Chapter IX

RESEARCH AND DEVELOPMENT

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The Federal Railroad Safety Act of 1970 marked the beginning of increased Federal interest in railroad safety research and development. The congressional hearings for the Act indicated that accidents caused by human factors, equipment, and track were believed to be the predominant causes of the safety problem. Moreover, the dramatic impact of and the rise in tank car ruptures as well as the significant number of railroad grade-crossing deaths were clearly documented in those hearings. From this setting, the Federal Railroad Administration (FRA) initiated its regulatory and research programs. The Association of American Railroads (AAR) and individual railroads also began to increase research and development activities in the early *1970's.* An overview of the 7-year span of research and development activities conducted by the Government shows the following:

- Government programs related to railroad safety have included: track research program and track safety research; a rolling stock program, including tank car research, equipment component failure research, personnel protection, and other research programs; human factors research; and information and support research programs; grade-crossing research; and automated inspection and surveillance technology programs. Each of these areas has application to safety and has been discussed by the FRA in its various annual safety reports. However, several programs have been funded through agency appropriations for R&D, while others have been funded from R&D monies made available by the **1970** Safety Act. Therefore, distinguishing between the origin of funds for specific safety R&D projects is difficult.
- Part of Government efforts, time, and resources have been devoted to establishing test and research facilities. Included among the facilities was the development of the Facility for Accelerated Service Testing (FAST) Test Track at Pueblo, Colo. Earlier, the industry relied on the AAR Technical Center in Chicago and railroad facilities for much of its research efforts.
- Greater research efforts for both Government and industry have been directed at technological studies of track and equipment R&D, areas which are more related to the property and lading loss and damage problem, rather than to human factors research. Typically, research efforts have been directed at problems with technological solutions, because it is generally assumed that such research has higher payoff and more clearly measurable results than human factors efforts. Government and industry research and development programs have been no exception to this rule.
- Of the research efforts directed at the casualty problem, emphasis has been placed on grade-crossings (where most fatalities occur) and on tank cars (which have the potential for the greatest catastrophe).
- Track-related and equipment R&D programs were scheduled to span the decade before comprehensive research findings were anticipated. In track and equipment research, the lack of scientific data, insufficient understanding of track and equipment life cycles, and lack of knowledge of track and equipment interaction under a variety of operating conditions created the situation where research and development, if it was to be fruitful, had to be directed initially at identifying and understanding the problems, before solutions could be developed.

The emphasis on track and equipment R&D seemed appropriate for both industry and Government programs, given the frequently cited accident rates caused by track and equip-

ment, the **1970 congressional** mandate, and the general technology orientation of most transportation research. Moreover, while FRA was charged with addressing these problems through regulation, it was the expressed goal of the track and equipment research programs that a more scientific basis for those regulations was desirable in the future. * As noted in the early FRA Annual **(1972)** Safety Report:

> Out of the FRA Track Structure R&D will come recommendations covering the level of track maintenance required for safe operation, and concurrent recommendations to the railroads for new track structure with reduced maintenance characteristics. . . . Considerable impact from these programs is anticipated late in the **1970's as** track maintenance standards are defined and railroads act to bring their level of maintenance up to these standards.

- In track structure research, attention has been focused on track stability and life cycle, track maintenance, and, to a lesser degree, on track geometry and wheel rail compatibility, Initial efforts in the track structure program went toward establishing the track-test facility at Pueblo from the high-speed rail R&D appropriations. Subsequently, research has concentrated on track componentry and track stability. The types of track structure efforts have included research on rail structure and stress, rail performance, track maintenance, track durability and geometry, and track-testing. Cooperative efforts between industry and Government have been extensive in these areas. The individual AAR efforts have also been directed in these and other areas of track research. Examples of specific track research projects include track-buckling studies, cross-tie research, and bolt-hole practice studies.[2]
- In the rolling stock program, Government and industry research efforts have concentrated on tank car safety, equipment componentry and failure prevention, and the track-train dynamics program.
- The inspection and detection surveillance research effort has concentrated on automated track inspection, vehicle development, data collection, and analyses utilizing that equipment.
- The human factors research conducted by FRA has consisted of several job analyses, including those of the train dispatcher, engineer, and conductors positions, and a medical qualifications study for selected railroad employees. Participation by all concerned parties in these earlier human factors research efforts was not characteristic of the projects. Generally these projects have not been considered successful, compared with several more recent efforts. Other efforts have included research in locomotive/train handling, cab environment, and on the vandalism problem. In addition, the Office of Policy and Program Development initiated the survey of industry alcohol and drug abuse programs and an industry-wide survey of training programs.
- There have been several cooperative efforts directed at employee problems, which have successfully demonstrated cooperation as a means for obtaining and implementing safety measures directed at the casualty problem. Among projects where management, labor, and Government have worked cooperative y are: locomotive cab research, glazing research; alcohol and drug abuse program inventory; and the St. Louis terminal project, which had safety implications.

