bulletin was posted announcing the start of RCL operations. Several RCOs in different locations felt that management "kind of threw it on us."

The trend among those railroads represented by the 78 RCOs was to convert one or a few conventional switching jobs to RCL operations and solicit volunteers for the first RCO class to fill these jobs. If a railroad was unable to fill the class with volunteers (e.g., at several locations, the first and second shift jobs were taken, but no one wanted the third shift RCO job), those with the least seniority were forced to bid the RCO job. Subsequent classes were generally assigned by the railroad as more jobs were converted to RCL operations.

4.1.1 Initial Problems with RCL Operations

RCOs were asked to discuss initial problems they encountered when RCL operations were first implemented. RCOs identified a host of initial issues. They include the following:

Adequacy of training. RCOs cited several problems associated with their initial training. These included equipment failures that caused delays and downtime during training, inadequately experienced instructors, and training that did not cover the types of operations or consists RCOs eventually encountered when working on the job. For example, an RCO may be trained on a cut of 30 cars, but his/her first day out he/she was expected to move a larger cut of cars.

Consistency of procedures. RCOs noted that some confusion and inconsistencies existed about operating practices, who does what (crew roles), how to use the new technology, and what practices were permissible and which were prohibited. According to RCOs, often in the beginning RCOs were given the RCDs and told to figure out the operation themselves. Operating practices also changed over time; what was common practice one day was prohibited the next. In addition, very little guidance from local management existed. One RCO noted that every trainer or manager would say something different.

Safety of procedures. RCOs from two separate locations noted that early on they were allowed to make drops.[2] They felt that this practice was dangerous. The railroads had since stopped this practice, according to RCOs.

Reliability of equipment. The greatest equipment problem noted by RCOs was communication failures between the RCD and OCC. Repeaters installed in the yard have helped to significantly reduce, but not eliminate, this problem. Other problems that were encountered include inconsistent RCL braking responses, wheel slide, RCL acceleration surges, loose antennae on the RCDs, and a stuck horn. RCOs also experienced a host of weather-related problems, particularly the extreme heat and cold. According to RCOs, the extreme cold would cause the OCC to periodically freeze up or cause valves to freeze, while the extreme heat would cause the OCC to occasionally overheat. Some of these problems have been fixed by changing the braking (software) logic in the OCC, reducing the amount of air that can be applied to slow or stop the RCL, or placing fans inside the locomotive cab to keep the equipment cooler. Reduction in the amount of air applied to the independent (locomotive) brakes helped to minimize the amount of wheel sliding but created new problems, chiefly a reduction in the overall ability to slow or stop the RCL and any attached cars.

Reporting of accidents/incidents. RCOs from several locations observed a general pattern by their railroad of covering up, or tolerating, accidents/incidents in which an RCL crew passed a signal, ran through a switch, or was involved in a minor train accident or injury. RCOs felt that this created a double-standard since similar accidents/incidents involving a conventional crew would be investigated. RCOs also felt that this was unsafe and preferred to be treated equally and that the accident/incident be properly investigated to determine and eliminate the hazard(s).

Morale. RCOs described a general malaise in the atmosphere following initial RCL implementation. Tensions existed between labor and local management, as well as tensions between switchmen-turned-RCOs and yard engineers. The tolerance of RCL accidents/incidents was viewed negatively by most, and this contributed to low morale. RCOs observed two general best practices that have helped to improve morale, which were when management began to work with RCOs to resolve the problems and when employees began to accept that RCL operations were there to stay.

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[2] A drop is a switching move in which one or more cars trailing a locomotive are uncoupled while in motion and allowed to roll freely onto a track other than the one on which the locomotive continues to run. Care must be taken that the governing track switch operates freely, the hand brake to stop the cars operates, and the locomotive accelerates enough to avoid being hit by the following cars. If the drop is made too slowly, the cars could hang up and stop over the governing switch, thereby trapping the locomotive on its track, causing its coupler to face a car side and not a car end with a coupler. Precise coordination of tasks and timing are essential for a safe, efficient drop.

4.1.2 RCL Implementation Advice

RCOs were asked to give advice to someone who was just about to introduce RCL operations in their own yard. Their advice includes the following:

Improve training and general education. Specific suggestions in this category include more hands-on training (OJT); training should include train handling, troubleshooting, explanations of RCD error codes, how the RCL operates, and how the automatic train air brake system[3] works; use instructors with more hands-on RCL operations experience and knowledge of RCL equipment; train RCOs on all jobs that they will work and the whole range of consists that they will work with; provide RCL operations familiarity training (e.g., definition of an RCZ and how it functions) to yardmasters, carmen, and others who interact with RCOs or who work around RCOs; and train mechanical crews on the mechanical aspects of the RCL equipment. Some RCOs suggested standardizing RCO training, while others suggested a flexible program to allow more time for those who require it.

Research RCL operations needs before implementation. RCOs suggested that it would be worthwhile to understand how RCL operations will specifically affect the yard and what will be needed (e.g., will there be a need for a RCZ?) and to resolve any potential problems before introducing RCL operations (e.g., if there will be a need for a repeater, install one beforehand).

Develop rules and procedures. RCOs suggested that, before implementing RCL operations, a railroad should develop applicable and proven rules and procedures to support and guide RCL operations and ensure that everyone knows the rules and procedures.

Balance safety with productivity. RCOs suggested that management should understand that RCL operations will start off slowly and will result in lower productivity than conventional switching. Notes one RCO, "basically sympathize with the guys a little more." At one location, according to RCOs, production remains down about one-third, even after 2 years (yr) of RCL operations. RCOs at other locations made similar observations. In fact, explains one RCO, occasions still occur when an RCL job is converted into a conventional job to increase productivity in the yard.

Take it slowly. One suggestion was to start with one to two RCL jobs and work out the kinks before expanding the operation to other parts of the yard.

Use reliable/new equipment. RCOs indicated that new RCL technology should be matched with new locomotives. They felt that the current mismatch between new RCL equipment and old locomotives (some are 30 yr old) was a cause for many reliability problems, which may be resolved if the locomotives used with the RCL equipment were also new.

4.2 RCO Training

This section is divided into several sections. Section 4.2.1 discusses current RCO training practices. Section 4.2.2 discusses RCO concerns with current training practices. Section 4.2.3 discusses how prepared RCOs felt to do the job at the conclusion of their training, and Section 4.2.4 presents some suggestions for improving RCO training based on RCO experiences.

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[3] The automatic train air brake system controls the brakes on the cars via brake pipe connections, as well as locomotive brakes. The locomotive brake, when used without the automatic train air brake system, is referred to as the independent brake.

4.2.1 Current RCO Training Practices

According to RCOs, generally training is comprised of classroom training followed by OJT. The amount of each type of training varies, depending on such factors as the number of trainees in a class and availability of equipment. The classroom portion of the training addresses the mechanics of how to operate the RCD and covers definitions and any applicable RCL rules and procedures (e.g., establishment of an RCZ). The amount of time spent on classroom training ranges from 2 days (d)–1 wk, though actual instructional time is often less, according to many RCOs. For example, although counted as one full day of training, trainees my be let out at noon, or in a second example given, trainees received 1 h of training and then went to take their vision tests. Usually some part of the classroom training also included a limited amount of hands-on operation of an RCL in an area of the yard where there is no traffic to expose trainees to the RCL equipment.

The OJT portion of training ranged from 1 wk–1 mo (i.e., 30 trips), and the type of OJT training ranged from a class of trainees working with one instructor to a pair of trainees switching cars (functionally the same as a revenue service assignment) under the supervision of one instructor. Trainees' OJT exposure in the yard ranged from the same job or location each day to different locations in the yard or different yards (within one geographic area).

OJT fell into one of the following basic categories:

- *Group instruction*. A class of trainees shared equipment and time to gain hands-on experience using the RCD over the course of a week, supervised by a trainer.
- *Peer training*. A pair of trainees were assigned, or selected, to work with a two-person RCO crew during revenue service work, for 30 trips. The RCO crew served as peer trainers. The trainees observed the operation and were given opportunities to operate the RCD at the discretion of the qualified RCOs.
- *Revenue service*. At one location, a pair of trainees operated an RCL among other RCL crews for 1 wk, supervised by one (formerly two) instructor. This crew was considered a training crew rather than one of the regular RCL jobs, but the training crew, nonetheless, was expected to operate just like another revenue service assignment and switch cars in the yard using the RCL.

4.2.2 Concerns with Current RCO Training

RCOs identified and discussed a number of concerns they had with initial training. One of the greatest concerns RCOs expressed was the lack of instructor experience with RCL operations. RCOs noted that often the classroom instructors have only 2 wk of RCL training and do not have any actual RCL operations experience. This lack of experience results in a lack of ability to address real problems that RCOs encountered later when working, and more generally, a lack of credibility. One RCO notes, "it's like the blind leading the blind." RCOs pointed out that they had come across many different (new) situations in revenue service that they had never encountered during training. In these situations, they had to figure out what to do on their own.

Another concern repeated by numerous RCOs concerned the limited scope of training relative to revenue service. Many RCOs were trained on only one job or part of the yard but were expected to perform any job in any part of the yard once trained. That is, once qualified as an RCO, they

were qualified to work anywhere. For instance, an RCO may have received their OJT working a bowl job but then were expected to work the hump or service local industries. RCOs felt that each location in a yard has unique operating requirements, and these requirements are not addressed if an RCO only works in one location during OJT. RCOs compared their situation to the situation in which locomotive engineers must qualify on each territory over which they will operate in order to understand train handling requirements. Further, RCOs noted that their training was limited because they may have only trained on a small cut of cars, but then they had to move much larger cuts of cars on the job. Other RCOs noted that they did not learn how to control a cut of cars using the automatic train air brake system, or operate over a public grade crossing, but were expected to do these things once qualified. Similarly, some RCOs never received any sort of troubleshooting experience when a problem arose while operating the RCL.

A third concern expressed by several RCOs focused on peer training. RCOs pointed out that peer trainers, qualified RCOs, do not receive any train-the-trainer training; depending on the situation, some RCO peer trainers may not let the trainee operate the RCD during a shift because the RCO peer trainers do not want to be responsible for any accidents/incidents in which the trainee is operating the RCD. Furthermore, some of the peer trainers themselves may have just completed their training and therefore have little, if any, actual RCL operations experience to share. This is problematic because these new RCOs have the added responsibility of training the trainees after having just learned how to operate an RCD themselves.

A fourth concern focused on a two-person RCO trainee crew that is expected to work an actual job during their training, supervised by one trainer. RCOs felt that one trainer could not sufficiently supervise or train both trainees (i.e., cannot be in two places at once). A fifth concern addressed group instruction. Specifically, RCOs felt that not enough hands-on opportunity existed during the week of OJT, since trainees had to compete for access to the equipment. This was especially problematic early on in RCL implementations when equipment was scarce or unreliable and therefore was not available to every trainee during OJT.

A last concern expressed by RCOs was that sometimes they would receive contradictory or inconsistent instructions from different trainers, or between a trainer and a manager.

Separately, RCOs noted several aspects of their training which they liked. These best practices include the following:

- Expose trainees to different parts of the yard during their OJT.
- Teach trainees how to troubleshoot problems related to starting up the RCL.
- Train experienced and knowledgeable RCOs to become classroom instructors.

4.2.3 RCO Preparedness

RCOs were asked how prepared they felt at the conclusion of their own training. A few RCOs felt adequately prepared; however, the majority of RCOs felt they were not prepared and were not comfortable at the end of their training. One RCO noted that he was comfortable pulling small cuts of cars but was not prepared, for example, to pull large cuts of cars over public grade crossings using the automatic train air brake system.

