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Concerns Regarding Remote-Control Locomotive (RCL) Operations

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This paper discusses some of the safety issues regarding the operation of a Remote Control Locomotive (RCL). By RCL operations is broadly meant the movement of any railroad rolling equipment in which an operator controls a locomotive via the coded radio signals from any kind of remote control device and a corresponding device on the locomotive operated. A complementary and prefacing paper to the present one discusses some of the safety issues regarding One-Person Crewing (OPC) of Trains and Engines (Gamst 2001).

Remote-Control Locomotive (RCL) use has a wide range of technologies and operations, but this session limits presentations to the RCL subset of "remote control of switching locomotives." Presumably this includes both yard and road switching. The continuum of RCL operations is not empirically separable, however; thus, a brief overview should be given.

RCL operations, among other things, could mean: (A) RCL helper/pusher units--controlled via wire or radio signal by the engineer on a locomotive at the head end of a train--which are in mid-train (swing) or rear-end locations; (B) as on Australia's Robe River Iron, rear-end helper units, first, remotely controlled, then, cut off while in motion (on the fly); (C), an RCL on a switching lead or hump controlled by wire (tether line) or radio signal from a fixed central location such as a tower; (D) an operator switching railcars with an RCL via radio signals from a body-mounted, remote-control device (RCD); (E) the off-board control of a locomotive from an automotive vehicle; and (F) the running of what the FRA terms fully automatic train operation in Positive Train Control (by a central computer and its auxiliary devices).

The (A) example is often also called distributive power (DP) and the (B) example is a variety of (A). What we learn from DP is instructive for some aspects of RCL operations because both use the same kind of coded radio signals. Furthermore, DP has a decades-long history of successes and failures that cannot be eschewed in review of RCL operations.

- For those workers who inspect, repair, maintain, or install any RCL equipment of types (A) through (F) the FRA must make the same uniform rules for governing their tasks, configuration of equipment, and training.

- If any RCL equipment should fail, intermittently or fully while in use, all movements must stop and not be resumed until (1) new replacement equipment can be used in accordance with the rules, (2) the failed equipment can be repaired and tested in accordance with the rules, or (3) a suitable number of crewmembers is present for manual operations.

- The FRA should not allow any RCL operations implemented on a piece-meal basis. "Best practices" should be assessed for uniform implementations.

- Coded radio signals from RCDs should be tested for continuity and functionality, at times to be determined by the FRA.

- Suitable training must be provided not just for RCL crewmembers but also for all *workers* (both railroad employees and those on the railroad working under contract) who can potentially come in contact with or be physically impacted by RCL operations.

- Above all, just as the FRA used a Railroad Safety Advisory Committee (RSAC) to develop rules for standards and practices for Positive Train Control PTC), so too it should do the same for RCL operations.

1. Federal Railroad Administration Has Jurisdiction over RCL Operations:

An RCD mounted to the body of an RCL operator and its corresponding device on a controlled locomotive is a locomotive appurtenance or part of an appurtenance. RC devices/ appurtenances thus clearly fall under the

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jurisdiction of the federal Locomotive Inspection Act (45 U.S.C. § 23) and the federal Locomotive Safety Standards (49 CFR § 229.7). RCDs thereby come under the regulatory review of the Federal Railroad Administration (FRA). Under the charge of the FRA, the agency must insure that emerging technologies such as that of RCL do not pose a danger to railroad employees, contractor employees on railroads, members of the public, and property.

Federal regulations have long protected American public health and safety regarding railroad operations. In the United States, for any rail operations involving one-person traincrews or remote control of a locomotive by a portable, body-mounted radio RCD, used separately or together, FRA investigation and rulemaking are needed for their regulation and development of human-machine interfaces in design criteria. Design criteria and governing rules are the sine qua non of RCL operations.

The FRA regulates the Class-I, Class-II, and Class-III carriers of the US but not the sequestered industrial plants having their own internal rail operations, such as for switching of railcars. Such work sites, including steel mills, quarries, grain facilities, and manufacturing plants, are not accessible to the general public. These railed sites are outside of the general system of transportation. Such sites, ordinarily, cannot endanger members of the general public by their rail operations, which are outside of FRA oversight. An exception would be, for example, if a long cut of cars under RCL operations at a grain elevator facility were moved out of control on the tracks of an FRA-regulated railroad with a consequent runaway movement. Then FRA jurisdiction would obtain.

Covered in this presentation are movements of rolling equipment, for the three classes of railroads. Such movements include over public and private highways and pedestrian walkways and across innumerable unsanctioned shortcuts through their unmonitored and unsecured rights-of-way. These movements are on and adjacent to main and branch tracks and in yards. Whether or not a person is trespassing, as per virtually unchallenged American custom, in violation of the ubiquitous "no trespassing" signs on rail property, the danger to humans is equally grave.

2. The Issues Concerning Rail Accident and Other Safety Data.

First, we examine the integrity of rail safety data. Second, we reflect on questions about RCL accident data. Third, we see how quantified data from the blaming of just one employee for an accident does not provide valid information for accident assessment. And, fourth, we consider one historical RCL performance.

2.1. The Integrity of Rail Safety Data:

- Historically, not all data provided by railroads are valid or reliable. Additionally, sometimes data from railroads are false, and sometimes they are not reported in full or at all. For the purposes of this paper, we need not discuss whether particular errors are by accident or design.

(Validation is a procedure for determining if an instrument of assessment, including a test, for measurement measures what it supposed to measure. Here *validity* means the extent to which data relate to a criterion that is an accepted measure of the phenomenon under investigation. Reliability is the dependability of an instrument as found in the consistency of its measures from repeated measurements of the same group. Here *reliability* means the constancy between data obtained by repeating the same measurements on the same phenomenon under at least highly similar conditions.)

For analyses and conclusions based on data concerning rail safety, the information must be collected and reported uniformly, consistently, and entirely openly (publicly fully available). The information reported should be defined in a way to eliminate subjective judgment in the classification or categorization of the data and in the decision as to whether or not it crosses the threshold of being reportable. Railroad safety data have always been questionable, with problems ranging from local managerial pressures for desired levels of reporting of accident and personal injury data to systematic biases in the data collecting and reporting.

For one example, the GAO investigated and found (GAO 1989) that the FRA necessarily relies on safety data provided by the railroads. "However, GAO found substantial underreporting and inaccurate reporting of injury and accident data by the railroads it visited, which raises questions about the overall effectiveness of FRA's safety program and the extent to which railroads have become safer" (GAO 1989:3, also see 14-23). One datum uncovered by the GAO was that the five railroads it visited reported 2,176 missed workdays from 156 injuries, but the true number was 8,023 missed workdays (GAO 1989:4). Another finding, incredibly, was that Amtrak did not report 32 of the passenger injuries from the catastrophic collision in 1987 at Gunpow Interlocking, Maryland (GAO 1989:16).