*Initial regulations promulgated were based largely on existing practices and existing industry standards. By law, some regulations had to be published within a year of the enactment of the 1970 Federal Railroad Safety Act.

‘1972 *Annual Safety Report to Congress*, Federal Railroad Administration, Research & Development Section.

zı **975, Ninth Annual** *Report on Railroad Technology Program,* FRA, p. 34.

- A trend in cooperative research efforts with labor, management, and Government working together as an effective means for improving safety has become more common in recent times. This is evidenced by cooperative efforts previously mentioned, as well as by the establishment of the Railroad Safety Research Board, whose purpose is to set priorities for safety research based on accident data and the increased understanding resulting from the 1976 accident analyses. Initial efforts resulting from this committee are to be directed toward identifying safety problems related to the yard brakeman, the employee category with the most statistically significant injury rate.

- The only comprehensive research or analysis conducted on the accident data, trends, or causes of accidents has been the *1976* Shulman-Taylor Accident and Casualty Reports conducted by the AAR. (These reports are covered extensively in chapter V.)

- Recent labor/management negotiations have temporarily precluded labor's continued efforts on all cooperative safety committees.

COOPERATIVE PROGRAMS

Throughout the course of this study, repeated attention was called to the need for cooperative efforts in safety research and development, if such research was to be either successful from an analytical perspective or acceptable from the perspective of those who would be affected by it. Technological studies related to track and equipment have typically included railroad and supplier input to the projects. However, only recently have any strides been made toward cooperative efforts in casualty research (the early establishment of the Locomotive Control Compartment Committee is one exception to this). Several cooperative research efforts frequently cited by labor, management, and Government officials include:

—Locomotive Control Compartment Committee.

—Alcoholism Project.

—Glazing Project.

The Glazing Project was established as a result of repeated labor concerns and the resulting legislative initiatives about the problem of objects being thrown at rolling stock and injuring the train crew. Specifically, labor argued that Locomotive engineers were being unnecessarily subjected to bullets and thrown objects. As a result of these concerns, the FRA Office of Safety Research formed a joint labor-management committee to determine the extent of the problem and to research alternative solutions to that problem. Accordingly, the AAR collected data from *52* railroads on missile impacts to railroads rolling stock for a 2-month time period. The following information was collected and analyzed as a result of the effort. "If the data for the 2-month period is assumed to be typical, the following table reflects the problem:"[3]

	Number of incidents	
	Z-month period	*l-year*
Hand-thrown.	*754*	4,524
Guns	109	654
Overhead suspension	9	54
Slingshot	5	*30*

Once the problem had been identified, the FRA research team, in conjunction with the Glazing Project team, conducted field tests of

[3]1nternal Memorandum, FRA Office of Safety Research, Apr. 27, 1977, p. 1.

existing crash-resistant technology to determine performance specifications for glass in the locomotives and caboose. As a result of this effort, performance specifications for glass for new equipment or replacement in damaged equipment were drawn up. The adoption- of these standards is awaiting final approval by railroads early in **1978.**[4]

The Locomotive Control Compartment Committee was established in 1971 as a "labor-Government-industry coalition sharing mutual interest in the study of locomotive crews." Membership on the committee included representatives of FRA, Brotherhood of Locomotive Engineers, UTU, and AAR. While this committee's work is ongoing, its initial efforts began in the early *1970's.* An initial in-depth analyses, and ministudy by FRA on locomotive cab accidents and injuries was conducted and a review of the interior cab design was made. As a result of this analysis, the locomotive suppliers were requested to provide clean mockups of cabs with recommended changes. After the mockups, 17 safety changes and features were adopted. The equipment purchased since that time has reflected these changes.[5]

