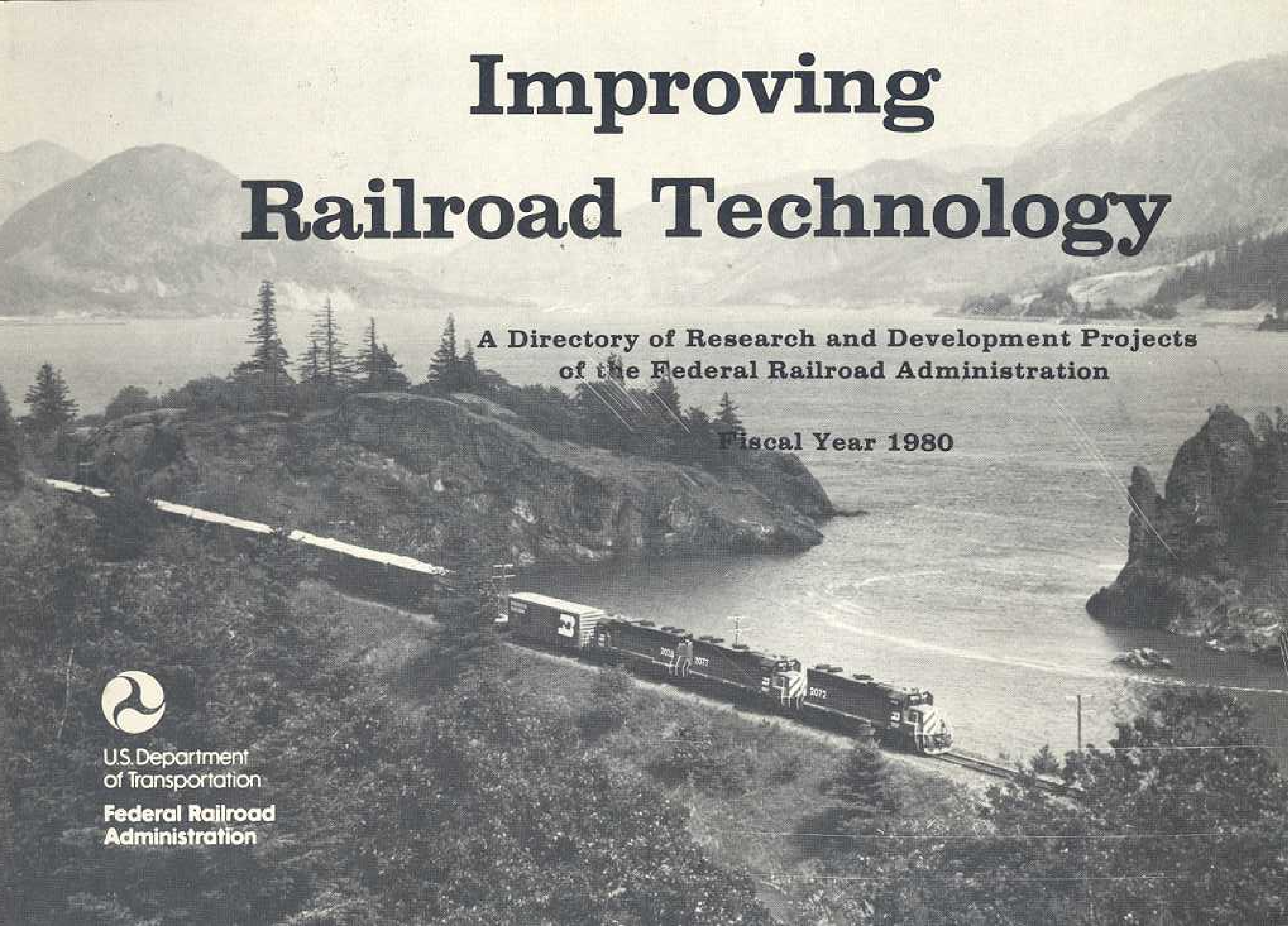
Improving Railroad Technology

A Directory of Research and Development Projects of the Federal Railroad Administration

Fiscal Year 1980



U.S. Department of Transportation

Federal Railroad Administration

Report Number FRA/ORD-81/14

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Foreword

It is impossible to imagine the building of our nation's commercial and industrial strength without the railroads. The railroad industry has a proud tradition and it remains an indispensable part of our economy.