2.2. What do the categorized, analyzed, and reported accident data regarding RCL reflect?:

Carriers and suppliers furnish safety data regarding RCL operations. The FRA must not use unverified data presented by a carrier or supplier from its own perspective. Furthermore, superficial submissions such as a bare skeleton outline of a bulleted PowerPoint slide presentation should weigh lightly as information presented about RCL operations.

The following general questions about data validity and reliability arise.

• Could so-called noise (information deemed irrelevant, or even unwanted, by an analyst) have been removed from the analysis?

• Do choices for categories of data preordain particular analytic findings and mask possible alternative results of analyses?

• Assessments of risk from different parties could have different meanings and could be based on different levels of confidence.

• In short, when a statement is made that no human casualties are attributable to RCL technology, just what assumptions were made in the handling of the underlying accident data?

• Are the RCL data presented to the FRA selective in that they come from "safer" yards? That is, Are yards on a gradient--thus subject to run-outs of railcars-- not operated or not operated as much by RCL, thus, skewing the data?

• For RCL operations, given the varying kinds of terrains (e.g., ascending and descending grades, curves, obscured vision, and close clearances, etc.) and the various kinds of service (e.g., bowl yard, gradient flat yard, road switcher, road movement of considerable tonnage, etc.), it must be realized that "one size does not fit all" manner of RCL operations. These kinds must each be reviewed for any safety limitations on RCL operations.

Clearly the raw data, their categorization, and their analyses must be scrutinized. Analyses delimited from particularized formal constructs to "show" improvement in safety could indeed do just that. These analyses, however, could exclude full or entire consideration of genuine issues of safety in the rail world. Relevant to this point the FRA summarizes (FRA 2000:14):

> Further, quantitative risk assessment as applied to the safety of railroad operations is best viewed as an art, rather than a science. A proper analysis must correctly describe salient elements of the operating system, correctly assess the contribution of the risk dimension under review to key scenarios, accurately estimate the frequency with which the risk will arise, accurately describe the severity of hazardous events that may occur, and fairly evaluate the impact of mitigating measures on the prevention, or reduction in severity, of the hazardous event. This requires that the analyst(s) be fully conversant with the railroad operating system, that input data be available (and be properly selected if various data are available), that the analysis be structured to produce a credible result, and that the result be appropriately characterized. There are challenges associated with each of these steps.

Field verification of the raw accident and related data might have to be conducted, including:.

• What actually occurred in an accident?

• What was the, usually complex, chain-of-event causation for an accident? We expand upon this matter as follows.

• RCL-related accident data must reflect established cannons for collecting and reporting such data, including what are known as equal exposure accident metrics. Thereby data can be comparable across railroads and operating variations. In making comparisons between RCL and ordinary manual operations, both the quantity of human operatives and their interfaced machines must be included.

• Carriers with RCL operations should report accident data so that the following formula can be used:
Accident Rate = (Accident Frequency, p.a.)/(train miles X labor hours). This formula will correct for one kind of "increase" in safety that is statistical artifacts of reductions in numbers of operatives owing to technological innovation.

• The Switching Operations Fatality Analysis Working Group (SOFA) is currently studying such rail accidents.[2] SOFA develops statistical measure and makes recommendations for reduction of switching fatalities and injuries. SOFA could be assigned the vital task of identifying the new modes of human error consequent to the introduction of RCL operations. The FRA's human-factors section can provide expert guidance to SOFA for such task.

2.3. Assumptions underlying quantified data from the common practice of blaming of just one employee, or one event, for an accident do not allow valid information for accident assessment:

Above all, for the safety assessment of new rail operating technologies, organizing of work, and procedures for work, use of past accident data must not reflect the well-established and well-known railroad practice of simplistically blaming just one employee (often an accident victim), or one event, for an accident or incident.

The traditional blaming a rail accident on one employee (sometimes an employee victim of the accident) is a practice from an outmoded and discredited managerial philosophy at times called behavior-based safety. H. W. Heinrich developed the classic, "scientific" approach to behavior-based safety (1941), including the railroad industry's classic finding of cause as a management-absolving "man failure." Heinrich's research data for his concepts consisted mainly of information collected and reported by supervisors. As James Howe instructs from a labor-union viewpoint also shared outside of the labor movement (2000:226):

These [behavior-based] programs blame workers (the victims of occupational health and safety exposures to hazards) by focusing on worker behavior rather than problems in the system, such as hazards inherent to the work process. By focusing on workers' 'unsafe acts' as the causes of injuries and illnesses, companies do little to address the root causes of safety and health risks.

In short (Howe 2000:227):

Behavior-based safety programs include a broad array of programs that focus almost entirely on modifying the behavior of workers in order to prevent occupational injuries and illnesses. The fundamental premise of these programs is that the overwhelming majority of injuries and illnesses are the result of "unsafe acts. . .".

Safety specialist Fred A. Manuele highlights the underlying flaw in industrial applications of behavior-based safety (1997:62, see also 135):

[M]any safety practitioners, for years, based their work on Heinrich's theorems, working very hard to overcome "man failure," believing with great certainty that 88% of accidents were primarily caused by unsafe acts of employees. How sad that we were so much in error.

As the dean of British accident specialists, Trevor Kletz, cautions regarding any behavior-based analysis of a collision of a following passenger train into another, owing to a momentarily lapse of engine-driver attention (1993:122):

His [the driver's] error was due to one of those momentary slips or lapses of attention which affect us all from time to time and which we cannot avoid. The responsibility for the accident lies with those who failed to provide the equipment which could have prevented it..., not with the man at the bottom of the pile who could not pass the blame onto someone below him.

Although operator errors are frequent in most industries, they constitute an insufficient and misleading explanation of accidents in today's complex industrial systems, wherein a number of small errors accrete in an unanticipated, lethal manner. In the Tranz Rail case outlined below, the underlying question is, Can elements of RCL operations bring about peculiar happenings conducive to railroad accidents of an RCL nature? Merely asserting that RCL technology is "safe" begs the question of safety.

As Charles Perrow explains in his influential *Normal Accidents* (1999:9):

"... time and time again, the operator is confronted by unexpected and usually mysterious interactions among failures, saying that he or she should have zigged instead of zagged is possible only after the fact. Before the accident no one could have known what was going on and what should have been done.... Patient accident reconstruction reveals the banality and triviality behind most catastrophes."

Regarding what caused the sinking of the R.M.S. *Titanic* in 1912, James Cameron correctly notes it was not the accused brittle steel plates or faulty rivets: "The real cause of the disaster lies in the series of decisions and actions of the Captain and crew in the hours preceding the collision" (2000:431).

And as James Reason concludes in his influential *Human Error* (2000:250):

> Thanks to the effectiveness of engineered safety measures, complex technologies are now largely proof against single failures, either of humans or components.... [B]ut we still know very little about how... individual tendencies interact with complex groupings of people working with high-risk technologies. It is these social and institutional factors that now pose the greatest threat to our safety.