The Alcohol and Drug Abuse research effort was initiated by the Office of Policy and Program Development of the FRA. The Office of Safety within FRA had initiated proceedings for a regulation prohibiting alcohol use on railroad property. (Rule G, a part of the railroad standard code, prohibits alcohol consumption on railroad property.) Both labor and management objected to the proposed regulation. The Alcohol Research effort is a two-phased project, with Phase I completed. Phase I identified those railroads with Alcohol and Drug Rehabilitation Programs, the type of program being conducted, and the results, if available, of the programs.[b]

At the time Phase I was conducted, there were 20 railroad programs identified. Subsequently, an additional 5 railroads established programs. The success of many of the alcohol rehabilitation programs was unknown at the time of the Phase I study, a factor not uncommon to alcohol research. The types of programs sponsored by railroads ranged from in-house counseling centers to referral programs for community alcohol, drug abuse, and mental health centers. ' Phase II of the alcohol research is designed to identify several model rehabilitation programs. The information is to be disseminated to railroads without alcohol programs. Of significance to the alcohol research effort is the fact that only recently have attempts been made to document the extent of the railroad alcohol problem, while attempts had already been made in the accident data collection process. Although the tendency to mute the usage of alcohol as a safety problem is prevalent in this society, it would appear that an increased understanding of one aspect of the human factors problem might become clear if further research were conducted. Highway fatalities resulting from alcohol involvement are estimated between 35 and **50** percent.[8]

These cooperative research efforts represent some successful efforts toward human factors studies. They have been relatively inexpensive for the results produced. Findings from these efforts have been successfully incorporated into the industry structure. Moreover, the research conducted appears to have been pragmatic, short-term, and responsive to perceived needs at a given time.

'Interview with Dr. William T. Harris, AAR, December 1977.

'Interviews with Mr. Ed McCulloch, Brotherhood of Locomotive Engineers, and Dr. William Harris, November and December 1977.

'Interview with Mr. Theodore Voss, Policy and Evaluation Division, FRA, November 1977.

'A Survey of Alcohol and Drug Abuse Programs in the Railroad Industry, FRA-OPPD-ORD 76-283, conducted by Naval Weapons Support Center, Crane, Ind., November 1976.

[8]*Fatal Accident Reporting System, 1975 Annual Report,* DOT, National Highway Traffic Safety Administration (NHTSA), p. 57 and *Traffic Safety '76,* U.S. DOT (NHTS), p. 16.

RAILROAD GRADE= CROSSING RESEARCH

Federal cooperative efforts on grade-crossing safety research were begun in 1968, when the Federal Highway Administration and Federal Railroad Administration were instructed by the Secretary of Transportation to form a joint national program. In 1972, a report was submitted to Congress outlining the extent of the grade-crossing problem and several alternatives for improving the problem. Since that report, the railroads and Federal Government have inventoried approximately 402,000 to 410,000 grade-crossings or 98 percent of the Nation's grade-crossings. [9] (Discussion of railroad grade-crossing programs is included in chapter X.)

In the last 7 years, research and development efforts on the grade-crossin$_g$ problem have focused on development of equipment, materials, and innovations in barrier protection; identification of and experimentation with equipment and devices for locomotives in preventing or minimizing grade-crossing impacts; collisions and crash-worthiness of vehicles at grade crossings; driver behavior; and analysis and development of computer models to assist States in determining the best complement of equipment for different classes of grade-crossings. FRA expenditures on grade-crossing research during 1973-76 were approximately $3 million, while Federal highway funds for research over the same period were approximately $1.7 million. 10

TANK CAR RESEARCH

The strong emphasis placed on accidents involving hazardous materials during the hearings for the 1970 Railroad Safety Act resulted in quick initiation by the FRA of research efforts to improve tank car design and performance. The AAR also has initiated research on the hazardous materials problem. The FRA, AAR, and Railroad Progress Institute (RPI) then combined research efforts on the problem.

Over a 5-year period, the tank car research effort involved testing for fire protection, examining the conditions of ruptures, and testing a number of hypotheses regarding improvements which could be made in tank car design. The results of the research now incorporated in regulations include: thermal protection systems, safety relief valves of adequate capacity to protect thermally insulated tanks, shelf couplers, and tank head puncture resistance systems.