In recent years, however, the railroad industry has fallen on difficult times. Return on invested capital is among the lowest of major industries. Railroad plant and equipment have not been renewed, and deferred maintenance over the past decade has accumulated to well over $5 billion.

Much of the relative decline in railroad freight can be attributed to changes in the American economy as well as to competition from trucks, barges, and pipelines. Railroad passenger service, in competition with the private automobile, airplane, and bus, has suffered even sharper declines.

Despite its problems over the last several decades, the railroad industry continues to support an extensive network of track, rolling stock, and ancillary facilities.

The Federal Railroad Administration (FRA) is working with the railroad industry to help it recover. The FRA has been addressing such issues as economic regulatory constraints, federal financial assistance, taxation, competition with other modes, revision of safety regulations, improved management of railroad assets, and improvements in railroad technology.

This booklet describes one segment of FRA work -- those programs, projects, and contracts which come under the auspices of the FRA Office of Research and Development.

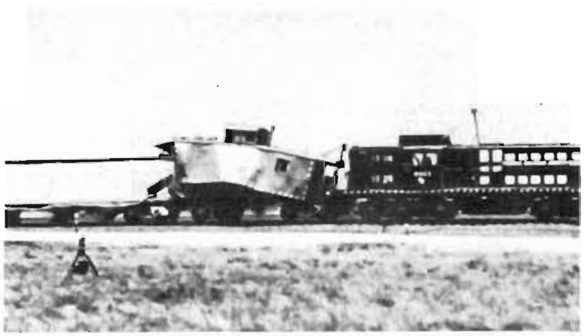
Federal railroad research, originally carried out in the Office of High-Speed Ground Transportation, is now the responsibility of the Office of Research and Development of the FRA. The initial aim of the federal effort in fixed-guideway technology was directed toward rail passenger service and high-speed ground transportation, including such unique developments as air-cushion vehicles and magnetic-levitation vehicles. Since that time, FRA's technological research has been redirected to focus more sharply on near-term conventional railroad issues and problems. FRA continues to place the highest priority on safety-related research.

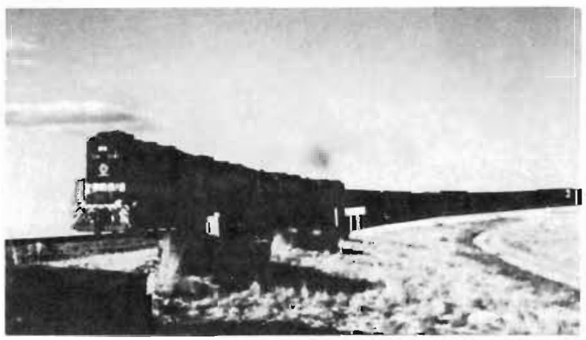
Working closely with the railroad industry, the FRA has structured its R&D program to develop new technologies and techniques to solve near-term problems, to coordinate its research with other groups investigating the same problem, to work with the railroads to put the new technology in practice, and to develop a forum for the exchange of ideas and information between those performing research and those using the results of that research.

This directory is presented in the interest of information exchange. If any questions, comments, or suggestions come to mind while reading it, please do not hesitate to call the technical contacts listed, or write them at the following address:

U.S. Department of Transportation
Federal Railroad Administration
Office of Research and Development
400 7th St., S.W.
Washington DC 20590

FRA Research & Development





SAFE MOVEMENT OF PEOPLE AND GOODS

Table of Contents

Introduction

The FRA's Research and Development program has as its goals near-term improvements in products and processes which would enhance safety, improvements in the economic viability and efficiency of the Nation's railroad operations, and reduction of adverse environmental effects of railroad operations.

The Office of Research and Development has responsibility for three major programs: 1) Track, Equipment and Personnel Safety, 2) Railroad Operational Improvements, and 3) Improved Passenger Systems.

The Track, Equipment, and Personnel Safety Program is aimed at reducing the number and severity of railroad-related accidents. In turn, much of the effort of this program has been to conduct research and development to study the causes of accidents and to improve rail tracks, rolling stock, wayside signals, inspection techniques, crew operations and safety, and grade crossing protection systems.