In sum, because accidents ordinarily do not have only one cause but multiple causes, RCL accident and incident data reported to the FRA should reflect this reality and modern way of assessing accident information.[3] This reporting must include explanation of the use of appropriate accident rate metrics, experimental design, statistical analyses, among other to-be-determined items. As Howe summarizes regarding the outmoded behavior-based approach to safety (2000:234):

> Victim blaming is at the heart of behavior-based safety programs. The original [i.e., underlying] theory that 95% of accidents are the result of unsafe acts was based on seriously flawed research. The companies selling behavior-based programs that continue to support this position have a financial interest in promoting the folklore.

• The Switching Operations Fatality Analysis Working Group (SOFA) uses the modern model of multiple causes to accidents, whether or not involving human factors. Undoubtedly, all concerned could learn from SOFA's methods.

2.4. The RCL Fatality at Palmerston North:

Regarding past RCL performance, the New Zealand Transportation Accident Investigation Commission (TAIC) in its Railway Occurrence Report No. 96-115, investigated a shunter/switchman falling into path of freight car and being killed, at Palmerston North, on September 6, 1996.

• What was the operational cause of the accident, and how could the death have been prevented?

TranzRail shunting job P35 was supplied with a remotely controlled DSG locomotive manned by one Remote Control Operator (RCO) and one shunter. Three cars to be switched at 0155 hours were for delivery to a shipper's siding accessible off an industrial track, which was too short to hold the total. The RCO was standing on the locomotive's leading step during the movement and the shunter was probably on the leading wagon. The RCO heard the shunter calling the distance as the shunt approached the track switch leading to the main freight siding off the shipper's siding. The RCO stopped when told, the points being set for the main freight siding. The shunter threw the switch and then called the RCO to move again and the RCO had just started moving when he heard static on the shunter's radio. The RCO stopped the movement and on he found the shunter under the leading car.

The TAIC report found that the most likely accident cause was that after the shunter had thrown the switch, he had attempted to cross too closely in front of the movement as it started. The shunter was described as particularly enthusiastic and known to have occasionally placed himself at risk by crossing too closely in front of moving wagons.

Here we might well have another common example of investigators blaming a rail accident on an employee victim, without examining the chain of events and circumstances resulting in an accident. A common, cross-societal investigatory practice in investigation of a rail accident often is to "blame it on the railroader."

But, does this traditional practice absolve rail managers--and their government overseers who accept such practice--from probing for all the underlying human actions that create both accidents and accidents waiting to happen on a railroad property? Such practice ordinarily contributes little to eradicating the entirety of the causes of human failure in a railroad accident. Such practice usually contributes little to understanding RCL safety.

3. When Introducing New Technology, Can Railroads Always Be Trusted To Take Safety First As The Course Of Action?

RCL operations exist in an economic context. Because technological innovations by railroads not required by government usually have been motivated by cost cutting, often labor saving, safety has not always been a paramount managerial motivation in the change. Coming to mind are federal regulations, since 1893, for railroad safety which were originally strongly opposed by the carriers. These regulations mandated use of automatic couplers, automatic air brakes, safe ash pans, and, in the 1920s, some form of supplementary signal system for rail traffic control such as ACS or ATS. (See for examples, the Safety Appliance Act of 1893, as amended, 45 U.S.C. 1-7; Safety Appliances Act of 1903, 45 U.S.C. 8-10; Safety Appliances Act of 1910, 45 U.S.C. 38-42; Hours of Service Act of 1907, as amended, Public Law 274, approved March 4, 1907; 34 Stat. 1415, 45 U.S.C. 46-66, and Hours of Service Amendments of 1969, Public Law 169, 91st Cong., 83 Stat. 463; Locomotive Inspection Act of 1911, as amended 45 U.S.C. 22-34; and Ash Pan Act, 45 U.S.C. 17-21.)[4] Numerous railroad, collisions, derailments, and injuries and fatalities to persons became a strong, if not the determining, influence for the enactment of the Railroad Safety Act of 1970 and subsequent rail safety acts.

• An issue arises, then, with an introduction of RCL technology, might the carriers, once again, be more interested in increasing revenue over safety to persons and property? The question must be answered validly and reliably.

In his book*The Economics of Railroad Safety*, transportation economist Ian Savage, intellectually powerfully, supports concern for the issue of revenue over safety. He demonstrates that the market forces for safety make "myopic behavior" of rail management an actuality. Costs of preventative actions are in the present, but costs of accidents, including liability to persons and for property occur at random future times. Accordingly, Savage notes "there are incentives for railroads to *cheat* in the short run." Savage summarizes: "Although the financial condition of the railroad industry is much healthier than in the 1960s, the concerns of myopia are still with us. The rapid expansion of the Union Pacific Railroad in the mid-1990s lead to safety problems as the railroad attempted to reduce costs and improve its short-run financial performance." Directly relevant to RCL operations: "There are also genuine concerns that some small new railroads may be myopic due to inexperience" (Savage 1998:115-121).

Instructive is Savage's current analysis that improved finances of railroads have only reduced, but not eliminated myopic behavior. Specifically, he explains, in the1990s, the Union Pacific absorbed the Chicago & Northwestern and the Southern Pacific systems, thereby growing by eighty percent. "In an effort to recoup some of the costs of acquisition, and to demonstrate to shareholders that the acquisitions had improved profitability, the railroad took several cost-saving actions. Some of these actions, such as reductions in the number of dispatchers and supervisors, had safety implications. Savage notes: "Fortunately, from a societal point of view, this attempt to cheat backfired because the reduction in preventive effort quickly led to a visible increase in service delays and accidents" (Savage 1998:117).

4. RCL SHOVING MOVEMENTS (AND THE RULES).

Shoving, or back-up, moves of rolling equipment have potential danger, and blind shoves of whatever duration or distance are unquestionably fraught with danger.

Formerly, all books of rules had a crucial rule reading: "Blind shoves must not be made at any time." To do so was a major infraction of both the rules and the safety deportment on the job. As the number of persons in a train or yard crew is downsized, the rules should not likewise be downsized for the sake of an accommodating expediency.

A person or motor vehicle can be overrun by a blind shove, including those trespassing illegally but frequently on the typically unsecured right-of-way. GCOR Rule 6.6 directs: "A train may back up on any main track or on any track where CTC is in effect to pick up a crew member under the following conditions:" As originally worded, such back up move under the rules, then, does not allow for a blind shove on the main track for other than " to pick up a crewmember (GROC 2000:6-3). " Presently, then, GCOR Rule 6.6 permits a blind shove to "pick up a crewmember," where authority for track occupancy is thought not to be compromised. But individual carriers can modify Rule 6.6. For example, by general order, the Wisconsin Central had extended this loophole in the rules to a cart blanche: "Under Rule 6.6 a train may make a backing movement on a main track for purposes other than picking up a crewmember" (WC G.O. No. A-47, June 3, 1996).

A number of concerns arise regarding blind shoving.

• In response to railroaders' concerns regarding RCL operations and one-person crewing, when they hear as a permission, "a back up movement can be made under Rule 6.6," they must be assured that an expedient loophole is not being widened further in the rules.