RCOs were then asked how much hands-on experience was necessary before they felt adequately prepared to operate an RCL. Responses ranged from less than 1 wk to 4 mo per job, with most

of these indicating that they felt adequately prepared after 1 mo on each job or location in the yard. Notes one RCO, it "took about a month to understand what these cars are gonna do." One RCO said that he felt comfortable right away operating the RCL at low speeds. In contrast, several other RCOs said that they still do not feel comfortable operating an RCL, even after as much as 18 mo on-the-job. They attributed this lack of comfort to a lack of consistency in RCL response from day-to-day, encountering new error codes of which RCOs do not know the meaning or solution other than to re-set the RCL, and concern over having more responsibilities.

Many of the RCOs pointed out that, due to operational and territory differences among different jobs (e.g., bowl, hump, or industry), the time it takes to get comfortable is location-specific and suggested that this comfort is an additive function. For example, it may take 1 mo to become comfortable working the bowl job and another month to become comfortable at the hump. This is especially important since some RCOs may work on a rotating extra board and consequently work all RCL jobs and locations. RCOs also suggested that prior experience as a switchman, conductor, or engineer helps in becoming more comfortable. One RCO explains, "How fast you get comfortable with [RCL operations] depends on how much [switchman] experience you have."

4.2.4 Suggested Improvements to RCO Training

Lastly, RCOs were asked how they would improve initial RCO training based on their work experience. Suggested improvements to RCO initial training revolved around three basic areas of training, which were the trainers, training procedures and methods, and the content of the instruction. The following presents specific suggestions by RCOs organized by general category.

Trainers

- Use more experienced and knowledgeable trainers who understand RCL operations and yard switching.
- Provide train-the-trainer training to peer trainers and classroom instructors.
- Use dedicated trainers.
- Employ railroad employees, not manufacturer representatives, to train RCOs.
- Use two experienced RCO peer trainers during OJT.
- Pay OJT peer trainers for their extra effort and responsibility.
- Have someone oversee and be responsible for the overall training effort to ensure that RCO training is comprehensive.

Training Procedures

- Reduce the amount of classroom training spent on the mechanics of RCD operation, and increase the amount of time spent in OJT.
- Provide more hands-on experience operating the RCD.
- Familiarize yardmasters, managers, carmen, dispatchers, and others who interact with RCOs or work in proximity of RCL operations, with RCL practices and procedures.

RCOs repeatedly noted that other crafts do not understand RCL operations, and this creates dangerous situations. One example that was given involved a yardmaster who believed he had the authority to permit a cut of cars to enter an RCZ that had previously been established.

- Address seasonal differences during training. RCOs noted that some differences exist between operating an RCL in the summer versus the winter, and these differences should be addressed so RCOs will know what to expect and can adjust as necessary.
- Cover the entire range of locations, operations (e.g., using the automatic train air brake system), and configurations of cuts of cars (e.g., heavy and/or long cuts) that RCOs will encounter on the job. More specifically, train RCOs during OJT on every job and every part of the yard, as well as every condition that RCOs can be expected to work. For example, if RCOs are expected to use the automatic train air brake system to service an industry, then RCOs should learn how to service the industry with the automatic train air brake system. A significant number of RCOs noted that during their training they had been trained on one part of the yard or were only exposed to small cuts of cars, but once qualified, they were expected to work any yard job with any type of configuration of cuts of cars.
- Expand training on RCL-related rules (e.g., address every scenario in which a particular RCL rule may apply).
- Enable peer trainers to stop the RCL if necessary (e.g., by providing a panic button or extra RCD). Currently, if a trainee is operating the RCD, no way exists for the peer trainer to stop the RCL in an emergency unless he or she is shadowing the trainee immediately next to him in order to grab the RCD and apply the brake[4].
- Have a manufacturer representative be onsite and available 24 h a day during initial training and implementation to troubleshoot problems that arise.
- Require employees to have a minimum amount of ground experience as switchmen before promoting them to RCOs. A range of experiences was recommended, generally from a minimum of 6 mo to 3 yr. According to RCOs, ground experience aids in understanding the yard layout and how to switch properly, so that the added responsibility of operating the RCD will not compete with other newly learned skills.
- Retrain RCOs on new RCL equipment if new equipment is introduced into the yard.
- Provide refresher training (e.g., familiarization trips) to those who have not operated an RCL for a period of time[5]. The range of time periods suggested varied from 3 wk to 6 mo. As one RCO notes, in as short a time as 3 wk, procedures and rules may have changed.
- Provide flexibility in training to allow extra time for those who require it.

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[4] A second way, not mentioned, is for the trainer to cut off the fuel to the RCL by pressing an emergency fuel cut-off switch on either side of the RCL. Most locomotives are equipped with such external fuel cut-off switches.

[5] An RCO who is also qualified as a switchman or road conductor may work these other jobs rather than an RCL job.

- Apply the same medical screening to RCOs as are applied to locomotive engineers[6].
- Inform RCOs of changes and updates to the RCL software.
- Allow trainees to try all available vest configurations during training to determine the most comfortable one. Some RCOs noted that they were stuck with a vest that was uncomfortable, even though other vests were offered by the railroad that may have been more comfortable.

Training Content

- Include more train handling instruction, including operation with and without the automatic train air brake system.
- Expand classroom training to include basic coverage of the mechanics of the locomotive, the air brake system, and other locomotive and RCL components, to give RCOs a deeper understanding of the equipment they use. RCOs felt that their understanding of many of the mechanical aspects of the locomotive was superficial. RCOs pointed out that locomotive engineers receive thorough training, and they would like more thorough training as well.
- Thoroughly train RCO trainees how to conduct locomotive daily inspections if they are expected to conduct them. Current locomotive inspection training was described as minimal. RCOs did not feel that they had a meaningful understanding of what they were supposed to look for and inspect.
- Provide explanations for each RCD error code, including what each code means and what should be done to resolve the error. RCOs noted that they received error codes from time to time that they had never seen before and did not know what the code meant or how to resolve the problem other than to reset the RCD.
- Develop operating practices to address what RCOs can and cannot do while operating an RCL.
- Include training on safe work practices (best practices), such as how to read a switch list safely while controlling an RCL.

4.3 Current RCL Operations and Safety

Next, RCOs were asked several questions pertaining to current RCL operations and safety. These questions focused on two core issues:

- Current problems encountered in yard and industrial service
- Suggestions for improvements

The following discusses each separately.

[6] FRA regulations do not distinguish among different classes of service; anyone operating a locomotive must meet the same medical screening standards set by 49 CFR § 240.121.

4.3.1 Current RCL Yard and Industrial Operational Problems

RCOs were asked whether or not they had experienced any problems or difficulties operating an RCL or whether or not there were particular moves that were difficult to control using an RCL. A number of issues arose from the responses of the 78 RCOs. The following discusses and organizes these issues.

Train Handling

Train control. According to RCOs, the OCC does a poor job of train handling compared to a conventional locomotive engineer. Specifically, RCOs describe the OCC's train handling as the alternating application of the throttle and brake. In other words, after an RCO selects a given speed, the OCC revs up the throttle, then firmly applies the brakes, then revs up the throttle, then firmly applies the brakes, and so on, creating a herky jerky response from the RCL as it attempts to match (or hunt for) the selected speed. According to RCOs, this can cause a rough ride, potentially creating enough slack action (jerk) to throw the RCO to the ground if he or she is not expecting the change in acceleration. This also makes coupling very difficult when the RCO has stopped short of the coupling location because the RCL may rev up the engine, and, by the time the brakes are applied to stop the RCL, it has already made a hard coupling, slamming into the car to which the coupling is being made. RCOs noted that it was not possible to feather either the throttle or the brakes using the speed selector-type RCDs, as locomotive engineers can do under conventional switching operations. Spotting cars at an industry is especially difficult, several RCOs noted, especially when cars must be spotted within 2 to 3 feet of a location. If cars are close to the end of a track, the RCO also risks running into or through the end block. RCOs at one location noted that an accelerator exciter has been installed on some RCLs so that the RCL will accelerate more quickly to an RCD command. However, the exciter compounds the problem RCOs noted of not being able to control a short move.

Operating with the automatic train air brake system. RCOs from several railroads noted that it was difficult to operate the RCL using the automatic train air brake system other than to completely stop the locomotive. RCOs reported that they could apply the minimum automatic train air brake system setting (brake application), but anything higher caused the RCL to come to a stop. RCOs wanted to use the automatic train air brake system to help them control a heavy train or to power brake in situations where more braking capacity was required for precise spotting. RCOs noted that they were limited in the particular amount of automatic train air they could apply to control a heavy move which made controlled stops difficult. At one location, RCOs noted that, every time the automatic train air brake system was cut in (i.e., used), the locomotive would shut off. Thus, at this location, the automatic train air brake system was unavailable as a tool to aid RCOs in controlling their moves. Lastly, some RCOs explained that, not only did it take a long time to charge the air in the cars, creating a delay, it is often problematic because the RCL will not allow the locomotive to operate with less than 90 pounds (lb) of pressure in the brake pipe. So, if a leak does occur in the brake pipe, then the brake pipe may never reach a full charge, and the cut of cars may not be able to be moved, or the leak requires the RCO crew to operate the cut without the benefit of the automatic train air brake system. RCOs noted, in contrast, that an engineer can operate a locomotive with less than 90 lb of air pressure in the brake pipe.

Braking. RCOs felt that an RCL's brakes do not respond quickly or firmly, and the brake shoes wear out more quickly than during conventional operations, probably due to the frequent brake applications initiated by the OCC. According to RCOs, the RCL's herky jerky train handling can result in wheel sliding in some situations. RCOs note that some railroads have changed brake shoe types and/or reduced the amount of independent (locomotive) brake pressure applied by the RCL to avoid or reduce wheel sliding. However, RCOs noted that, although wheels may no longer slide with these changes, now it takes much longer (in time and distance) for the RCL to stop.

Snow brakes. Snow brakes may be used at some locations to help prevent wheel sliding in wintertime by applying a constant, minimal amount (e.g., 10-18 lb) of independent brake pressure. According to some RCOs, though, snow brakes cause the RCL to surge when accelerating. Further, if any type of inadvertent activation exists that would cause the RCL's brakes to apply, the cut will stop more quickly than usual because of the pre-existing snow brake application, creating a potential hazard for an RCO riding the RCL or a car. And if two RCLs are joined together (referred to as multiple units (MU)), each with snow brakes applied, an accordion-like action can occur between the two RCLs because of differences in snow brake settings.

RCL overspeed. RCOs explained that an RCL may exceed the speed selected on the RCD, especially when traveling down a grade where speed can pick up rapidly. One example was given where a locomotive was traveling 13 mph even though the speed selector was set to 10 mph. Several other examples of this overspeed were given as well.

Kicking cars. RCOs noted that kicking cars can be problematic, especially uphill. Kicking cars is a switching move in which leading cars are shoved by a locomotive/RCL before they are uncoupled and allowed to roll freely into a designated track, while the locomotive/RCL decelerates or stops. A challenge to kicking cars using an RCL are the RCL-induced acceleration surges that cause bunching of knuckles followed by decelerations that cause the knuckles to stretch out. This stretching-and-bunching (a.k.a., slack action or buff and draft forces) can cause a pin that has been pulled already to separate two cars to drop down before the cars separate. The pin, in a down position, holds or couples two cars together. An RCO must pull the pin up to allow the cars to separate. The pin separating the cars must stay up until the two cars are physically separated. However, the pin may drop back down before the cars are able to separate due to the bunching and stretching that occurs as a result of RCL operation. Consequently, the RCO may have to walk alongside the moving cars (while operating the RCD) and hold the pin up to ensure the cars will be able to separate. RCOs noted a lack of control needed to keep the bunch between cars to allow the pin to be pulled up and keep the pin up. In conventional operations, RCOs noted that a smoothness exists in the movement that allows the pin to remain up after being pulled.