The effective implementation dates of this research and the regulations vary according to the specific research feature, however, the final date for retrofitting is 1982. The estimated cost to the railroad industry is *$200* million. Federal expenditures for tank car research have been approximately *$5* million.

In addition to research on tank car design, growing concern has been voiced by the industry regarding transportation of nuclear wastes. While the issue has been one of economics, i.e., rates charged by the industry for shipping nuclear wastes and the economic liability of the industry in the event of an accident, discussions also have taken place between railroad industry and energy officials regarding the methods and containers to be used in such transportation and the testing of those containers. To date, the Department of Energy (DOE) has conducted research related to *trans*portation and containerization to be used in rail shipments. Current discussions between the FRA and DOE are focused on potentia} for cooperative testing of these containers. [1]

[9] *1974 Annual Report to Congress on the Administration of the Federal Railroad Safety Act of 1970*, p. 34.

[10] "Telephone interview with Mr. Sid Louick, Federal Highway Administration, January 1978.

[1] Interview with Mr. Lev Peterson, Office of Safety Research, FRA, December 1977.

R&D EXPENDITURES

Federal expenditures for railroad research and development applied to contemporary railroad concerns in the late 1960's and early 1970's were small in comparison with the research dollars being spent today. As shown in table 36, Federal research dollars (FRA) increased dramatically during 1971-76. (Part of this went into construction of the test facility at Pueblo, Colo.) Moreover, safety expenditures for the period 1973-76 rose from $3.6 million in 1973 to $8.0 million in *1976,* or **124.5** percent (not adjusted). Safety R&D expenditures (Federal Railroad Safety Act funds) were approximately $20 million during 1973-76, while overall R&D expenditures related to safety (including FRSA funds) were approximately $47 million (tables 36 and 37). In 1976, safety R&D accounted for 13.1 percent of total R&D.

Industry expenditures for research and development also were quite small in the early 1970's. However, industry resources* from 1973 to 1976 rose by 560 percent, excluding Government contributions, as seen in table 38. In *1977,* safety R&D expenditures accounted for 3.3 percent of the total industry R&D, exclusive of the Government contribution. Definitionally, research placed in other categories by the AAR, typically has been included under safety research in the FRA annual safety reports.

Table 36.—FRA Research and Development Obligations
(Dollars in millions)

	1971	1972	1973	1974	1975	1976
Safety	—		$3,568	$3,406	$5,023	$8,004
General R& D.	$ 1,218	$ 1 ; G 4	43,534	35,045	35,037	53,206
Total*	$1,218	$12,964	$47,100	$38,451	$40,060	$61,210
Percent safety of total.	—	—	7.6	8.9	12.5	13.1

• Includes obligations from Office of Research and Development, Transportation Systems Center, and Office of Program and Policy Development.
SOURCE: Task IV Report, PMM, & Co., for Office of Safety Research, FRA.

Table 37.—Total FRA Research and Development Office Expenditures for Safety-Related Research, * 1973-76
(Millions of dollars)

Program	Expenditure
Track structures research.	$20
Inspection and test support	7
Rolling stock.	14
Human factors & information support.	3
Grade crossing.	3
Total.	& 4 a

● Approximated.
aThis figure includes Federal Railroad Safety Act funds ($20 million) for the 1973-76 time period.
SOURCE: FRA, Office of Safety Research.

Aggregate research and development expenditures of the Federal Government and industry in 1975 represent only .3 percent of industry operating revenues (table 38). Given the discrepancy between industry and Government definitions of safety research and development, it was not possible to establish the relationship of safety 1<L'D to total operating revenues. As

*Industry resources is defined as those monies expended by AAR Research and Test Department; these funds do not take into account individual railroads R&kD budgets, although it includes railroad contributions and RPI contributions to the AAR. This definition of industry R&D applies whenever industry R&D is referred to in this report.