• Except in a fully protected zone of movement, no instance of blind shoves can be tolerated, whether permitted by FRA-approved operating rule, by local carrier's informal practice, or by rule infraction compelled by excessive physical burden on a one- or two-person RCL crew. As the National Safety Council correctly has instructed the

RCL operator: "Always position yourself so you can observe in the direction of travel to see that the track is clear" (NSC 1985:2).

• Although GCOR 6.6 allows a blind back up move when authority for another train's movement is not lapped, a lap occupancy of a track might indeed occur, as follows. In a blind back up move, the position of the next block signal to the rear of the shove is not known exactly. Thus if train No. 1 is several car lengths ahead of the next block signal to the rear and, under Rule 6.6, backs past and fouls it, an overtaking train No. 2 advancing on a green signal (of a three-indication green, yellow, red sequence) would receive a red aspect for the next signal ahead after the green. Train No. 2 might not have enough distance to stop, with all that not stopping portends. Or train No. 2 might have to go into emergency braking, not a prudent way to handle a train.

• Using RCL operations with not-directly-supervised, one-person crewing, the temptation to make blind shoves--those not protected by line of sight, along the entire distance, from the point of a movement to its stopping place--will mount. But apart from blind shoves, one-person traincrews will be unable to adequately deal with certain kinds of moves. For example, one-person shoves would be particularly hazardous when doubling over or tripling over a train or cut of cars.

• RCL back up movements of any distance would also be hazardous with a one-person shove. Setting out or picking up cars at the end of a "long handle," of say a cut of 30 cars, would be hazardous.

• When RCL switching with a long train while standing at or near the head end, how does a one-person crewmember protect a grade crossing to the rear? Will there be a temptation to "just shove a little bit more"? And, how does the one-person crewmember know exactly where a grade crossing begins, when blind shoving toward it from a position, say, thirty car lengths distant?

• How can a one-person RCL crew shove cars ahead of the engine for any distance, when this is necessary either in an "emergency" situation or for expediency? Is an "emergency" situation a potential loophole in the rules? How is an "emergency" defined under operating rules, as approved by the FRA? What are the behavioral devisors between operational emergency and operational expediency, and from whose viewpoint?

• A particular problem exists with one -person RCL operation and backing over crossings at grade, whether or not these are gated. With sufficient cars, the single crewmember operating the engine by RC near the head end will have to walk back an appreciable distance to the crossing, either to protect it or to see if it is clear of approaching highway vehicles. The employee might at times be tempted not to walk back to visually observe the crossing, or visually unaware of a need to do so at a particular time.

• Further, GCOR Rule 6.6 cross-refers to GCOR Rule 6.32.1, reading: "When cars are shoved, kicked, or dropped, over road crossings at grade, a crew member must be on the ground at the crossing to warn traffic until crossing is occupied." But, with a one-person crew with or without RCL operations, What *actually* happens when such a second qualified operating person is either missing or late in arriving and a crossing must be fouled under Rule 6.32.1?

• An RCL movement must be stopped when the RCL operator must read any on-paper information.

For rail management to respond to any of the above nine concerns with, "We have zero tolerance for rules infractions or for accidents" is a piety not related to the social factors of railroad work.

5. Vision from the Locomotive Cab and on the Ground.

The ocular viewpoints from up in the locomotive cab and from down on the ground provide quite different prospects, in vision and for operational behavior.

• Protection of the point of a movement must be afforded at all times. (This includes a movement going onto a track for which authority or protection is required for track occupancy.)

• Operating an engine from a workspace on the ground adjacent to the track does not provide the, sometimes operationally necessary, elevated angle of vision obtained from the locomotive cab.

• On track where members of the public might walk, whether or not they are trespassers, a second crewmember is needed to monitor movements to insure continuously that no person will foul rolling equipment on the engineer' blind side of the cab. Such movements range from a light engine to an engine moving one or many cars. This second crewmember might be on the engine or on the ground, as necessary. Danger to heedless members of the public is particularly acute after the movement has stopped for a while, during which time a person might attempt to cross between the cars. The areas where persons might walk, according to varying circumstances, frequencies, and manners, include public and private streets, formal and informally used pathways, and industrial areas. Although the legally correct designation of *trespasser* for a victim of a rail accident might afford some manner of monetary protection to a carrier, it does not answer society's humane concern for injury and fatality reductions.

• An RCL operator, to save walking and other time and effort could be tempted to make a movement with a line of sight not fully protecting such a movement. As OSHA cautions for in-plant RCL operations: "Unfortunately, accidents are occurring because of unsafe work practices on the part of locomotive operators, usually because of limited line of sight operations and operations with blind spots in congested areas" (OSHA 1988). Given the ubiquitous trespasser on unsecured railroad rights-of-way, the areas need not be congested.

• The federal Mine Safety and Health Administration recommends as one of its "Best Practices" that: "A remote controlled locomotive should only be used when the operator can maintain visual contact with the locomotive and cars" (MSHA n.d.). This recommendation was issued after a car repairer was fatally injured at a stone quarry while performing repairs under a 70-ton ore car. A 125-ton RCL (an EMD SW 12) impacted the car. The RCL was being operated out of the operator's sight.

• Not just blind shoves of cars can be hazardous but also shoves with an unobstructed line of sight can be hazardous, where the distance of the movement is great. As the National Safety Council instructs the RCL operator: "It is difficult to judge distances from a remote location, particularly if the viewing angle is narrow" (NSC 1985: 2).

6. RCL Weather and Other Elements of On-Ground Environment.

• Distractions and diversions of attention upon an RC engine operator are caused by the vicissitudes of weather, such as snow, hail, rain, wind, and blown soil. Such circumstances add a potential for hazard in RC operations not found in operations with two crewmembers.

• Ground surface condition is a factor when an RCL controller walks while operating the RC engine. At times, the RCL controller could divert, quite understandably, a major part of attention to personal concerns of footing, on loose surface materials, on uneven surfaces, on debris-strewn surfaces, and on surfaces slick from slippery substances such as water, ice, snow, or oil. Such circumstances add a potential for hazard in RCL operations not found in operations with two crewmembers.

• For safety, no crewmember operating an RCD should ride the point (or any other) freight car in a back-up movement. With sufficient cars, the single crewmember operating the engine by RC will have to walk back an appreciable distance to work at the rearmost car. The employee might at times be tempted not to walk back to work at the rearmost car. For a multi-tasked, single-crewmember required to perform both engine and groundwork, the temptations and rationalizations not to walk back when required to do so will become manifest. Riding the freight-car point while using RC could also become manifest. The pressures on a one-person crew from extensive walking while having to perform many kinds of tasks is discussed regarding other operational situations, below.