Dropping cars. Some RCOs explained that, early on in the RCL implementation process, they were allowed to drop cars. Dropping cars is a switching move in which one or more cars trailing a locomotive are uncoupled as a cut while in motion and allowed to roll freely onto a track other than the one on which the locomotive continues to run. Care must be taken that the governing track switch operates freely, the hand brake to stop the cars operates, and the locomotive accelerates enough to avoid being hit by the following cars. If the drop is made too slowly, the cars could hang up and stop over the governing switch, thereby trapping the locomotive on its track, causing its coupler to face a car side and not a car end with a coupler. Precise coordination

of tasks and timing are essential for a safe, efficient drop. These RCOs found this practice to be particularly dangerous. RCOs noted that this practice has since been stopped at railroads where these RCOs work.

Locomotive roll-back. RCOs noted that it is difficult to prevent roll-back when starting a move on an ascending grade. When roll-back occurs, after a certain period of time the RCL may set the brakes (determining that a problem exists). The RCO must then initiate the move on a grade, or he/she must return the cut of cars to the bottom of the hill and re-initiate the movement.

Uphill moves. RCOs noted experiencing difficulty moving an RCL uphill at low speeds. They note that the RCL does not always automatically administer sand when RCOs feel it would help. The result is that, to avoid roll-back, RCOs must use the RCD to command the RCL to give sand. Since a delay exists between the RCD input and the RCL response, RCOs must request sand at just the right time and location, generally several seconds ahead of time. If the cut of cars does not make it up the hill, RCOs explained that they would have to bring the cut back down to the bottom of the hill and try again, since it was difficult to start an RCL on a hill because of roll-back.

RCL performance inconsistencies. RCOs noted that an RCL may respond differently from one day to the next. However, RCOs were unsure of the cause(s) of this lack of consistency. One suggested cause was brake wear over time.

Equipment

Inadvertent activation of RCD. RCOs explained that inadvertent activation of the RCD was a significant problem. For example, RCOs noted that wearing winter (i.e., thick) gloves can cause an RCO to inadvertently bump an adjacent switch while making an input to the RCD. Another problem was bumping into rail equipment (e.g., a locomotive grab iron or cab door) while wearing the RCD. RCOs felt that the shape of the box facilitates inadvertent activation since some of the RCD's switches/controls (e.g., the speed selector or independent brake paddles on either side of the RCD) are exposed or not well protected. The RCO may not receive any feedback about a change to the RCL status (that a change has occurred) when an inadvertent activation occurs. For example, if an RCO sets the speed selector to 4 mph and then looks up to begin monitoring the cut of cars, and the speed selector then gets bumped up to 10 mph, the RCO may not know about the change in speed selection until some point or time after the RCL has surpassed 4 mph. Further, if an RCO is riding the RCL, and an inadvertent activation occurs that causes the RCL's brakes to be applied, there may not be any advance warning to the RCO that the RCL is going to brake.

Communication problems. RCOs noted two particular communication-related problems related to how the RCD sends and receives information to the OCC. First, RCOs expressed frustration with communication delays between an input to the RCD and the time it takes for the RCL to respond. For example, one RCO commented that he would make an input and wait for a response. After a period, he assumed the input had not been received, so he began to make a new input, just as the RCL began to move. This caused a fault that forced the RCL to stop. Another example of a problem related to the delay in communications is the delay in RCL response. Specifically, a cut of cars may continue to travel 4-5 car lengths between the time an RCD input is made and the time the RCL begins to brake. Second, RCOs noted that RCD-OCC communications seemed unreliable. RCOs noted that sometimes an OCC would receive an input

by the RCD, and other times the same OCC would not respond to the same command. One RCO gave an example where it took seven tries to successfully command the RCL to apply the emergency brakes to stop. Another RCO noted that she fell once while wearing a RCD, and the RCD did not send the RCL into emergency. Other RCOs noted that an RCL would just stop due to a communication failure. RCOs noted that the use of repeaters around the yard has eliminated many of these communication failures, but some communication failures still occur.

RCD display readability. Some RCOs noted that the RCD display was too bright at night and too dim during the day to read.

RCD size and location on body. RCOs explained that walking in the yard was more difficult because the RCD, worn on the front of the torso using a vest, obstructs the RCO's view of the ground and path directly in front of him or her, and creates a blind spot where the RCO is walking. RCOs commented that they tripped more often now because they were unable to see the ground directly in front of them. Further, in cases where an RCO falls, the presence of the RCD prohibits the RCO from tucking-and-rolling safely as he or she falls. Separately, RCOs noted that it was difficult and dangerous to walk [sideways] between tracks with narrow track center separations due to the added dimension of the RCD worn on the front of the body.

RCOs identified a number of issues with the vests that were worn. RCOs explained that the vests can get stuck on a piece of equipment, do not always break away when RCOs feel they should, are uncomfortable, are hot in the summer, and contain vertical rods located in front of the vest that pose an eye and face hazard if they come out of the vest. An example was given where an RCO sat down and the rods in the vest were pushed through the top of the vest (nothing exists to prevent the rod from exiting the top of the vest) and almost struck the RCO's face (and eyes). Several RCOs commented that they had had sore necks, shoulders, and backs as a result of wearing the RCDs. Female RCOs specifically pointed out that the RCD was too heavy, does not sit right on their torso, the vests were too long, and the vertical rods were poorly designed for a female body. RCOs also noted that it is difficult to lace hoses or do anything requiring the RCO to bend over while wearing the RCD. Lastly, several RCOs at several locations expressed health concerns related to possible electromagnetic radiation emissions from the RCD, especially when worn close to the body for hours at a time.

Unrecognized error messages. Many RCOs explained that they periodically receive unrecognized error messages on their RCDs. RCOs noted that they did not know the reason for the message, the meaning of the message, or the required response to correct the problem. Further, according to RCOs, many of the front-line managers (e.g., yardmasters) do not know what many of the messages mean. The result is that often RCOs simply reset the RCL, and the message often goes away; yet it is not known whether or not the problem has been fixed.

Damaged RCD. RCOs at several locations pointed out that the vigilance reset buttons (also used to release sand to aid RCL traction) were wearing out due to excessive use. That is, the RCD will not register an input when the vigilance reset button is depressed. Consequently, it may take several button presses before the RCD registers this input and communicates to the OCC.

Separately, one RCO observed an occasion where an RCD had a dent near the vigilance reset button that caused the vigilance reset button to stick in the depressed position. This resulted in the temporary nullification[7] of the vigilance safety feature. According to RCOs, one location has introduced a new vigilance reset button stuck error message that will set the RCL to full service brake to stop the RCL if the vigilance reset button is pressed (stuck) down continuously for 30 s. This is to prevent loss of the vigilance safety feature. However, sometimes RCOs want to keep the button pressed when sanding. As a result, RCOs at this location now press and hold the vigilance reset/sand button until they receive the warning, then they release the button and press it again, repeating this process as long as sand is needed. A separate criticism focused on the ruggedization of the RCDs and their ability to operate reliably in normal railroad operating conditions. One RCO noted that an RCD was "trashed" after working in the rain for 5 h, indicating that the RCDs are not completely waterproof.

Bypass of speed selector unintended activation safety feature. Some RCOs explained that they had encountered a problem with the speed selector. If an RCO moves the RCD speed selector from any speed setting to the stop position, it is possible to then initiate a new move by inadvertently (or intentionally) moving the speed selector up to any speed selection as long as the RCL has not yet come to a stop. In this case, no requirement exists for two deliberate inputs to initiate RCL movement, as there is when the RCL is stopped. That is, the safety feature requiring two deliberate inputs (which is presumably designed to help avoid unintended activation) is bypassed. Further, the RCL's bell does not ring in this case, whereas it does ring when a move is initiated from a stop. The RCO may not be aware of the change in speed selector status and, thus, may expect the RCL to come to a stop when, in fact, it may begin to increase speed.

RCL strobe lights. RCOs at one location commented that the four strobe lights originally mounted on RCLs to increase awareness of the unmanned locomotive were too bright at night (they produced glare). The railroad then reduced the number of strobes from four to two, which has helped reduce the glare from the lights.

Ice buildup. One RCO observed that ice builds up on the RCL's grab irons and creates a hazard to RCOs who are constantly climbing up and down the RCL. The RCO suggested that fixing the RCL's rain gutters would correct this problem.

Procedures

Additional tasks and responsibilities. Several RCOs felt that it was an advantage to be able to control the move from the ground. However, the extra tasks and responsibilities that went with the new control were a concern. RCOs felt that the added tasks are a burden and can lead to excessive workload. Notes one RCO, "When I get a switch list in my hand, I forget I'm running an engine." Another RCO explained that so many things are now on your mind that you can become distracted and then it is easy to overlook something. Figure 7 illustrates an example of an RCO lining a switch as part of his RCO responsibilities, which may also include checking a switch list, monitoring movement of the RCL and cut of cars, and talking on the radio.

[7] Nullification was temporary because, in this instance, after the cut came to a stop, the RCL did not allow the cut to move again.

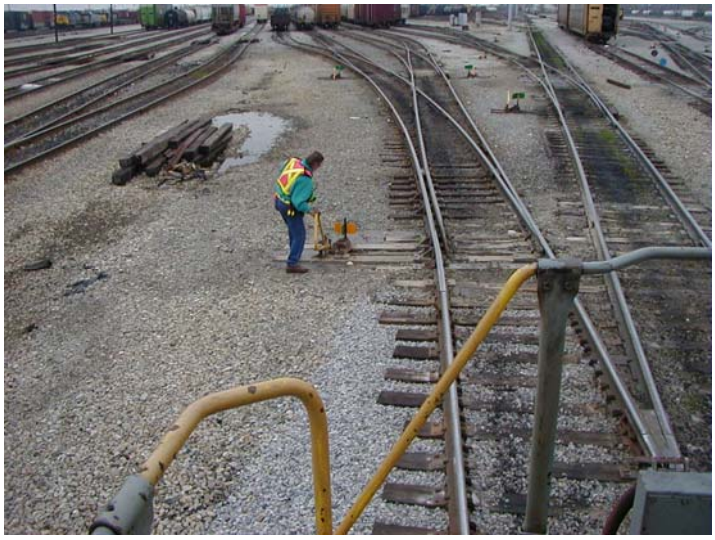

Figure 7. RCO lining switch

Rest breaks. RCOs observed that with the new job comes added tasks and responsibilities, as well as the added weight of the RCD, but they are not given any additional rest breaks to recover from the added responsibilities and weight.

Reliance on non-crewmembers to line switches or provide point protection. RCOs noted occasions where they were supposed to rely on a yardmaster or other non-crewmember to line a switch, provide point protection, or set up/take down a derail. RCOs felt that this was an unsafe practice since the yardmaster or other non-crewmember may be busy with other responsibilities and may not have a vested interest in ensuring the RCO's safety. RCOs noted that yardmasters are not part of a crew and therefore may not be held responsible if anything does happen. Alternatively, observes an RCO, if a yardmaster is lining switches for a one-person hump job, it is possible that another cut of cars, or a train, could enter the target track, but the RCO will not see the problem. This could happen, for example, as a result of a foreign or inexperienced crew that miscounts or misidentifies the designated track which they are supposed to enter. For instance, at one location, RCOs are responsible for a particular derail being set up properly to protect the RCZ. A camera is focused on this derail, but the yardmaster is the only one who can set up the derail (or take it down) and the only one with access to the camera view to check the derail position, as well as a train's location relative to the derail. Yet the RCO crew is responsible if anything happens with the derail. If the yardmaster is busy or distracted when the RCO calls the yardmaster to check the derail (as may be the case when the RCO is working on the other side of the RCZ), the yardmaster may quickly say "Yeah, it's up" when, in fact, it is not up. Further, RCOs explained that they are discouraged from walking up to the derail to check its position because it is time consuming. Thus, RCOs are responsible for the derail and anything that happens as a result of the derail position, yet they are discouraged from directly determining or confirming the derail position.