The Railroad Operational Improvement Program is aimed at improving freight classification and switching yards, promoting the exchange of technology and information between railroad companies, improving intermodal equipment, facilities and operations, and conserving energy.

The Improved Passenger Systems Program is designed to emphasize train technology and subsystem development including equipment reliability improvements and techniques for reducing trip time, together with feasibility studies on adopting the radial axle concept to electrically powered vehicles and on incorporating a tilt body arrangement. The program is also investigating the use of chopper propulsion systems for electric locomotives and is putting a railbus into revenue service to test the feasibility of this new self-propelled passenger vehicle.

A detailed discussion of the three program areas of the Office of Research and Development follows. Included in each discussion is a description of each subprogram, project and its related contracts and publications.

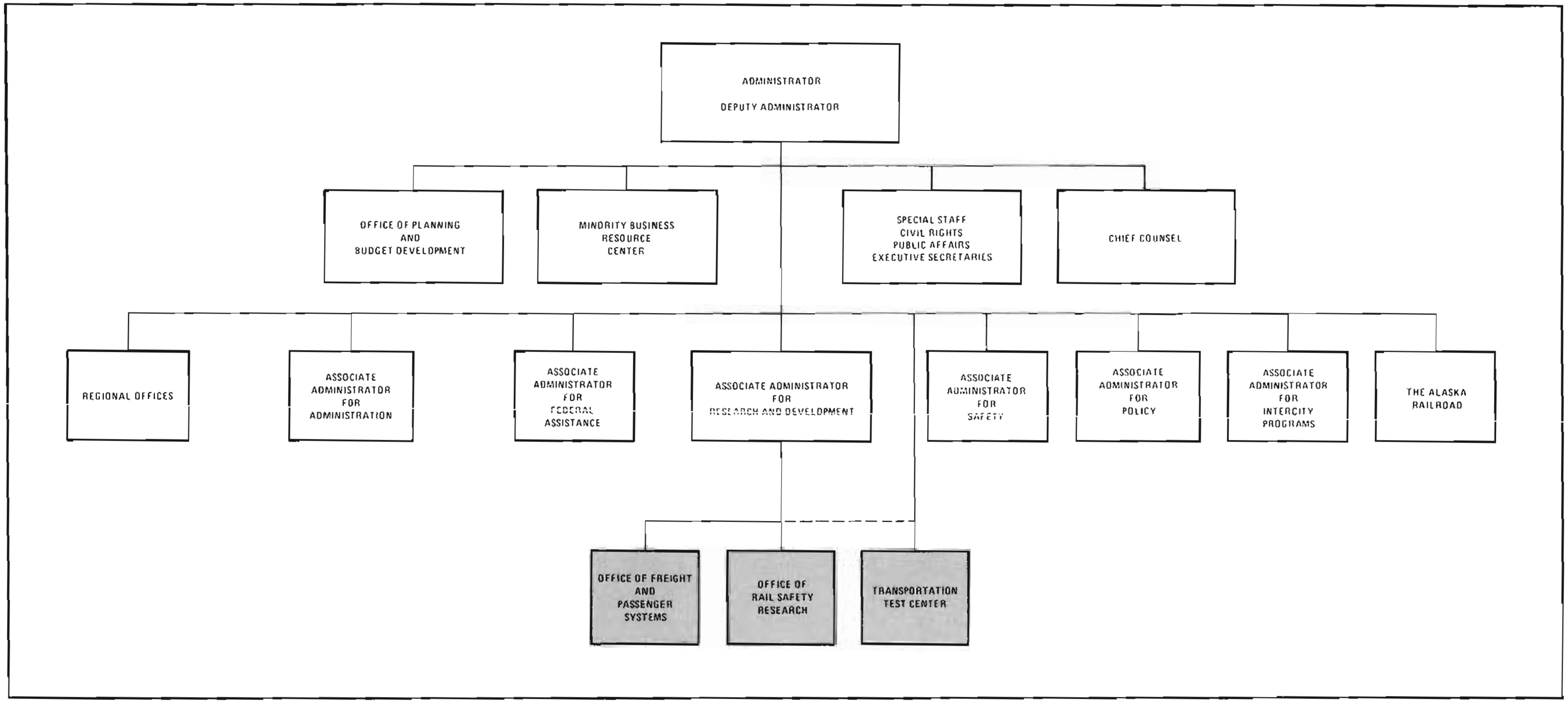
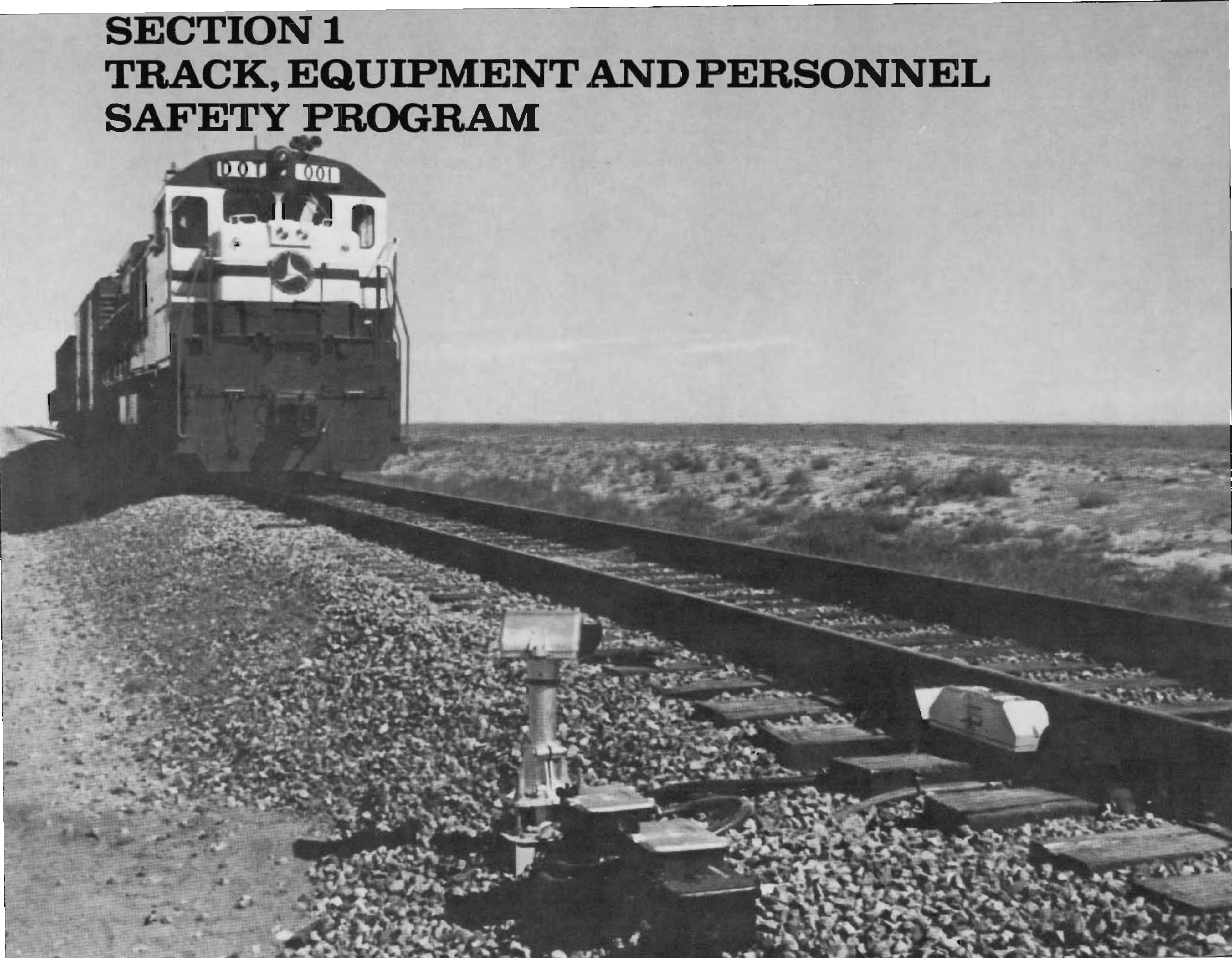