7. RCL Car Handling (Switching).

The groundperson's worktasks and responsibilities in car handling (switching) are considerable. These are reviewed in "Appendix, Part Two: Brief Explanation of Conductor's Worktasks and Responsibilities" (of F. C. Gamst, "Human and Operational Factors in the Use of One-Person Train Crews." Presentation FCG-UTU-96-2, before the FRA, Appleton, WI, Dec. 5, 1996). Discussed there are groundperson specializations requiring arcane knowledge and athletic dexterity such as: mounting and dismounting from railroad freight cars, riding on deck of a flat car, hand braking cars to a coupling, and dropping a car.

• Whenever an RCL crewmember must consult a switch list or other written information, the movement must be stopped.

• Sometimes a chess-like mental concentration is required for switching cars (while also caring for safety of one's body). Divided and diverted attention during execution of safety-critical operating tasks requiring both groundman's car handling and engineer's running an engine could well cause hazards. In short, concentration on a sequence of switching moves means less cognition available for a sequence of actions in running the engine from a RCD.

• Pondering chess-like movements for future tasks does not constitute undivided attention to an RCD operating of an engine. As the National Safety Council has advised: "The operator of the remote-control unit must give undivided attention to the train being controlled" (NSC 1985:2).

• Use of an RCD should not overburden a crewmember with additional tasks and responsibilities added to customary ones.

• Mounting and dismounting from freight cars, even when they are stopped, takes an athletic agility using a number of motor skills which must be specially acquired through experience.

• The groundman often has to handle a switch list, and when night signals are required, carries a hand lantern. This person might also be holding a voice communication radio. At times, the ground person might carry an ignited fusee. These hand-held items would be in addition to using the hands to manipulate the RCD, usually equipped with a harness for ease of portability. Additionally, in cold or freezing weather the ground person will be wearing heavy gloves, to some degree impairing dexterity, and thus ability to precisely manipulate the correct control on the RCD.

• An anti-tilt override is built into the RCD to prevent continued operation of an engine when the RCD is not perfectly horizontal. By an arm, it is, nevertheless, possible to touch and move inadvertently an RCL control, while in an untilted position. This could happen when performing other tasks such as handling a cutting lever, adjusting a coupler, or throwing a switch. (A tilt bypass switch permits the control unit/box to be tilted during tasks such as throwing a switch or picking up an object.)

• Tying down hand brakes with a RCD attached to one's body could reduce one's hold on the ladder or grab iron of a car.

8. Other Precautions Necessary and Concerns for RCL Operations.

• For personal safety communication to other personnel, each RCL crewmember must have a holster-mounted voice radio with a wired microphone not needing to be hand held.

• As the National safety Council has advised: "Operators should not attempt to operate radio-remote control locomotives while riding on the side of a moving car" (NSC 1985:2). Further, "No one should attempt to get on or off a moving locomotive or train without having the use of both hands" (NSC 1985:4). Even if an operating rule exists prohibiting RCL operation by a ground person riding on the side of a car, the temptation would exist to do so, to save extensive walking, to preclude walking where footing is difficult, or to save time, especially in inclement weather.

• As the National safety Council has advised: "The operator on the ground has no real sense of motion and may be easily distracted" (NSC 1985:2).

• Where other movements can be expected on the same track, a one-person, RCL crew might not always be able to provide continuous self-protection when having to go between cars. As the National safety Council has advised: "Before entering between the cars, have a thorough understanding with other people involved. Be sure there will be no movement of the train, and make sure that protection has been provided against approaching equipment on the same track" (NSC 1985:3). The safety issue is not whether the protection *has been* provided but if it is *continuously* provided until after the RCL operator emerges from between cars.

• Where a tilt bypass switch is used on the RCD for RCL operations, the possibility exists that either by lack of intent or by intent the tilting safeguard will be manually bypassed in unpermissible circumstances.

• When, for repair, maintenance, or inspection of rolling equipment, a worker must be on, under, or between rolling equipment under any remote control, the RCD and the RC equipment on the locomotive must be deactivated and the equipment provided with blue signal protection.

• For RCL operations, the FRA should determine any other required blue signal protection.

• Any RCL operation must be equipped at the RCD both for a remote-controlled emergency air braking with the de-energizing of the power throttle and for a remote-controlled shutting down of the RCL's diesel engine(s).

• Safeguards should be provided to prevent any RCL movement from fouling a main track.

• To reduce fatalities from movements of mobile equipment at mining sites, the Mine Safety and Health Administration of the U.S. Department of Labor, recommends enforcing a "basic safety rule" as follows. "Prohibit foot traffic in safety areas" (MSHA n.d.-b). Such an operating rule might well be necessary for all or most locations of RCL operations occurring in places accessible to the public.

• A tilt control mechanism for stopping a movement does not in any way insure railroad rolling equipment can be stopped before an accident occurs. On February 25, 1999 a RCL operator at a USX steel plant fell and had both legs amputated by the flanged wheels of his slow movement of rolling equipment, which stopped some 50 feet after the stop was initiated (Sommers 1999).

• Workers must be informed that the RCD's anti-tilt mechanism does not ensure safety from rolling equipment if an RCL operator or a worker falls.

• Safety mechanisms in RCL equipment do not prevent all fatalities during RCL operations. On August 28, 1988 at a USX steel plant, a RCL operator had his head crushed between two cars while attempting to uncouple them by means of a defective cutting/uncoupling lever (OSHA n.d.).

• It is mechanically possible for cars being switched to become uncoupled from other cars without any human action or design to this end. Without the automatic air brake system both cut in and charged, such uncoupled cars thus can become uncontrolled "free rollers." Such cars are also known by railroaders as "silent death" owing to the lack of sound made by these juggernauts. How do RCL operations take account of inadvertently uncoupled free-rolling cars?

• After study, railroad operating, air brake and train handling, and safety rules must be carefully drafted and FRA approved to ensure safety in any RCL operations.

• After study, railroad operating employee and, as needed, other employee training must be carefully planned, executed, and FRA approved to ensure safety in any RCL operations. A cavalier "no additional operating rules are necessary for RCL operations" must not be allowed carriers operating RCLs in the US.

• After ergonomic study, the maximum train length must be ascertained to ensure safety in any one-person RCL operations.

• RCL operations conducted from outside of a locomotive cab must be made at restricted speed, but not to exceed 10 mph.

• RCL operations conducted in excess of 10 mph must be from inside the locomotive cab.

• RCL operations past a block or interlocking signal, a manual railroad interlocking plant, a highway crossing at grade, or a stopped passenger train must have a crewmember on the point.

• Are risks from RCL system coding errors in software fully accounted for?

• Independent air, automatic air, and any dynamic brake values must be displayed for the RCL operator on the RCD. A response that a computer oversees related functions and the displays are unneeded is not acceptable for American operational safety.

• Locomotive speed must be displayed for the RCL operator on the RCD. A response that a computer oversees related functions and the display is unneeded is not acceptable for American operational safety.

• RCDs must be equipped with dual capacity event recorders--recording both the RCL function executed and the command given by the RCL operator. Such dual capacity will enhance carrier investigations of mishaps and provide data for FRA assessments of safety.