Position of the switch relative to RCZ. At one location, RCOs noted that the switch lead into the roundhouse is a problem. The lead is located just outside of an RCZ and used heavily by RCOs as well as others using the roundhouse. As a result, RCOs must be especially careful to ensure that the switch is lined properly when moving beyond the RCZ. The location of this switch, right next to a RCZ where point protection is not required, creates a potentially hazardous

situation if the RCO makes a move just beyond the RCZ without point protection. A suggestion was made to move access to the roundhouse to a location further away from the RCL operation.

*Right-handed pin pullin*g. RCOs note that sometimes pins do not stay up when they are initially pulled up (one RCO estimated that around 30 percent of pins do not stay up on their own), so it is necessary to hold the pin up to ensure that cars separate. If an RCO is using his or her right hand to hold the pin and needs to make a speed adjustment, it can be awkward to reach over with the left hand to make the adjustment. Such is the case if an RCO is kicking one or more cars—the RCO must ensure bunching to pull (and hold) the pin, then must stop the RCL to allow the cars to separate.

Misunderstanding of rules and procedures. Confusion existed among some RCOs regarding what procedure to follow when operating an RCL over a public grade crossing when the crossing is within an RCZ. Some confusion also existed regarding whether or not RCOs are permitted to operate the RCD from inside the locomotive cab.

Riding locomotives and equipment. Some RCOs felt that it can be hazardous to ride moving equipment while operating an RCD. For example, RCD buttons and switches can get caught on clothes or equipment and cause the cut of cars to stop unexpectedly and potentially unknowingly by the RCO. Such a sudden stop could throw an unsuspecting RCO off the equipment. Riding the side of a car can also be dangerous due to close clearances (which an RCO may not notice while trying to operate the RCD). One RCO explains that, when you hold onto a car, you give up the ability to either control the speed (on one side of the RCD) or the independent brake. Another RCO points out that, once you add a lamp and a switch list, it is a challenge to hold onto a moving car. Some RCOs noted that certain types of cars are easier to ride than others while operating an RCD. Specifically, RCOs felt that tank cars are safer than flat cars (a.k.a., piggy backs or simply pigs), auto racks, and box cars. States one RCO, "Don't make me ride box cars." Some RCOs felt that riding a light engine (one or more RCLs linked together with no cars) can also pose dangers, for example when making a hard coupling to a cut of cars. Such a hard coupling can cause the RCO to fall, for example, if he or she is adjusting the RCD at the same time the coupling is being made.

Removal of RCD. At one location, RCOs are permitted to take off their RCD when working between cars, such as to adjust a drawbar. The RCO must first inform the other RCO crewmember to obtain three-point protection. However, the safety features of that first RCO's RCD (e.g., tilt time-out feature) are overridden in these instances.

Frequently changing rules. RCOs complained that it is difficult to work safely when the operating rules change frequently. The result is that RCOs feel like they do not know from one day to the next what is allowed and what is prohibited.

One-person RCO crews. According to RCOs at one location, if an RCO crewmember leaves early, the second RCO crewmember is expected to finish the shift as a one-person RCO crew.

RCL-related communications. Some RCOs noted that they were not always informed about updates or changes to the RCD or OCC. Further, according to RCOs, occasionally some, but not all, of the equipment has been updated with a fix to a known problem. The result is that, for any given RCD or OCC, an RCO may not know whether a known problem has been corrected, whether the problem still exists, or if a new function or feature has been added.

Adequacy of RCL maintenance. According to RCOs, when RCL operations were first implemented, maintenance on the RCLs (for example, replacement of worn brake shoes) was done immediately. After this initial implementation period, though, the frequency of maintenance was reduced. Comparing maintenance when first implemented to the present, one RCO explains, "it's like night and day." Some RCOs feel that their railroads are not adequately maintaining the equipment. RCOs recount that they have been told to take an RCL even if they suspected that something may be wrong with it.

Daily locomotive inspections. Some RCOs explained that they are now required to conduct daily locomotive inspections, but they do not have a sufficient understanding or appreciation of what to look for when conducting the inspection. Daily inspection training is superficial, according to some RCOs. For example, RCOs are told to check the air hoses and check that there are brake shoes on the RCL, but "there's tons more" that RCOs do not know about, according to one RCO. RCOs responsible for conducting locomotive daily inspections feel that they do not have a deep enough understanding of the different locomotive components to do a thorough or meaningful inspection. Notes one RCO, "You don't know how to shop an engine. You don't know what to look for [in terms of problems/troubleshooting]." Separately, at some locations, diesel shop employees now conduct the daily inspections. In some of these instances, RCOs note that the locomotives may not be thoroughly inspected. For instance, one RCO noted that he ran out of fuel in the middle of a shift, while another RCO ran out of sand in the middle of a shift. RCOs felt that, when the locomotive engineer performs an inspection, it is thorough because he or she knows what to look for and is motivated to ensure it is done correctly because he or she will be on the locomotive. Conversely, diesel shop employees may be in a hurry (e.g., to perform their scheduled maintenance work), and, since they will not be riding or relying on the locomotive, they may rush through the inspection or may even simply sign the inspection form without conducting the inspection.

Situation Awareness

Loss of locomotive orientation awareness. Some RCOs pointed out that it was sometimes difficult to remember which end of the locomotive was facing which direction. Since locomotives can operate in both directions, every locomotive has an F end. This end indicates the forward direction for the locomotive and corresponds to the forward position of the reverser. Setting the RCD reverser to forward will cause the locomotive to move in the direction that the F end is pointing, while reverse will cause the locomotive to move in the opposite direction. An RCO must know which end is the F end and what direction this end is facing in order to move the locomotive in the proper direction. If an RCO forgets which way the locomotive is oriented and is unable to verify where the RCL's F is located, it is possible for the RCO to set the RCL in the wrong direction before making a move. Notes one RCO, "It's easy to get it [RCL] in the wrong direction."

Lack of immediate RCL response feedback. If an RCO is working away from the RCL, and the RCL is out of sight, such as around a curve, or occluded due to a bridge or adjacent cut of cars, an RCO may not know for a period of time whether or not the RCL has responded to an RCD command. In other words, RCL response feedback is delayed. If an RCO moves a cut of cars in the opposite direction as desired, he or she may not become aware of this problem for a certain period of time. Other times, this lack of immediate feedback may cause the RCO to input an RCD command again, believing that the first command did not register. If the RCL, in fact, was

responding to the first command, the RCO's second set of inputs may induce an error and cause the RCL to unexpectedly stop.

Loss of movement awareness. RCOs noted that it is possible for an RCO to not be aware of a cut of cars that has broken in two or cars that have derailed, since RCOs lack kinesthetic feedback and may lack visual feedback as well. In other words, it is possible for the RCO to not feel the resistance (i.e., dragging) of derailed cars or may not feel or see that their cut of cars has broken in two. An RCO may hear an RCL laboring harder to overcome the dragging cars, but unless the RCO can see the derailed cars, he or she may believe that the RCL is compensating for poor traction or struggling to travel up a grade, or the RCO may simply assume the increased laboring is due to the RCL's computer algorithm for throttle and brake inputs. Separately, RCOs explained that sometimes an RCL with a heavy load may induce wheel sliding. If the RCO is positioned away from the RCL, he or she may not be aware of the problem due to a lack of visual and kinesthetic feedback.

Support

Adequacy of technical support. Some RCOs felt that the technical support they received from the RCL manufacturers was inadequate to address the RCO's specific questions and issues. For example, at one location, an RCO explained that the RCL's horn was stuck on for around 5 s. The RCD displayed an error code not previously seen. The code was then presented to an RCL manufacturer to resolve. According to the RCO, the manufacturer said it had no such code.

Adequacy of railroad management knowledge of RCL operations. Some RCOs felt that management did not know or understand RCL operations. This created several concerns. First, a few RCOs felt that some managers may not know what to do if an emergency occurred involving an RCL. For example, RCOs felt that some yardmasters would not know how to operate the RCL to move it if necessary, reset the RCD after an emergency, or cut in the locomotive to conventional mode to move it if necessary. Further, some RCOs expressed concern that yardmasters are often so busy that they may not even recognize that an emergency has arisen because they have so many other responsibilities. For instance, a yardmaster may not notice a man-down alert broadcast over the radio. Another concern expressed is that, when RCOs have questions about an RCL procedure or operation, no one has an answer, or the RCO is given inconsistent answers by different individuals.

Perceived pressure to work faster. Several RCOs pointed out that they had been pressured from management to work faster. RCOs noted that with current technology it is possible for someone to remotely monitor a crew's every move and position, using cameras and onboard (RCL) monitoring equipment. Compounding this problem, according to RCOs, is that many of those in management do not understand that it takes longer to switch cars with an RCL crew than with a conventional crew. This created stress in some RCOs. Notes one RCO, "They keep pushing."

Adequacy of union support. A few RCOs noted that, early on in the RCL implementation process, their union was not supportive of their concerns or problems, or knew of a railroad's plan for RCL implementation, but could not share this information. For example, one RCO described occasions where a local union representative would say, "my hands are tied," or "I can't do anything about that," when issues were brought up at a local union meeting.

Weather

Extreme and inclement weather. RCOs explained that extreme weather, both hot and cold, affected RCL performance. For example, batteries tended to have a shorter charge period in cold weather. RCOs also described times when the extreme cold caused the OCC to freeze up or valves to freeze, or the extreme heat caused the OCC to overheat. Some of the heat-related problems have been fixed by placing fans inside the locomotive cab to keep the OCC equipment cooler. RCOs also noted that it was difficult to operate the RCD wearing gloves due to inadvertent activation of adjacent buttons and not receiving critical tactile feedback to help locate a particular button or to inform the RCO that the button had been pressed. RCOs also noted that it was hard to find the vigilance reset button when wearing gloves since the button was almost flush with one side of the box. RCOs pointed out that an earlier generation of RCDs had a large mushroom-shaped vigilance reset button located on the top of the RCD that could easily be depressed in all weather conditions and provided clear feedback that the button had been pressed.

4.3.2 Suggestions for Improvements to Current RCL Operations

RCOs suggested a number of improvements to current RCL operations. These improvements fell into one of three basic areas–equipment, procedures, and facilities. The following presents and organizes suggestions by area.

Equipment

Suggested equipment improvements focused on the following themes:

- Prevent inadvertent activation.
- Improve existing functions and features.
- Provide additional feedback.
- Add new features and functions.

Specific suggestions are presented below, organized by theme.

Prevention of Inadvertent Activation

- Provide a way for the RCO to cancel or undo an inadvertent activation (i.e., to correct the situation) to avoid unnecessary and undesired braking and stopping.
- Place guards on the RCD to prevent inadvertent activation of RCD controls.
- Move the reverser switch to prevent inadvertent activation. For example, move the reverser switch to where the status button is located.
- Design the RCD switches to move horizontally rather than vertically. One RCO made this suggestion, noting that it should be possible to reduce the amount of inadvertent activation by creating switches that move in a perpendicular motion to that which is common to the RCO (and RCD) as he or she mounts and dismounts equipment. Thus, the up and down motions of the RCO will not accidentally displace a switch since the movement of the switch would be side-to-side.