TABLE OF ORGANIZATION – FEDERAL RAILROAD ADMINISTRATION

SECTION 1
TRACK, EQUIPMENT AND PERSONNEL SAFETY PROGRAM



TRACK, EQUIPMENT AND PERSONNEL SAFETY PROGRAM

SUBPROGRAM	PROJECTS
1. **Equipment Safety**	Hazardous Materials Rail Vehicle Component Failure Prevention Vehicle Structural Integrity/Occupant Protection Rail Vehicle Control Systems Truck Design Optimization Braking Performance Coupling and Braking Systems Optimization
2. **Improved Track Structures**	Track Standards Development Track System Safety Studies SAFE Development Support Track Performance and Safe Life Performance Standards Maintenance Requirements MOW Equipment and Techniques Evaluation
3. **Dynamic Analysis**	Rail Dynamics Laboratory Equipment Analysis Equipment Evaluation Lading Loss and Damage
4. **Inspection and Test Support**	Rail Vehicle Inspection Systems Track Inspection Systems Safety Life Cycle Testing Automated Wayside Inspection Systems
5. **Human Factors**	Crew Operations Employee Personnel Safety
6. **Grade Crossings**	
7. **Safety Testing (FAST)**	

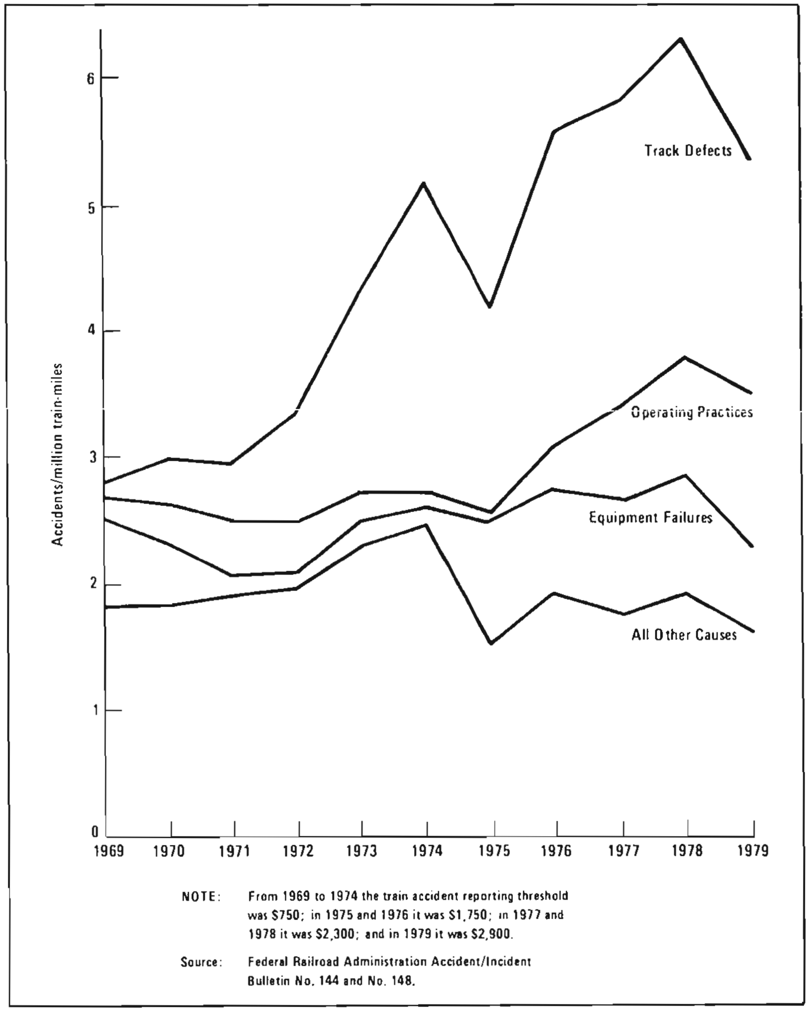
SECTION 1
INTRODUCTION

Poor financial performance has caused many railroads to defer maintenance and delay capital expenditures for track, signals, and rolling stock. Deferred maintenance had caused, by July 1976, 47,203 miles of track (15 percent of the track in the country) to be in such poor condition that orders were issued requiring the operation of trains at reduced speeds.