• Except in a protected zone, an RCL crewmember must always be able to see the point of a movement, otherwise the movement must be stopped.

• While operating an RCD, an RCL operator must not mount or be on any rolling equipment, with the exception of being in the locomotive cab (control compartment).

• Because of braking unanticipated by one or more RCL crewmembers, slack action for a person(s) mounted on rolling equipment must be dealt with.

• While operating an RCD, an RCL operator must not stand or walk within the width of the movement.

• Because the customary sensing devices and train-handling cues are not available during RCL handling of a cut of cars or train, RCL crewmembers must not be held responsible for derailments or slack action caused by terrain or consist makeup.

• An emergency notification system must be in effect during all RCL operations.

• An RCL crewmember must have the right to decline, discipline-free, any task he/she deems too hazardous to perform.

• The FRA should determine the specific RCL accident and incident data to be reported to it.

• Perhaps all accidents and incidents involving RCL operations should be reported to the FRA. Thereby data characterized by a carrier or supplier as not caused by or attributed to RCL operations would be included.

• Owing to the increased workload for the smaller-than-normal RCL crew, RCL crewmembers must not be subject to the fatigue pressures of irregular or long work schedules resulting in them being "caught short rested" through no fault of their own. Except in a railroad emergency, an RCL crewmember should not be denied his/her request to mark off an assignment for rest.

• Finally, in any one-person crewing of an RCL job or run, because of the physical and mental demands of the workload of the solo RCL operator, the federal Hours of Service Act should be reexamined to determine if a shorter maximum work period and longer minimum rest periods are necessary. Currently, the maximum continuous work period for operating railroaders is 12 hours. An operating railroader receives only a mandated minimum of 8 hours "rest" off duty. In an urban area, the commute to and from the rail work site could consume up to 2 hours each way. Consequently, disregarding necessary time for meals, personal hygiene, and any critical personal matters, the time for sleep could approach only 4 hours, or less.

9. Comparison of Class-I, -II, and -III Railroads with Industrial Plant Switching by RCL Operations.

• Is the experience with RCL operations in industrial plants entirely relevant to operations on ordinary railroads under FRA jurisdiction?

A great amount of commercial promotional literature exists describing the long experience with RCL operations at industrial plants, for example moving and spotting freight cars at a steel mill or a grain elevator.

Railroads which operate on track wholly separate from the general railroad system of transportation are exempted from most FRA regulations for railroad operations, covering their transportation, mechanical, and maintenance-of-way and engineering aspects. In-plant rail operations are under the general health and safety jurisdiction of OSHA. "Federal OSHA enforces the general duty clause (Section 5(a)(1) of the Occupational Safety and Health Act) as may be necessary in cases involving in-plant locomotive operations" (OSHA 1989a, 1989b). OSHA regulations for in-plant safety do no obtain on ordinary railroads. OSHA has exacting, meticulous rules for in- and around-plant industrial hygiene and safety not found in FRA rules.

• The high levels of customary and of OSHA-inspired trackside hygiene in industrial plants are not provided for railroaders working on ordinary railroads at ever-changing locations across the continent.

Because in-plant rail sites usually have a high level of hygiene conducive to safety, as enforced by OSHA, certain consequences obtain. That is, the places in which an in-plant RCL operator must walk, mount and dismount from rolling equipment, and perform other worktasks are free from underfoot small debris, larger obstructions such as lose track components, car draft gear components, high ballast level with reference to the underlying ground level, grease and other slippery substances liquids such as water or fluid mud, and snow and ice. Further, such in-plant sites ordinarily have a high level of nighttime illumination. Also, other personnel are in the vicinity in case of an accident or some other incapacitating mishap to the RCL operator.

Moreover, for RCL operations, the National Safety Council has in the past recommended that: "Signs should be used to identify all equipment and area that use radio control [RCL]" (NSC 1985:1). Such safety signing might not be feasible for the limitless, continuous distances of America's railroads.

Frank Grimes, the safety an health specialist of the United Steel Workers of America for the past 30 years, has testified before the FRA regarding the gruesome deaths that 13 steelworkers suffered while each worked with remote control locomotives (Grimes 2000).

10. Selected Ergonomics Specific Concerns for RCL Operations and Equipment.

RCL operations and equipment foster a number of concerns in ergonomics especially in the human-machine interface. These include the following.

- As was developed for Positive Train Control, a human-machine-interface for RCL-RCD equipment should be developed.

- The human body mounting of the RCL control box causes skeletal and muscular loads not ordinarily experienced and endured in railroading. Head, back, neck, and female breast pains have been reported by RCL operators. Problems are reported from RCL personal regarding the fit of the control-box harness (Laansoo 1999). Suppliers promise lighter-weight RCDs and improved RCD harnesses. The extent of such modifications for the human body, however, have not been verified to the satisfaction of all parties.

- Vital and safety-critical displays on the RCD (control box) are not easily read.

- The RCD and its harness and any other associated equipment must conform to the cannons of human-factors design, especially regarding the human-machine interface. Much work has been done on rail human-machine interface across two and one-half years of deliberations in the FRA's RSAC for PTC. Such information can be applied to problems with the human-machine interface of the RCD. Guidelines must be developed for the human-machine interface of the new RCL technology.

- Guidelines must be developed for task analysis and consequent training for the new technology of RCL operations, just as it has been done for the new technology of PTC operations.

- Discussed must be whether an industry standard is required for all RCL-RCD equipment.

- Discussed must be who determines and sets the methodology for mean time between failures of RCL-RCD equipment? What standards are used here?

- Discussed must be how RCL operations handle the buff and draft forces of undesired emergency brake applications.

- Discussed must be how RCL operations handles sliding wheels on the engine, when the RCL operator is not near enough to the engine for detecting this condition.

- Discussed must be whether the independent air brakes can be released inadvertently by the RCL operator.

- Discussed must be the allowable physical and time limits of tilt protection in the RCL system.

- Finally, it must always be remembered that in RCL operations on FRA-regulated railroads, all applicable operating rules, safety rules, air brake and train handling rules, general orders, and other instructions are in effect.

Accordingly, representations that any untrained person can easily operate a RCL are abject, dangerous nonsense.

For example, editor William Vantuono of *Railway Age* labeled one of his associate editors "Engineer for a day" because she operated a RCL using an RC control box. In the operational reality of railroads, she was nothing of that kind. She was merely an untrained and not-responsible person pushing control levers and buttons as instructed by a manufacturer's representative. (Similarly, I once flew an airplane for a while, but would you want to fly with me? I certainly would not.) Gushed the associate editor: "It was reminiscent of when I learned to drive a car..." (Vantuono 2000). Based on this experience she concluded that anyone could learn to use safely an RCL system. Indeed. Gus Welty would have smiled.

• As the Transportation Safety Board of Canada concluded after its investigation of an RCL collision on the Canadian National, "Safe LCS [i.e., RCL] operation requires strict adherence to company instructions and careful attention to the method of operation" (TSB 1996).