Improvements to Existing Functions and Features

- Make the equipment (RCD, OCC, and RCL) more reliable.
- Make the equipment (RCD, OCC, RCL) respond faster (e.g., the brakes need to engage faster when placed into emergency).
- Enable the RCO to exercise greater control over RCL movements. RCO suggestions generally fall into one of two contrasting ideas:
  - Replace the speed selector with brake and throttle controls like those found in the locomotive cab.
  - Include more speed settings, especially 1 mph increments between 1-5 mph.
- Extend the tilt time-out period.
- Suppress the tilt time-out function if the RCL is stationary.
- Provide the RCO with more control over, and more immediate response from, the horn. RCOs complained that it was difficult to effectively control the timing of the horn blasts because of the delay in communication between the RCD and OCC. Further, RCOs noted that they were unable to use the RCL's horn for short-long blows. RCOs felt that they needed better control of the horn for short-long blows. Lastly, RCOs suggested reducing the horn loudness or giving the RCO the ability to produce quieter horn blasts. RCOs note that it is uncomfortable to be right next to, or on, the RCL when the horn blasts. RCOs point out that engineers can feather the horn loudness and duration so as not to create such a loud blast when someone is near the locomotive.
- Improve the physical design of the OCC and where it is mounted. Specific suggestions include the following:
  - Make the OCC units smaller and install them in places where they are not potential hazards and do not impede vision from the cab. Inside some RCL cabs, RCOs note, OCCs are mounted on the wall, creating a potential hazard if an RCO bumps his or her head against the OCC. Separately, RCOs explained that some OCCs are mounted on or near a window in some RCLs, impeding an RCO's view outside the cab.
  - Improve OCC panel door latches to prevent accidental opening. RCOs reported problems with OCC panel doors opening during RCL operations, creating a hazard.
- Move the RCD speaker to the top. Currently the speaker is oriented toward the ground and projects audio away from the RCO's ears. Consequently, RCOs noted that it was often difficult to hear RCD audio.
- Provide separate radio channels for RCL crews and conventional crews to minimize radio interference.
- Make the vigilance reset button bigger, or move it to a more conspicuous (i.e., easy-to-find) location.
- Make the RCDs and radios hands-free and voice activated. Thus, for example, an RCO could say, "come ahead 10 [car lengths]" as if talking to an engineer, and the RCD would send a command to the OCC to initiate the move.

- Make the RCDs more durable (for example, the vigilance reset button should last longer).
- Develop an RCD system so that wearing and holding all of the necessary equipment and tools (RCD, radio, lantern/light, vest, and switch list) is less cumbersome and more comfortable. Some specific suggestions include the following:
  - Make the RCD smaller and lighter.
  - Improve the vests. Make them lighter, more comfortable, and ensure that they are break away. Replace the metal rods with plastic ones.
  - Design the RCD to be able to be worn like a fanny pack. Or similarly, as one RCO suggested, provide jumpsuits in winter that contain the RCD clips built into the suit so that an RCD can clip right onto the suit without the need for the vest.
  - Design the RCD to be small enough to be able to be worn like a Dick Tracy style watch.
- Provide and use every safety option that is offered by the RCL equipment manufacturer.

Additional feedback

- Add a display onto the RCD to indicate when the OCC receives an RCD command[8] and, separately, when the RCL responds to the command.
- The RCD should indicate whether or not the RCL is moving and in what direction the RCL is moving. Currently, on some RCL equipment, if an RCO presses the status button, the display reads "out" or "engine out," which means the OCC received the command. But this does not mean the RCL has responded by moving. Otherwise, the status display says, "consist ready," which means the OCC is waiting for the next command from the RCD.
- Provide a readout of the actual time remaining in the battery charge, or, at a minimum, provide an earlier warning regarding low battery power to allow the RCO to manage his or her remaining time better. Some RCOs noted that currently not much time exists between when the low battery power warning is displayed and when the battery runs out. One RCO noted that he once got stranded far away from the office where extra batteries were located when his RCD battery ran out of charge.
- Warn the RCO when an unsolicited braking application occurs. This will allow the RCO to prepare for the imminent deceleration.
- Enable the secondary RCO to obtain feedback on what the primary RCO is doing.[9]
- One RCO felt that it would be useful to show RCOs the inside of the RCDs. This RCO felt that showing the RCOs what they are wearing may help to alleviate concerns of electromagnetic radiation. This RCO thought that seeing what the RCD is made up of may reassure RCOs.

[8] At least one of the major RCL equipment manufacturers has this feature already.

[9] At least one RCL equipment manufacturer already has this function incorporated into its system.

New Features and Functions

- Add a camera with zoom capacity onto the head end of the RCL and a display onto the RCD to enable an RCO to see and protect the point when at the rear of the cut of cars. A few RCOs recommended this feature, but other RCOs raised concerns over using a camera on the head end. One concern focused on how the RCO will be able to tell which track is his or her own, given the narrow separation distances between tracks. Another concern was the potential inability to detect problems with the rail such as split rail. A third concern centered on the additional workload potentially introduced by the use of a camera.
- Add a light onto the front of the RCD and aimed at the ground ahead to help RCOs see switches and the ground in front of the RCO during nighttime or other low light conditions.
- Provide a display dimmer with a wide range of illumination levels to enable the display to be dimmer at night and brighter during the day.

Procedures

- No clear preference existed among RCOs for mounting and dismounting moving equipment. Some RCOs preferred to be able to mount and dismount moving equipment, while others felt it was unsafe and could cause inadvertent activation of the RCD.
- No clear preference existed for riding moving equipment while operating the RCD. Some RCOs felt that they should not ride any moving equipment except the RCL. Some RCOs preferred to ride the bottom step of the RCL. Other RCOs wanted to ride cars while controlling the movement with the RCD. These RCOs felt that three-point contact with an RCD is no different than it is with conventional operations if the yard foreman is riding a car and using the radio or giving a hand signal or holding a lantern.
- Require RCOs to always positively protect the point (i.e., see in front of the lead end of the cut of cars at all times) and line or confirm switches and derails (rather than allowing or requiring a non-crewmember such as a yardmaster to perform this function). RCOs felt that only they would be absolutely sure that their tracks are lined and protected since they are the ones responsible for their move. RCOs preferred this protection be by direct visual contact, but some RCOs mentioned other means of protection, such as use of an automatic pullback or video camera trained at the point of the move.
- Train other crafts, including yardmasters, trainmasters, conventional yard crews, and dispatchers, on basic RCL operations and how RCL operations impact the yard. The goal of this training would be to increase awareness and understanding of RCL operations so that these individuals can work safely around RCO crews. Part of this education should include knowledge of RCZ lengths and how many cars can fit into an RCZ so that those making up a switch list, for example, do not create a cut of cars to be switched that is longer than the RCZ.
- Require employees to obtain permission from the RCO to enter an RCZ. One RCO noted that, at the beginning of RCL implementation, RCZs were set up and no one entered without permission from the RCO. Now, anyone can enter as long as he or she watches

out for the RCL (i.e., as long as the employee is aware that he or she is entering an RCZ, that is sufficient protection). This procedure does not inform the RCO that someone has entered the RCZ, however, and point protection is still not required.

- More and better rules and guidelines for operating an RCL. RCOs felt that there were generally no consistent and good rules for the operation.
- Offload some of the RCO's responsibilities to free up mental and physical resources to dedicate to safe RCL operations. RCOs observe that they are now doing the tasks of a yard foreman, an engineer, and, in some cases, a carman. One RCO comments, "The responsibilities that go along with this box are unreal."
- Perform frequent, periodic (e.g., every 1 or 2 mo) maintenance on the RCDs, OCCs, and RCLs (especially the brakes which are subject to increased wear-and-tear), and perform all maintenance locally rather than returning the RCDs and OCCs to the manufacturer.
- Provide, and make available 24 h a day, local and knowledgeable employees to answer questions about RCD failure codes and error messages, and answer questions about RCL operations, maintenance, and troubleshooting.
- Periodically check the RCDs for electromagnetic radiation emissions.
- Consider limiting RCL operations to certain parts of the yard. Some RCOs felt that RCL operations were only suitable for the hump, the bowl, or tracks that have been designated as RCL-only tracks. Others suggested using RCL operations only in locations where automatic pullback protection exists and no other rail traffic is present.
- Never operate an RCL over a public grade crossing.
- Improve RCO training[10].
- Management should be more aware of the difficulties and challenges of RCL operations. Allow new RCOs enough time to become familiar and comfortable with the new tasks and responsibilities required of RCL operation.
- Make snow brake usage optional.
- Limit the speed of RCL operations to 10 mph (some railroads have a 15 mph maximum yard operating speed).
- Educate the public about RCL operations. Some RCOs felt that public education would increase public grade crossing safety if motorists think there may not be anyone on board the cut of cars (i.e., motorists would drive more cautiously).
- One RCO suggested placing garbage cans in RCL cabs to improve housekeeping. This may also reduce potential trip hazards resulting from trash and debris left in the cab.
- At one railroad, each RCL contains a lock box mounted inside the RCL. The lock box contains extra equipment so RCOs do not have to go to the office to pick up the RCD; they can simply pull one out of the RCL they will be using. One could also store extra batteries, in case they are needed.

[10] See Section 4.2.4 for RCO recommendations to improve RCO training.

- Many RCOs felt that there must be a consistency in terms, rules, and procedures used by the railroads in their RCL operations. RCOs felt that currently railroads make rules and procedures without much reason, and change these rules and procedures frequently.

Facilities

- Several RCOs suggested the following improvements to track that is protected by a permanent derail:
  - Require the RCO to either acknowledge the warning, or stop the equipment, once the derail warning goes off as the cut of cars nears the derail. Currently, it is possible for equipment to travel over the derail, despite the warning.
  - Standardize and increase the reliability of the automatic announcements that indicate the number of cars remaining before the lead end of a cut of cars reaches the permanent derail. At one location, RCOs receive an announcement indicating the number of cars remaining before the derail is reached. However, according to RCOs, the frequency with which the announcement is played varies. Sometimes an announcement will indicate 10 cars left, other times it announces when 5 car lengths remain, and other times the announcement does not play at all (e.g., if someone is on the radio at the time, the automatic enunciator may suppress the message so as not to step on the other message). RCOs suggested that standardization (e.g., always announce when five car lengths remain and then one car length) would aid them in making such a move in the absence of positive point protection.
  - Include information on the distance to a permanent derail on the RCD. For example, include a light that illuminates when the cut of cars is a fixed distance away from the derail (e.g., 1000 ft). Then either allow the RCO to check a display on the RCD to determine the remaining distance (e.g., 200 ft) or provide an automatic and standardized audio message that is updated as the cut of cars gets closer to the derail.
- Maintain switches and switch leads better since, according to RCOs, RCL operations tend to damage switches more than conventional switching operations.
- Add smaller ballast around the yard to walk on, and to cover the ties with, since ties can become very slippery when covered in oil or frost. Smaller-sized ballast is considered to be easier to walk on than larger ballast and may make walking easier for RCOs who cannot see directly in front of them due to the RCD's position on the torso.
- Widen track centers. An RCD worn on an RCO's torso protrudes from the front of the RCO. RCOs felt that with the RCD it was hazardous to walk between some tracks because of the narrow clearance between two tracks.
- Add yard lighting to locations where a large amount of switching occurs, such as up switch leads.