Deferred maintenance not only causes trains to operate at inefficiently low speeds, but also is directly linked to the increasing rate of train accidents. As shown in the figure, the number of accidents per million train-miles caused by track defects increased significantly from 1969 to 1979. Deferred maintenance costs over the 10-year period from 1967 to 1977 totaled $5.4 billion.

Although a case can be made that this deterioration of equipment and, therefore, of rail safety, is a symptom of more fundamental railroad problems in such areas as operating, planning, regulation, and competition, any decrease in the safety of rail operations is certainly a major cause for national attention.

In addition to accidents caused by track defects, concern has been growing over the number of injuries and deaths occurring as a result of grade-crossing accidents. Interest also has been mounting over the large amount of vandalism



TRAIN ACCIDENTS BY CAUSE 1969-1979

that has caused rocks, bullets, and bottles to smash windows and injure railroad employees and passengers riding on trains along major right-of-ways.

The FRA has developed, through its Track, Equipment and Personnel Safety Program, an extensive effort of research and development to ensure that America's railroads are run as safely as possible. The FRA is committed to taking preventative steps before major disasters occur. Many of these steps are directed toward achieving immediate results.

The Track, Equipment and Personnel Safety Program is designed to improve the safety of rail operations by: 1) reducing both the likelihood and severity of accidents involving the rail transportation of hazardous commodities, 2) reducing the likelihood of accidents resulting from the structural or mechanical failure of critical track and rail vehicle component parts, 3) protecting rail vehicle occupants from death or injuries resulting from collisions, fires, or acts of vandalism, 4) reducing the likelihood of accidents caused by adverse track/train interactions, and 5) improving the quality and performance of rail vehicle braking and control systems.

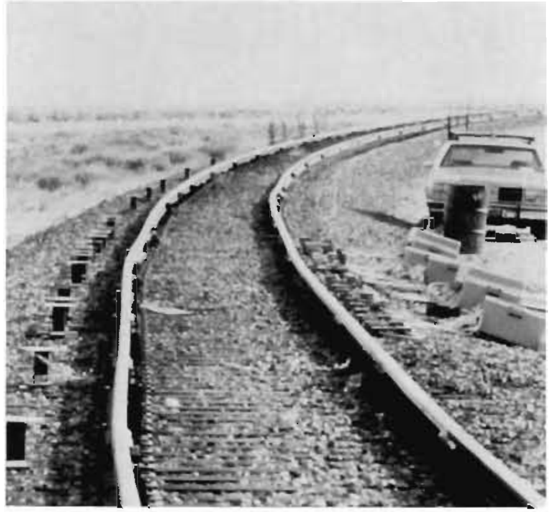
Major accomplishments of the program in FY80 include completion of a series of tests which were instrumental in identifying the derailment tendencies of a six-axle locomotive operated by Amtrak; completion of a study mandated by Congress on the effect of freight car size and weight on railroad safety and efficiency; and the beginning of construction of the Research Locomotive and Train Handling Evaluator, a unique device which will be used to conduct safety experiments on man/machine interactions. Use of this device will emphasize the development of countermeasures to causes of occupational injuries, guidelines and procedures of crew vigilance devices and new cab designs. Work is also continuing on data collection used to develop FRA safety regulations to improve the performance of track and rolling stock and to reduce accidents at grade crossings.

In past years, the program has developed: 1) performance specifications and design guidelines to decrease the probability of serious injury to occupants involved in a collision, 2) performance specifications for locomotive, passenger, and caboose windows to protect occupants from injuries caused by vandals, 3) prototype wayside vehicle inspection stations to anticipate and prevent derailments by sensing wheel cracks, axle cracks, and dragging equipment, 4) performance specifications for shelf couplers, head shields, and tank car insulation material, 5) the FAST track, 6) development of preliminary track performance safety standards, and 7) track inspection systems.

The Track, Equipment and Personnel Safety Program has seven subprograms:

1) Equipment Safety
2) Improved Track Structures
3) Dynamic Analysis
4) Inspection and Test Support
5) Human Factors
6) Grade Crossing
7) Safety Testing (FAST)

Descriptions of each subprogram, project, supporting contracts and publications follow.