Table 38.—AAR Research and Test Budgets, 1974-77

	1974	1975	1976	1977
R&D (excludes Government contribution; includes suppliers, railroads)*	5,177,200	5,820,577	9,998,147	12,127,700
Government contribution (includes safety)	2,517,000	2,258,700	5,906,000	13,548,900
AAR safety expenditures (excludes Government)	95,000	182,800	420,000	405,550
Total	7,789,200	8,262,077	15,324,147	26,082,150
Percent safety of AAR R&D budget	1.8	3.1	4.7	3.3

•Because of the Research and Test Department budget procedures, the tank car, grade-crossing, locomotive cab, coupler, and track-safety programs have been included in the general AAR R&D column of this table, rather than as a line item safety account. These programs represented $1,616,000 in 1974, $740,000 in 1975, and $558,750 in 1977. There are safety costs inherent i n most R&D projects specifically dealing with technological problems.
SOURCE: *AAR Research and Test Department Biennel Report, 1974-75, 1975-76* draft.

can be seen, the amount of investment by both Government and industry in R&D, though increasing, is still quite small.

Although not exact, comparison of Government safety-related R&D expenditures for track, equipment, and human factors shows that the major thrust of Government research has been devoted to rail and equipment problems. Of the total $47 million which has been expended on safety-related R&D, approximately $12 million has been spent on research most closely related to the casualty problem as shown in table **39.**

The recent AAR accident analyses have caused both Government and industry to begin to rethink their position with respect to safety R&D. As indicated by the accident analyses examined in chapter V, the significant number of employee fatalities and injuries do not occur in track-related accidents. Property damage from train accidents account for 45 percent of total cost claims while casualty claims, the majority of which do not occur because of train accidents, also account for about 45 percent. Therefore, the lack of R&D expenditures on human factors and on the casualty problem, given its equal economic magnitude with equipment and track problems, suggest that some greater attention may be focused in these areas.

While the previous data on Government expenditures indicates a growth in R&D expenditures, prior to this decade such emphasis was extremely limited. Railroads usually adopted technological innovations only after their effi-

Table 39.—FRA Office of Research and Development Approximation of Safety-Related Expenditures, 1973"1976 (Millions of dollars)

Safety-related programs	
Track-structures research	**$20**
Inspection and test support	**7**
Rolling stock	**14**
Human factors & information support	**3**
Grade-crossings	**3**
Total	**$47* ***
Safety research related to casualties	
Grade-crossings	*$ 3.0*
Tank car	*5.0*
Personnelprotection	*1.0*
Human factors	S.4
Total	$12.4
Rolling stock expenditures	
Tank carresearch •	*$ 5*
Equipment component failures	*7*
Personnelprotection••	*7*
Other	*I*
Total	*$14*
Human factors Research	
Task analyses	*$1.0*
Train-handling	*.5*
Locomotive evaluator	*.5*
Cab environment	*.5*
Information support	*.5*
Vigilance and vandalism	*.2*
Alcohol and drug abuse	*.2*
Total	$3.4

'Indicates those programs related to the casualty problem or human factors research.
•● Of the $47 million, $20 million was the result of Federal Railroad Safety Act funds.
SOURCE: FRA Office of Safety Research.

ciency and value were clearly proven and demonstrated to have railroad application. More~jver, specific research usually occurred in conjunction with suppliers and only on an incremental basis. As stated in the 1972-73 AAR Biennial Research and Test Department Report:

> In many fields, especially in track and equipment, the basic principles of design were established by research completed many decades ago. Problems encountered after research was completed were solved by iterative, trial-and-error laboratory and field studies. This approach sufficed during that time that the industry was not required to make rapid changes to accommodate new traffic demands or to respond to competitive and regulatory forces. In the last decade, major changes have been necessary to provide more transportation service and to adapt to safety and environmental regulations. Insufficient research had been performed to anticipate these requirements for change and to provide reasonable alternative solutions. 12

In more recent times, the reasons for the lack of R&D and the slowness with which innovation has occurred are numerous. However, the most apparent causes include: the poor financial condition of the industry at large and its lack of capital; the comparability problems of making new technologies co-equals to those already in usage, particularly in light of the differing life cycles of massive industry equipment and fixed plant; and the management philosophy and practices of the 1950's and 1960's, wherein R&D was not considered a priority in the industry.

Clearly there are several significant points concerning today's railroad research, irrespective of whether it is for the general industry or for safety. Because of the lack of resources, railroad economics have impeded innovation. Innovations which do occur in the present or future must be cost-effective. Finally, there must be a systematic economical method for implementation of research findings before there will be an overall willingness by the industry and interested parties to accept technological or operational change.

[12] *Progress in Railroad Research,* AAR Research and Test Department Biennial Report, 1972-73, p. 194.