4.4 Switchman/Engineer Experience

RCOs unanimously felt that their experience as either a switchman or engineer (including hostler) has helped them to operate an RCL. Engineers primarily noted that their engineer

experience has helped them in the area of train handling. The following advantages based on engineers' experience that were noted include that engineers:

- Understand how weight affects a cut of cars' ability to brake, which helps the RCO to know when to apply the brake(s). One RCO recounts, "You respect weight more."
- Pay attention to the track grade.
- Can diagnose problems with the locomotive to determine whether or not the locomotive must go to the mechanical department.
- Know when it is necessary to sand.
- Understand air brakes, including how to set up the air, and when to apply and release the air during a move.

One engineer noted that experience also helps "you plan ahead… and anticipate." Engineers noted that their experience did not help them with the mechanics of operating the RCD. Further, engineers noted that they lost the critical kinesthetic feedback cue, the feel of the in-train forces that helped them in their train handling.

Some switchmen with experience over the road or in the yard also felt that they had at least a rudimentary appreciation for train handling based on their past experience. Other switchman felt that they generally lacked train handling knowledge and an understanding of the mechanics of the locomotive and air brakes. However, they felt that their experience on the ground helped them to understand switching and track configurations; both of which were considered important in operating an RCL. These switchmen felt that, without their knowledge of switching and track layout, learning how to operate an RCL would be very difficult. Switchmen considered knowledge of track configuration especially important in order to switch cars into or out of the right track. RCOs noted that one can get easily confused regarding which track is which without the experience on the ground. Switchmen also felt that their experience lining switches helped them to work safely. One RCO noted, "switching is an art form," suggesting that switching must be learned over time to do it safely and efficiently.

Most RCOs, both engineers and switchmen, felt that some amount of experience was necessary before one could safely operate an RCL. RCOs noted that during their training, experience as an engineer or switchmen enabled them to focus on operating the RCD. They felt that without this experience, RCO trainees would be overtaxed by having to learn how to switch and learn track configurations of a particular yard at the same time they are learning how to operate the RCL.

4.5 Other-Than-Yard RCL Operations

RCOs were next asked what safety concerns they had with RCL operations outside of yards. These types of operations include transfer jobs from one yard to another yard, local freight trains, road switchers, or over-the-road, line haul trips. Some RCOs assumed these types of operations would remain a two-person RCO crew, while other RCOs suspected that these types of operations would call for a one-person RCO crew. Some RCOs even wondered whether there would even be a crewmember onboard. This question was difficult for many RCOs to answer for several reasons. First, some qualified locomotive engineer-turned-RCOs felt the issue was moot since they can operate a locomotive conventionally over-the-road anyway and wondered why one would even want to operate a train using RCL technology, given the presence of a

qualified locomotive engineer. These RCOs thought it made more sense to operate over-the-road conventionally, then switch to remote control to set out or pick up cars, and then return to conventional mode to return or continue on the main track. Other RCOs found it difficult to discuss something for which they had no direct experience. Some RCOs were just not comfortable with the idea of RCL operations outside a yard. Notes one RCO, "No matter what they do, I will never feel comfortable [and I] don't think they'll ever be safe [over main track]." Despite these difficulties and differences of opinion, most RCOs were able to express some concerns, as well as suggested changes to RCL operations before railroads should consider taking an RCL onto the main track.

4.5.1 Safety Concerns

Reliably stopping in time. Most RCOs expressed concerns about the inability of an RCL to stop in time at a public grade crossing or absolute signal, given their experience in yards where RCLs may not stop reliably even at relatively slow speeds. According to RCOs, for example, RCLs do not always respond to the first input given by the RCO. Furthermore, RCOs have observed delays from the time a command is given by the RCO and the RCL braking response. Consequently, some RCOs were concerned that an RCL would not be able to stop short of absolute signals or hazards at public grade crossings.

Amplification of existing problems and their consequences at higher speeds. All the existing problems (e.g., inconsistent RCL performance) become amplified at higher speeds. RCOs were concerned about what would happen if a communication failure occurred at 59 mph or what might happen if the RCD shuts down at 59 mph. RCOs were concerned that it may be possible, in such a case, for an RCO to lose control of, or access to, the locomotive's brakes. RCOs also expressed concern over in-train forces when the OCC receives an inappropriate command from the RCD (e.g., an accidental bump of the reverser switch), and the RCL goes into emergency at 59 mph. Separately, according to one RCO, the horn does not always blow when commanded by the RCO, so this could be a significant problem at grade crossings. RCOs also had safety concerns about being stopped on a high-speed main track as a result of some type of error and were also concerned about frequently causing traffic to back up in either direction as a result of frequent RCL failures. RCOs were concerned about losing RCD-OCC communications in a remote area and being unable to recover the RCL. According to RCOs, running with the automatic train air brake system is currently a problem in the yard, and they wondered what would happen on the main track if these problems persisted. For example, currently in some locations, an RCL will come to a stop if an automatic train air brake setting other than minimal application is used.

Terrorist take-over of an RCL. Some RCOs expressed concern that taking an RCL onto the main track to operate will increase the possibility that a terrorist can take over control of an RCL given that no one may be on board (e.g., if setting out cars after operating on the main track) and control is by radio.

Inability to set and release the automatic train air brake system or bail off the independent (locomotive) brakes. According to RCOs, an RCO cannot easily set and release the automatic train air brake system like a locomotive engineer can under conventional operations, for example, to determine the braking capacity required to slow down a cut of cars. Second, no way currently exists for an RCO to bail off the independent (locomotive) brake to prevent some of the

slack of a large train from running into the RCL.

Possible MU problems. RCOs described occasions where an accordion action occurred between two RCLs that were MUd together due to differences in braking and accelerations. RCOs felt that this problem would be even greater on the main track (since main track operation would involve more RCLs, higher speeds, and heavier trains).

No protection outside cab. RCOs noted that if they were required to operate outside the cab during main track operations, they would not have the benefit of cab occupant protection.

One-person crew concerns. Several RCOs felt that eventually one-person crews would be responsible for RCL operations. RCOs expressed several concerns related to one-person RCL crews. One concern centered on what would happen if an RCO became injured or incapacitated while operating an RCL on a main track in a remote area. RCOs were concerned that it was possible that an RCO could fall a certain way or suffer a heart attack but remain upright, in both cases without tilting the RCD. In these situations, the train would travel for 1 minute before the vigilance safety feature initiated a brake application. RCOs also noted that, with a one-person crew, if the RCO needs to set out cars, sooner or later the RCO is likely to get tired of walking back and forth, creating a potentially hazardous situation. One RCO felt that a one-person operation would just be too much responsibility for that person. Another concern addressed the practical nature of a one-person RCO crew. Specifically, if the RCO is on the ground counting cars as they go by (e.g., in order to set out some number of cars), or if the RCO is protecting a public grade crossing, RCOs wondered, who is protecting the point? RCOs also felt that it was less safe and harder to stay awake with a one-person crew compared to a two-person crew, where one of the crewmembers can provide a second set of eyes and can help the second person to stay awake. One RCO also pointed out that one-person road crews may be the least favorable job to have, so the person with the least experience or seniority might be assigned to the job, creating a situation where the least experienced employee is placed in a position with fewer safeguards.

Inexperienced RCOs. Numerous RCOs expressed concern over the situation where RCOs with little railroading experience (e.g., a new hire on the RCO spare board who only has a few months of yard experience and less RCO experience) could operate an RCL over a main track. RCOs explained that inexperienced RCOs may not have the experience to even recognize a problem when one arises.

Lack of required knowledge and skills. Many RCOs noted that those RCOs who have not received locomotive engineer or ESB training do not have the experience or knowledge of train handling, main track terrain, signal systems, grade crossing profiles, and locomotive problems; all of which are necessary to safely operate a train over main track at high speeds, according to RCOs. RCOs compared their 2 wk of training to the extensive (around 6 mo) training engineers/ESBs receive. In fact, some RCOs expressed discomfort at the idea of operating an RCL at speeds greater than 15 mph without locomotive engineer training.

Inadequate RCD automatic train air brake settings. RCOs noted that too few automatic train air brake settings exist on an RCD to adequately manage trains at high speeds and on descending grades.

Inability to conduct a terminal air brake test. RCOs pointed out that it is not possible with the existing RCD to conduct a terminal air brake test, which is required for main track operations.

Poor train handling. RCOs felt that current RCL train handling, with its constant accelerations followed by brake applications, would cause slack to constantly run in and out of a train on a main track, causing damage to lading, knuckles, and possibly leading to a derailment. Notes one RCO, "To handle a train, you have to be able to prepare ahead of time. [the RCL] …can't. [It] respond[s] after the fact." That is, it operates by accelerating for a period, then when speed is gained too quickly, the OCC reacts by setting the brakes. Then the train slows down too much, and the OCC reacts by accelerating again. This reactive cycle alternating between acceleration and braking, which causes stretching and bunching of the draft gear, may make train handling problematic at higher speeds, on different grades, or around curves.

4.5.2 Necessary Changes in Advance of Other-Than-Yard RCL Operations

RCOs were asked what changes to training, operating practices or procedures, or the RCD itself, would be necessary to make RCL operations safe outside a yard. RCO responses focused on three core themes:

- More thorough training
- More reliable equipment
- More control over, and information on, the RCL and consist

In addition to these themes, a few RCOs had suggestions that did not easily fit into one of the three core themes. These, too, are presented below. Some RCOs still had difficulty answering the question, given its hypothetical nature.

More thorough training. RCOs felt that more extensive training would be essential. According to RCOs, training would have to cover train handling, air brakes, locomotive components and troubleshooting, dispatcher communications, and territory familiarization. Some suggested it was necessary to be trained as a locomotive engineer, while others suggested a training program that paralleled an engineer's training to teach the core elements of an engineer training program. Several RCOs also noted that it would be necessary for main track RCOs to have RCL operations experience in the yard for a couple of years first.

More reliable equipment. RCOs felt that more reliable equipment was necessary to ensure safe RCL operation outside a yard. RCOs felt that the RCL's braking response must be improved to be more responsive (i.e., timely) to RCD inputs. RCOs also explained that the brakes must respond consistently 100 percent of the time. Further, RCLs must operate consistently from one to the next; that is, they must all setup the same, accelerate the same, and brake the same. RCOs also noted that the automatic train air brake system must work properly and not cut out the RCL or cause the RCL to come to a stop when applied. In fact, many RCOs explained that the RCL would have to perform just like a conventional locomotive, with no delay in response. Some RCOs were not confident that the technology could guarantee the ability to stop when needed. These RCOs felt, thus, it would be necessary to operate the RCL at low speeds (e.g., maximum 15 mph), or impose speed restrictions, to ensure the RCL would be able to stop when and where necessary.

More information on, and control over, the RCL and consist. RCOs felt that they would need more information to help guide their decisions and more control over the RCL. Some specific

areas where RCOs felt that they would need greater information or control included the following:

- Provide information on air pressure and the air pressure release status (i.e., access to air gauges).
- Provide information on the RCL's current amperage to determine locomotive engine loading.
- Provide greater ability to control horn intensity (i.e., to be able to feather the horn loudness).
- Provide ability to perform air leakage tests. According to RCOs, currently it is not possible to draw off precisely 20 lb of air as required in air leakage test procedures.
- Provide ability to apply dynamic brakes.
- Enable more precise speed and braking control. Some RCOs felt that this would be best accomplished with a greater number of speed selector and brake selections, while other RCOs felt that throttle and brake inputs should be used on the RCD rather than the speed selector to provide greater speed and braking control. The throttle and brake inputs would mirror the throttle and brake controls found on a locomotive control stand.
- Provide immediate access to the RCL's brake systems and throttle on the control stand if and when a failure occurs on the RCD or OCC.
- Equip the RCD and OCC with every safety feature offered by the manufacturer.