11. Notes on the Design Concept of Failsafe with Reference to RCL Operations.

At times, the concept of failsafe is incorrectly used to justify RCL or other rail technologies and operations. The term must not be used in a loose fashion without regard to its established range of application.

Ultimately, no system or part of it is failsafe in the loose sense that safety is assured, even though those responsible for the system either imply or allege such absolute safety. A large-scale set of examples are the various interlocked, redundant failsafe systems developed over the course of decades regarding the nuclear weapons strike capability of the US. In his *The Limits of Safety*, Scott Sagan uses a "normal accidents" among other perspectives. Based on relevant unclassified documents, he found that the probability of a serious nuclear weapons accident was not extremely low, and he learned that escalation from a single accident to thermonuclear war was even more unlikely (Sagan 1995). America's failsafe designs for nuclear war did notinvariably operate failsafe in the complex, ever-changing realities of their open-systems environments.

Failsafe is usually an adjective, but can sometimes be a noun. As with other concepts, it is variously defined and used. Generally, the term designates (that is, indicates or, more than that, specifies) or involves (that is, includes, uses, or requires) a procedure in design to react to a malfunction or an unintended operation of a system, subsystem, or component of a system. This reaction is usually done through a related subsystem of interlocking protective devices or computer programs, or both.

In other words, *failsafe* is a referent in *design*, that is, a planned arrangement of components in a system. This referent means that, if a system or component fails (stops operating, or, at times, operates to a design designation of less effectively, reliably, or tolerably than planned), the item goes to a more restrictive condition.

The more restrictive condition in failsafe design does not necessarily insure safety to persons, property, or the environment. For example, steam locomotives and tank cars have one or more safety (pressure relief) valves atop the boiler or tank shell. The valves are automatically actuated by an increase of internal pressure beyond a designed maximum. Such safety valves have not insured that the boiler or tank car shell would not rupture, sometimes in a violent or, less frequently, catastrophic explosion. This despite the fact that "relief valves have a low failure rate, typically once in 100 years. . ." (Kletz 1993:105).

• Despite all manner of spoken assurances of safety in RCL operations, it should be remembered that safety is a subculturally relative term. What is "safe" is a construction in the mind of the assurer, reflecting both personal experience and membership-group needs.

• RCL equipment has malfunctioned and directly contributed to accidents resulting in injury to persons and damage to property.[5] Such a historic record is one aspect of RCL "safety."

• The concept of failsafe in human factors/ergonomics is a defined design criteria. Consequently, no one should be allowed to use the designation of failsafe for RCL equipment or operations unless whatever it is in the design to allow use of the label failsafe is exactingly specified..

12. A Note on the Radiation of the RCD.

A 1991 study by a standards committee chaired by O. P. Gandhi for the Institute of Electrical and Electronic Engineers (IEEE) is sometimes cited, to posit that the emanation of radiation (electro-magnetic fields) from particular kinds of RCDs is at a safe level for humans (e.g., Dufresene 1997; CN 2000:16-17). This authoritative study by respected researchers, however, is not the final word on the subject of safety levels regarding human exposure to electromagnetic fields in radio frequencies. No single study permits a definitive conclusion regarding human health (and safety). Thus any assertion that "no objective evidence exists of a connection to human health risk" from RCD radiation might now be true, but it might not later be true.

Literature reviews and research by George Carlo and his colleagues funded by the wireless industry show the following. Despite the hundreds of studies often mentioned regarding demonstration of cell-phone safety from radiation, few exist. Furthermore, Carlo's studies uncovered a number of potentially dangerous consequences of radiation from cell phones, from creation of micronuclei in blood cells that are diagnostic of forms of cancer, to the weakening of the blood brain barrier that prevents intrusion into the brain by toxins (Carlo and Schram 2001). RCD do not, of course, have the same radiation emanations or bodily proximities as do cell phones. The now-raging cell-phone controversy merely indicates the state of flux and lack of definitiveness of knowledge about radiation hazard from personal devices.

Reports, during December 2000, in prestigious medical journals are cited to promote views on cell-phone safety regarding radiation. A report in the *New England Journal of Medicine* (NEJM) compared hundreds of cell-phone users having cancer to a control group of cancer-free subjects using cell phones. The study found no evidence that risks were higher for persons using cell phones for 60 or more minutes per day of for 5 or more years. But this NEJM report included a mere 45 persons out of the 1,581 in the study who had used cell phones for a total of more than 500 hours. Moreover, the report said the sample for the study was not large enough to find any increased risk of tumors in the area of the brain located near the ear! A report in the *Journal of the American Medical Association* (JAMA) also found no correlation between use of cell phones and brain cancer. But subjects in the JAMA study used cell phones , on average, for less than 3 years. As per usual in such studies of medical risk, the two reports concluded that further studies involving a longer term are needed. In all, the two "comforting" studies have partial and inconclusive results.

We must be aware that the current radiation standards for cell phones, with the current federal limit of 1.6 W/kg, are from guidelines established decades ago. The guidelines are rather arbitrary, and they are considered so even by those scientists who established them. They result from compromises reached in committees, dating as far back as 1982. As with many standards practical considerations as well as hard science go into the final product--perhaps not unlike sausage making ("don't ask"). Remember, established standards once considered certain levels of asbestos to be safe, when they indeed caused cancer. Also, safety standards for tires, established three decades ago, deem that, today, standardized tires provide safety, despite the tread separations from certain standardized Firestone tires. As yet, there are no uniform measuring standards for specific absorption rate (SAR) testing. [6]

Scientists, then, have not reached definitive conclusions about radiation from personal devices. Researchers must learn if the non-ionizing radiation from personal devices is dangerous, as is the ionizing radiation from, for example, X-rays, which change atoms in the body to possibly dangerous ions. Can the low-energy, low-heat radiation from personal devices inflict damage to the body? The test of time of long-term exposure to the radiation can be the only validation or falsification of the question for all human subjects. This test includes RCDs.

In all, science cannot prove that radiation from personal devices is safe. It may well be several decades before what kind of users, if any, are know vulnerable to the radiation.

- It is not known that the transmission of all RCDs never alter and transmit radiation outside of its designed limits, for example because of post-manufacturing defects in the RCD and its radiation shielding. The RCD is used in and "banged around" in a harsh operating environment.

- It is not known that if the transmission of an RCD is added to the radiation from a portable voice radio used by operating personnel whether the total for radiation would be consequential for health.

13. A Final Note on an RCL Runaway Movement.

On December 19, 2000 near Blair, Nebraska on the Union Pacific, a runaway, unmanned RCL with a consist of over 30 railcars, in part, derailed about 2000 feet from the Cameron Ditch, which empties into the Missouri River. The derailment occurred on a stretch of track owned by the Union Pacific, but leased to Cargill. The Cargill Industrial Lead begins at the main track switch at Blair, extends for 4.5 miles, and is ABS territory between lead MP 0.08 and MP 1.04. The yard switcher and the derailed 6 cars loaded with high-fructose corn syrup caused more than an initially reported $400,000 in damages. The most frightening aspect of this incident is that the RCL derailed at a control point related to the Union Pacific's main track of its Blair Subdivision, which is single-track, CTC, 60-mph territory. (A *control point* is the location of absolute signals controlled by a control operator. When displaying a red aspect, the indication of such absolute signal is stop [and stay].) This uncrewed runaway RCL if entering a main track might have caused a far worse accident, with possible fatalities to unsuspecting crewmembers of UP trains or to UP employees working along the track.