Other suggestions and comments. RCOs made a number of other suggestions that did not fit into one of the core themes discussed by most RCOs. These miscellaneous suggestions included the following:

- Make the RCD and vest lighter.
- Each railroad should follow standard operating procedures.
- Operate conventionally over the road, and then switch to RCL for switching operations.

4.6 FRA Oversight

Although not explicitly asked about FRA's oversight role of RCL operations, RCOs raised a number of issues related to FRA oversight during the conduct of the focus groups. RCO observations of FRA oversight included the following:

- Some RCOs felt that FRA field inspectors were not responsive to safety issues brought to their attention. One RCO said that one can complain about problems to the FRA, but nothing seems to happen or change. For example, one issue brought to the local FRA inspector's attention by an RCO was a railroad's practice of requiring both crewmembers to be on the ground tying or releasing handbrakes on auto racks. This practice requires one RCO to stand on each side of the cut of cars to tie down or release the handbrakes on

each side of the auto rack[11]. Given this scenario, there is no one to protect the point. According to the RCO, the FRA inspector was surprised by this practice, the inspector did not have an immediate answer, and he never followed up on the information. In contrast, though, one RCO described one FRA inspector who tries to fix every problem that is brought to his attention.

- One RCO commented that, regarding RCL operations, they [RCOs] "haven't seen anything positive from the FRA."
- Another RCO explains, "I think they [railroads] caught the FRA asleep a little bit on this one" with respect to what works and does not work using an RCL and what is safe and not safe.
- One RCO observes, "They're [FRA] supposed to be the overseer in all this…[but] there is none."
- Regarding the focus groups, one RCO asked why it took FRA so long to solicit input from RCOs.

[11] Some auto racks have two hand brakes, one on each side of the B, or brake, end of the car. One individual can tie or release each of the hand brakes separately, but a more efficient practice is to have one individual on each side of the auto racks, tying and releasing the hand brake that is closest to him/herself.

5. Key RCO Themes and Recommendations

This section presents key themes from the results of the focus groups with 78 RCOs, some RCO-suggested RCL operations best practices, and recommendations for further study of RCL operations. Section 5.1 presents the key themes, Section 5.2 presents some RCO-suggested best practices, and Section 5.3 presents recommendations for future research activities.

5.1 Key Themes

This section presents the key themes that emerged from the focus group discussions. These themes tie together one or more of the specific issues or problems raised by RCOs during the focus groups. The themes are significant because they are safety-related and likely to be applicable to many, if not most, U.S. railroads using RCL operations.

RCO Training

RCOs identified a number of perceived shortcomings in how RCOs are trained and reported a variety of different methods of RCO training. Many RCOs felt that 2 wk of training was inadequate to fully prepare them, given the added responsibilities and qualitative change to the nature of the job from a switchman or engineer to an RCO. Focus group results suggest that railroads spend too much time on the classroom portion of training teaching the mechanics of how to operate the RCD and not enough time on the OJT portion instructing RCOs how to switch cars safely and efficiently in RCL operations. Training for some of the RCOs did not cover all types of operation (e.g., use of the automatic train air brake system) or expose trainees to all locations within a yard or terminal in which the RCO was expected to operate. According to RCOs, the need to share equipment or inadequate access to operating the RCD during OJT resulted in some RCOs receiving less than 40 h of hands-on OJT. Separately, a number of RCOs reported receiving unknown or unrecognized RCD error messages. Training on how to conduct daily locomotive inspections was also identified as inadequate.

Prior Railroad Experience is Important in Learning to Become an RCO

According to RCOs, experience as either a switchman or engineer helps individuals perform RCL operations. Engineers primarily noted that their engineer training and experience has helped them in train handling (e.g., how combinations of tonnage, track grade, train speed, and air pressure in the brake pipe affect train performance); however, their engineer experience did not help them with the mechanics of operating the RCD. Switchmen generally felt that their experience on the ground helped them to understand switching and track configurations, which enabled these RCOs to move about the yard and switch safely while learning how to operate the RCD and control the RCL. Both engineers and switchmen felt that, without experience as either a switchman or engineer, learning how to operate an RCL would be very difficult.

Other Operating Employees and Managers Should Have a Greater Understanding of RCL Operations

RCOs felt that other operating employees and management have a limited understanding of RCL operations. RCOs felt that those who make RCL-related policy decisions (e.g., procedures, rules, equipment acquisition) have insufficient knowledge of RCL operations to fully support RCL operations and RCO crews. This has resulted in few rules, little guidance on what to do in

unusual circumstances, changing sometimes problematic practices and procedures, cuts of cars that are as long as the RCZ (rather than smaller to allow movement within the RCZ), poor communications between RCOs and management, and inadequate maintenance of equipment (e.g., RCL brakes, RCDs). Second, RCOs noted that they have encountered employees who work in the vicinity of, or with, RCOs not familiar with RCL operations and procedures. This is a concern since anyone who works around RCL operations must be familiar with relevant rules and operating procedures, especially since point protection may not be provided in some RCL operations. RCZs in particular can be a very hazardous location if other employees do not know what the operating procedures and rules are for entering the RCZ. For example, often when a RCZ is established, another employee must contact the responsible RCO to obtain permission to enter the RCZ. However, it is possible for someone to enter the RCZ without notifying the RCO. Or, as one RCO explained, a yardmaster once tried to deactivate an RCO's RCZ, creating the potential for two separate individuals to provide authority to operate in one location.

Reliance on Non-Crewmembers to Carry Out Some RCO Crew Functions

RCOs noted occasions where a non-crewmember, generally a yardmaster, provides point protection, lines switches, or checks the status of a derail for an RCO crew. A couple of potential problems exist with relying on a non-crewmember. First, the potential for miscommunication or misunderstanding exists between the two parties regarding an activity or status of equipment. Further, a yardmaster may be occupied with his or her other responsibilities and may not give the task the attention it requires, or the yardmaster may be distracted and give an incorrect answer to a question by an RCO (e.g., "is the move lined?"). The result may be that the task does not get completed or an error occurs in task execution. Further, the RCO crew may have no way of determining that a problem exists until it is too late.

Reliability of RCL Equipment

RCOs reported several types of reliability problems associated with the RCL equipment, including communication failures between the RCD and OCC, frequent error messages, delays in RCL response, updates to some, but not all, RCL equipment, and RCL overspeed (the RCL acquires a speed greater than that selected by the RCO). This lack of reliability was a major source of frustration for RCOs, and has the potential to create a hazardous situation when there is a need for the RCL to respond and stop immediately. Furthermore, a lack of reliability can instill mistrust in the equipment.

Limited Control Over the RCL

RCOs described the RCL's train control as herky-jerky, whereby the locomotive constantly cycles or hunts between accelerating and braking. This creates a very rough and non-fluid motion. This poor train control combined with delays in RCL response make train handling difficult for RCOs especially when small travel distances are required.

One of the RCD Safety Features can be Inadvertently Bypassed

Some RCOs described a situation where it is possible to initiate a move by inadvertently (or intentionally) moving the speed selector from the stop position to any speed selection while the RCL is moving. In this situation, no requirement exists for two deliberate inputs to initiate an RCL movement, as there is when the cut of cars is going to be moved from a stopped position. In other words, this safety feature is bypassed in this condition. Further, the RCL's bell does not ring in this situation, whereas it does ring when a move is initiated from a stop. Thus, an RCO

may not be aware of the change in speed selector status, creating a potentially hazardous situation.

Frequent Inadvertent Activation of the RCD

Inadvertent activation of the RCD was noted to be a frequent problem for RCOs. Causes of inadvertent activation include the location of switches, bumping into rail equipment as a result of mounting or dismounting equipment, and use of thick gloves in wintertime. Often an RCO may not be aware of the activation and change in RCL actuation. At a minimum this can be a nuisance, and at worst it can create a potentially hazardous situation if the RCL accelerates without the RCO's knowledge or goes into an emergency brake application while the RCO is riding the RCL (there may not be any advance warning to the RCO that the RCL is going to brake).

RCO Situation Awareness

RCO focus groups identified three specific types of situation awareness that can be lost when the RCO works away from the RCL. First, RCOs may lose awareness of the locomotive's orientation (i.e., which direction the F is facing) on the track. Second, RCOs may not be aware of RCL movement or its response to an RCD command. Third, an RCO may not be aware that his or her movement has broken in two or that cars are dragging.

FRA Oversight

A number of RCOs feel that FRA is not concerned about RCL operations given the technical problems RCOs have experienced, the lack of FRA involvement at the local level, and the lack of Federal regulations. Further, several RCOs felt that FRA does not know much about RCL operations. This perceived lack of understanding and lack of involvement has led some RCOs to conclude that FRA is not in a position to approve railroads' RCL operations programs.

Other-Than-Yard Operations

A few RCOs were comfortable with the prospect of taking the RCL out onto the main track. However, a majority of RCOs were not comfortable, citing among their main reasons that they felt that the equipment is currently too unreliable, and they lack the required knowledge and skills to operate on the main track. Equipment reliability problems (for example, delays in RCL braking response) can be amplified on the main track where heavy trains are traveling at high speeds, and it may be necessary at any time to stop short of a signal, public grade crossing, or other unanticipated hazard.

5.2 RCO-Recommended Practices

This section presents some of the key RCL operations practices suggested by RCOs.

Improve RCO Training

RCOs had numerous suggestions for ways to improve RCO training. These suggestions centered around three main areas of training–the trainers, training procedures, and training content. In terms of the trainers, RCOs suggested that railroads should be sure to employ instructors who have as much experience and knowledge of RCL operations as possible, since these individuals will be able to impart information about RCL operations beyond the mechanics of operating the RCD or initiating the OCC. Further, railroads should provide formal train-the-trainer training for their instructors, so that training is as effective as possible. As far as training procedures, some

suggested improvements include increasing the amount of OJT. OJT should cover the entire range of locations, operations, and configurations of cuts of cars that RCOs will encounter on the job. RCOs should also have a minimum amount of operating experience as a switchman or engineer before becoming an RCO. Other employees who can be expected to interact with, or work with RCOs, should also receive some awareness training of RCL operations to increase their understanding of how to work with and around RCOs. In terms of training content, major suggestions include incorporation of train handling methods and familiarity and knowledge of basic locomotive systems, as well as safe operating practices that inform RCOs what they can and cannot do as an RCO. Currently much of the content of RCO training programs focuses on the mechanics of operating the RCD, rather than on handling cuts of cars using RCL equipment.

Improve RCL Equipment

A number of suggestions were made regarding how to improve RCL equipment, including the RCD and OCC. Several of the most frequently cited suggested improvements include prevention of inadvertent activation of RCD controls, more reliable and responsive equipment (e.g., the RCL's brakes should respond sooner to an RCD input), and additional control over, and feedback from, the RCL (e.g., some type of indication regarding whether or not the RCL is moving, and if so, in what direction).

Improve RCL Procedures

Several suggestions were made to improve RCL operating procedures. One of the more significant suggestions was to require RCOs to protect the point at all times, especially given the variety of operating practices found in any one yard and the confusion that appears to exist among different employees that work around RCL operations. A few other common procedural improvements that were made include familiarity training for those who work around RCL operations and more frequent maintenance of RCL equipment.

Standardize Operating Practices

Given RCO suggestions for standardized practices and the apparent confusion among some railroad operating employees regarding what an employee can or cannot do in proximity to an RCO crew, there appears to be a need for standardization of practices and more education to ensure railroad employees are familiar with safe operating practices. A few RCOs suggested that FRA should regulate RCL operations to enforce standardization of RCL-related terms, rules, and procedures among and within railroads.

Improve Railroad Facilities in Support of RCL Operations

Suggested improvements by RCOs include the provision of additional information to an RCO about a cut of car's proximity to a derail, increased maintenance of switches and switch leads, smaller ballast to walk on, and more yard lighting.

Make Adjustments for Other-Than-Yard Operations

RCOs identified three core areas where RCL operations should be improved before any railroad considers taking RCL operations out beyond a railroad yard, which were more extensive training, more reliable RCL equipment, and more information on, and control over, the RCL and consist. Specific areas that the training must address include train handling, air brakes, locomotive systems and troubleshooting, communications protocols, and territory familiarization. In terms of reliable equipment, RCOs explained that the RCL's brakes should

respond reliably and quickly (i.e., as responsively as a conventionally operated locomotive). The biggest concern voiced by RCOs was that the RCL, as it currently performs, may not stop when and where it is necessary to stop, such as in the case of an absolute signal or a vehicle stuck at a public grade crossing. Lastly, RCOs wanted to have more information about the train (e.g., air pressure status, release status, locomotive electrical amperage reading), as well as more control over the RCL (e.g., access to dynamic brakes) and consist. Essentially RCOs wanted as much control over, and knowledge of, the RCL and consist as locomotive engineers have when operating a locomotive conventionally.

5.3 Future Human Factors RCL Operations Studies

The ultimate goal of conducting human factors RCL operations research is to eliminate or, at a minimum mitigate, operational hazards that create potentially unsafe working conditions for railroad employees. This goal can be reached by providing human factors research-driven support for drafting operating rules, developing operating practices, and designing physical and procedural safeguards. Based on the focus group results, there are a number of future human factors research studies of RCL operations that the FRA might consider to help eliminate or mitigate operational hazards. The studies are proposed to complement FRA's current RCL operations research program. Many of the studies do not depend on quantitative RCL operations safety data (i.e., accidents/incidents), since these data will not be available for several years. Each of the proposed studies is described below.

5.3.1 Conduct FMECA of RCL Operations

One method of identifying operational hazards is through the conduct of a FMECA. FMECA is a risk assessment method in which failure modes, their effects, and the criticality of the failures are systematically identified and described. FMECA is a qualitative approach to determining what can go wrong and what is likely to happen in each case if something does go wrong. FMECAs can support risk assessments or can serve as a stand-alone method. FMECA is particularly attractive, given the current lack of quantitative data to use to assess the safety of RCL operations. The results of the focus groups described in this report provide some preliminary insights into how RCL operations can be problematic. A FMECA would more systematically identify potential failure modes and effects and would determine what the likely consequences of these failures would be. FMECA could assist FRA and the railroad industry in prioritizing potential RCL operations risks and in developing appropriate corrective actions or countermeasures to eliminate or reduce these risks.

5.3.2 Develop RCL Operations Training Objectives

The FRA Office of Research and Development's Human Factors Program previously sponsored the development of training objectives, syllabi, and test designs to aid in creating more uniform railroad dispatcher training programs across the United States (Reinach, Gertler, and Kuehn, 1998). This approach was well received by the industry as a means in which FRA assisted the railroad industry to enhance safety in a nonregulatory manner. This approach, or a similar one, might be considered to assist the railroad industry in making RCL operations as safe as possible.

Based on the findings from the focus groups, a variety of training approaches appear to be currently used by the railroad industry to train RCOs. Further, most RCOs appear to feel

inadequately prepared to do the job upon completion of their training program. FRA could sponsor the development of a common set of training objectives that railroads could use to base or modify their own RCO training programs to ensure a minimum set of core learning objectives are satisfied. The goal of the research would be to help the railroads produce competent and adequately prepared RCOs. The research would be another nonregulatory approach to increasing safety by helping the railroads to help themselves.

The product of the research could be a document that contains training objectives and other instructional design tools and assistance that railroads could adapt for their own purposes. Much like the earlier FRA-sponsored training research, this approach would be based on input from the industry, modeled after current training practices, and nonprescriptive. Railroads would be encouraged to select and adapt those components of the training objectives that are appropriate and specific to their own operational circumstances and training needs. Development of such training aids requires knowledge of instructional design methods and RCL operations subject matter expertise.

5.3.3 Analyze RCL Operations Accident/Incident Data

Effective May 01, 2003, railroads must report to FRA the involvement of RCOs and RCLs in train accidents and incidents (FRA, 2003). In future years, FRA will be able to examine the nature and types of accidents and incidents involving RCL operations and compare these to conventional yard switching operations. These data will help broaden FRA's knowledge and understanding of RCL operations, as well as provide a quantitative component to FRA's RCL operations research program. Such data may also be able to be used in future risk assessments of RCL operations. To the extent that is possible, appropriate exposure data should be collected to normalize RCL operations accident/incident data. FRA's Safety Advisory 2001-01 (FRA, 2001) already encourages railroads to collect these exposure data. Such normalization will allow valid comparisons of RCL operations accident/incident rates to those of conventional yard switching operations.

6. References

Canadian National Railroad. (2000). *Canadian National experience with locomotive remote technology: Review of the design, implementation, use and safety record of the BELTPACK® system at CN*. Federal Railroad Administration Docket No. FRA 2000-7325. Retrieved December 20, 2004, from http://dmses.dot.gov/docimages/pdf57/118236_web.pdf

Federal Railroad Administration. (2000). *Technical conference remote control locomotives minutes of meeting July 19,2000*. Federal Railroad Administration Docket No. FRA 2000-7325. Retrieved December 21, 2004, from http://dmses.dot.gov/docimages/pdf51/107527_web.pdf

Federal Railroad Administration. (2001). *Recommended minimal guidelines for the operation of remote control locomotives*. FRA Safety Advisory 2001-01. 66 Fed. Reg. 10340, (Feb. 14, 2001)

Federal Railroad Administration. (2003). *FRA guide for preparing accident/incident reports*. Report No. DOT/FRA/RRS-22. Washington, DC: FRA Office of Safety.

Krueger, R. (1994). *Focus groups: A practical guide for applied research. Second edition*. Thousand Oaks, CA: Sage Publications, Inc.

Reinach, S., Gertler, J. & Kuehn, G. (1998). *Training requirements for railroad dispatchers: Objectives, syllabi, and test designs*. Federal Railroad Administration Technical Report No. DOT/FRA/ORD-98-08. Springfield, VA: National Technical Information Service.

Appendix A.
Focus Group Moderator Script

Hello everyone. My name is Stephen Reinach, and this is Sarah Acton. We are from Foster-Miller, a research engineering company located outside of Boston. Thank you for joining us in this discussion today. As you know, we have asked you here to share your experiences and opinions on some issues surrounding remote control locomotive operations. We are interested in what safety issues presently exist, as well as what some of the best practices and lessons learned have been from your experience. You have been asked to participate because you are the most familiar with the operations and equipment, and therefore are in the best position to discuss safety issues and best practices.

This is strictly a research project. It is being sponsored by the FRA Office of Research and Development. We will be conducting several focus groups like this one over the next month, and, at the end, we will write up a report that summarizes our findings from talking to RCOs like yourselves. The report will be made available to the entire railroad industry, including both labor and management, as well as RCL suppliers.

It is important to know that we will not include any participant's name or carrier affiliation, in the report. That is, we are not interested in reporting what any particular individual thinks or what a particular carrier is doing. We will be on a first name basis today, but in the report, we will not use anybody's name. Your anonymity can be assured.

We will be tape recording the session. This is because we don't want to miss any of your comments. Tape recording allows us to concentrate on what you say today, and then we can go back to our offices and take more detailed notes later. The tapes are strictly for us; neither the FRA nor the carriers will have access to these tapes.

Now let me quickly go over some housekeeping items:

- Our session will last about an hour and a half. At the end of the meeting, we will pay each of you $50 for your time.
- Feel free to get up anytime to stretch, get some refreshments, or to go to the bathroom.
- As you share your views, please speak up, but only one person at a time. If someone else is talking, please wait your turn. We want to hear what you have to say, but having more than one conversation going on at once makes it difficult to hear.
- There are no right or wrong answers but rather differing points of view. I encourage each of you to share your point-of-view even if it differs from what others have said.
- We are interested in hearing about both positive and negative experiences.

Before we begin, there is a background survey in front of you. Please take a moment now, if you haven't already done so, to complete the survey. Remember, no names. When you are done, please hand them to either Sarah or myself.

To start, let's go around the room and introduce ourselves and say how long you have been an RCO. My name is Stephen. I am <u>not</u> an RCO, as you may have guessed. I am a human factors engineer who has been studying railroad operations safety for the FRA for over 6 yr.

Appendix B.
Background Questionnaire

1. Age: _____

2. Gender: Male Female

3. What type of remote control device do you use at your yard (circle all that apply): Speed selector Brake-and-throttle

4. What brand of remote control device do you use at your yard (circle all that apply):

   CANAC Cattron-Theimeg Control Chief GE Transportation Other

5. Total experience working in the railroad industry: _____ years and _____ months

6. Experience working in a yard: _____ years and _____ months

7. Experience as a trainman: _____ years and _____ months

8. Experience as an engineer: _____ years and _____ months

9. Experience as an RCO: _____ years and _____ months

Appendix C.
Focus Group Questions

RCL yard implementation

1. Briefly, how did local management introduce RCL operations in your yard?
2. What were some of the initial problems you encountered when RCL operations were first implemented? How were these resolved?
3. If you were to give one piece of advice about implementing RCL operations in a new yard, what would your advice be?

RCO training

4. My understanding is that each of you received two weeks of RCO training—one week of classroom training and one week of OJT in an isolated area of the yard. Did anyone have a different training experience?
5. At the end of your RCO training, how prepared did you feel you were to operate an RCL?
6. How much hands-on experience do you feel you needed before you felt adequately prepared to do the job?
7. What improvements, if any, would you make to an initial RCO training program?

RCL operations and safety

8. Have you experienced any problems or difficulties operating an RCL? How were they resolved?
9. Are there any particular movements that are hard to control with an RCL? How could these moves be made easier?
10. What improvements would you make to the remote control device or to railroad operating rules and procedures to make operating an RCL as safe as possible?

Switchman/engineer experience

11. How do you feel your experience as a trainman or engineer has influenced your ability to operate an RCL?

Other-than-yard operations

12. What safety concerns do you have with RCL operations outside of yards?
13. Of the concerns just mentioned, I'd like to go around the room, and have each person say what their biggest concern is.
14. What changes to training, operating procedures or practices, or the remote control device do you feel are necessary to make RCL operations safe outside of a yard?
15. Are there any other factors that were not mentioned that you feel are necessary to ensure safe RCL operations outside of a yard.

Other

16. Are there any other safety concerns that we have not discussed? How would you recommend addressing these concerns?
17. Do you have any other thoughts before we wrap this meeting up?

Abbreviations and Acronyms

BLET	Brotherhood of Locomotive Engineers and Trainmen
d	day(s)
ESB	engine service brakeman (Canada)
FMECA	failure modes, effects and criticality analysis
FRA	Federal Railroad Administration
h	hour(s)
lb	pound(s)
mo	month(s)
MU	multiple (locomotive) unit(s)
OCC	onboard control computer
OJT	on-the-job training
RCA	root cause analysis
RCD	remote control device
RCL	remote control locomotive
RCO	remote control operator
RCZ	remote control zone
UTU	United Transportation Union
wk	week(s)
yr	year(s)