The RCL operations were conducted by remote-control manufacturer CANAC, a contractor to Cargill for rail services at its Blair facility. CANAC has repeatedly represented and testified regarding the safety of its RCL operations including at the July 19, 2000 FRA conference on such operations. A Union Pacific spokesman said the railroad's investigators have determined that "human failure" caused the derailment of the remotely controlled unit. Now, "Uncle Pete" (as its employees call this carrier) no longer blames it on a singleton hoghead, the Company, instead, has a singleton RCL operator to blame. The outmoded and discredited managerial philosophy of behavior-based causation is alive and well on this mega-railroad. Both Cargill and CANAC continue their own inquiries. The FRA conducted its preliminary investigation. A full report must be filed under the FRA's accidents/incidents reporting.

The runaway, unmanned RCL related to the UP main highlights dramatically the absolute need for FRA rulemaking on RCL operations before any further hazardous RCL events occur in the US.

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End Notes

[1] I can give locomotive engineers' and other railroaders' viewpoints, but I cannot represent organized labor or give the BLE or UTU positions. These are under the authority of the apical international officers of each labor organization.

[2] Established by the Railroad Safety Advisory Committee (RSAC) of the FRA in February 1998, SOFA investigates fatalities to employees in rail switching and develops measures of safety and recommendations to improve safety.

[3] In short, the North American railroad industry's long-outmoded, 150-year old, "kick-ass" practice (as their employees call it) of blaming an accident solely on the hoghead or other employee, while shirking managerial fault must be terminated, by federal edict if necessary. For "blaming it on the hoghead," see: F. C. Gamst, "'Man Failure' Once Again: Is Rail Management's 'Blame It on

the Hoghead' the Finding of Cause or an Operating Excuse?" *Locomotive Engineers Journal* 105, no. 2(1998):6-7, and the affirmative, amplifying response: James Hall, "Dear Dr. Gamst," *Locomotive Engineers Journal* 105, no. 3(1998):4-5.

[4] It could be argued, as colleagues in the rail industry have done over the years in conversations with me, that the railroads were not against the implementation of these rail safety acts, merely against their rapid, hence, more costly, implementation. But the facts show that the implementations, when finally enacted into law were long past overdue in terms of monstrously enormous number of human fatalities and mutilating injuries preventable by the acts.

For example, in, 1907, three years prior to enactment of the Ash Pan Act, 136 employees were killed or injured (usually cooked by hot ashes) by going under engines to clean ash pans. "That it is necessary for an employe to get under an engine to clean out an ash pan, in these days of mechanical devices that provide safety appliances of this kind, serves to emphatically demonstrate the negligence of railway companies in this matter.": *The Railroad Trainman* 25(1908):631.

On March 4, 1907, the U.S. Supreme Court found for Catherine Schlemmer, the widow of a brakeman on the Buffalo, Rochester & Pittsburgh Ry. Co. and against the carrier. Brakeman Schlemmer was ordered to couple a rail steam shovel to a caboose. It was necessary for Schlemmer to go between and under the cars to make the coupling, because the steam shovel did not have the automatic coupler (but, instead, a link-and-pin iron bar) required by the Safety Appliance Act of 1893. Through no fault of his own, Schlemmer had his head crushed between the steel platforms of the two heavy railcars. To make the coupling he had to hold up the iron bar while under the cars and between their platforms. *Railroad Trainmen's Journal* 24(1907):365-367. By this case, Mr. Justice Holmes broadened the construction of railroad employer's liability for employee injury on the job.

Often the railroads interpreted safety laws for cost savings rather than safety. Thus the original Safety Appliance Act of 1893 required a "sufficient" number of air brakes to control a train. This vague term subject to parsimonious interpretation was increased by statute to 50 percent air brakes in 1902. But this amount remained unsafe. For example, in early May 1904, an accident killed 23 and injured about 100 persons. A freight train, of 68 cars, about one-half mile in length, had to brake for a suddenly appearing switch engine. The freight had air brakes only on the forward part of its consist, and it jack-knifed at the 35th car when the run-in of its unbraked cars hit the head end. The piled-up freight cars fouled the opposite of the double-track main, just before an express passenger train approached at high speed. The boiler of the passenger engine exploded in the ensuing collision, thereby detonating a carload of blasting powder in one of the derailed freight cars, resulting in the casualties just mentioned. "A Mean Attack on the Safety Appliance Bill," *Railroad Trainmen's Journal* 21(1904):600-603.

Regarding not injury but length of time on duty, the carriers strenuously fought implementation at any date of the Hours of Service Act (the "16 hour law"). Accordingly, the Brotherhood of Railroad Trainmen editorialized: "The railroad companies, one and all, are opposed to any measure that will destroy their right to urge men to remain on duty after they have served longer than safety warrants. . . . In defense of this 'right' to accede to the wishes, or demands, of his employer, the railway train and engine men remain continuously in service after their powers are deadened and perceptions numbed to the extent that they are unsafe.": *Railroad Trainmen's Journal* 24(1907):151.

Judge Spear of the Circuit Court of the U.S. for the Eastern Division of the Southern District of Georgia, in *Lucy Snead vs. the Central of Georgia Ry. Co.*, found the following summation regarding railroad employee injuries. "Surely at a period when every day brings its story of crashing and murderous collisions, of derailed and shattered trains, the long catalog of the slain, the mangled and dismembered, such efforts on the part of Government to extend its protecting care around its people employed in its mightiest interest, should not be lightly discredited.": *Railroad Trainmen's Journal* 24(1907):434.

[5] The US steel industry has a long period of history with RCL operations. For some reporting of RCL malfunctions regarding the steel industry in Ohio, contributing to injury to persons and damage to property, see: Comments of Cooperative Legislative Committee Railroad Brotherhoods & Railroad Unions, State of Ohio, Before the Federal Railroad Administration, in the matter of Wheeling & Lake Erie Railway Company Petition for Waivers of Compliance with FRA Regulations, Waiver Petition Docket Numbers LI-92-6 and RSOP-92-1. A wider swath of the steel industry is covered in a fatalities report covering RCL and non-RCL rail operations: United Steel Workers of America, "Railroad Fatalities -- Summary," February 1, 1996.

[6] A specific absorption rate (SAR) measures the energy in watts per kilogram (W/kg) that a gram of human tissue absorbs from a radiation-emanating device, such as a voice radio, cell phone, or an RCD (see Internet site: www.sardata.com/sardata.htm).