TESTS ON "PERTURBED TRACK SHOW THE OUTER LIMITS OF STABILITY AT VARIOUS SPEEDS OF LOCOMOTIVES AS THEY RUN OVER TRACK GEOMETRY IRREGULARITIES. THE RESULTING PERFORMANCE SPECIFICATIONS WILL ASSURE SAFER RAIL OPERATIONS.

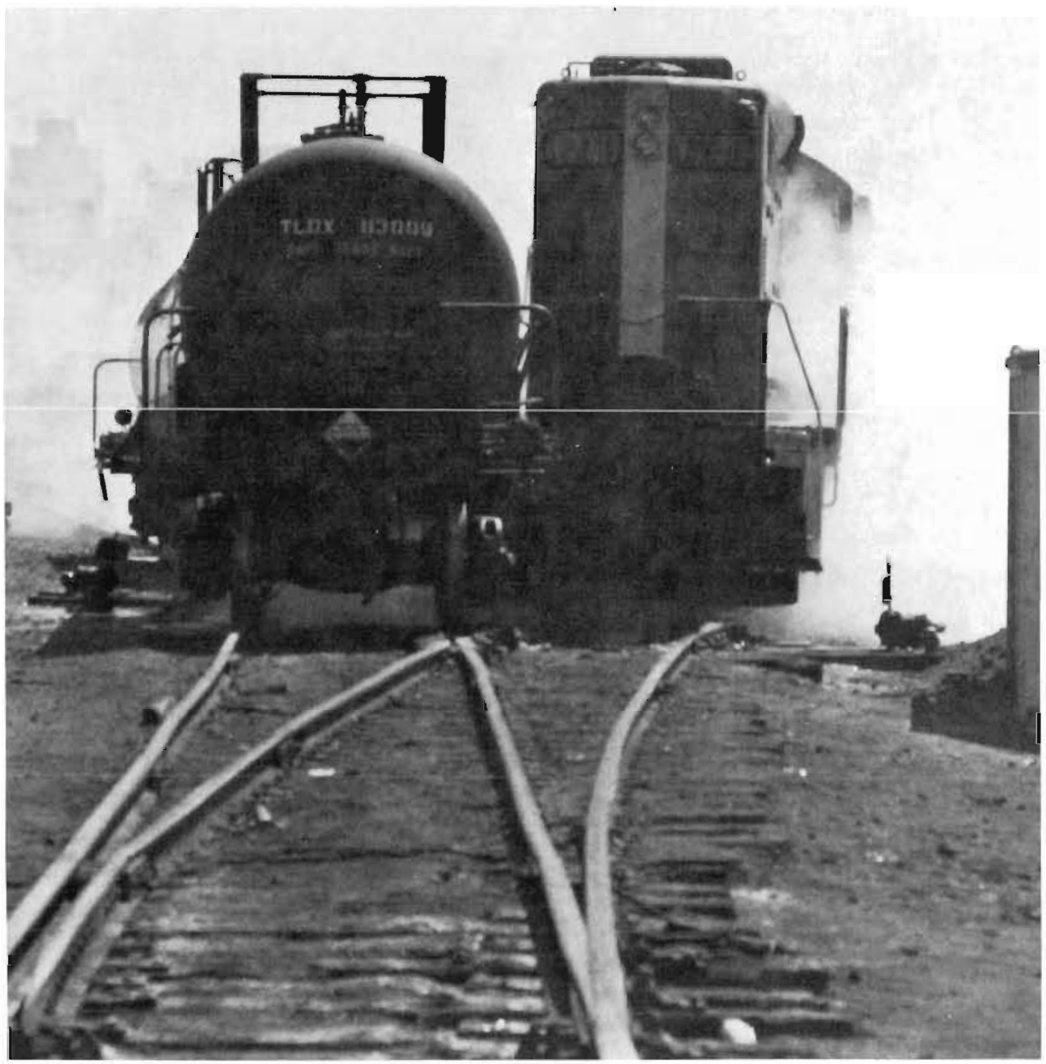
CHAPTER 1
EQUIPMENT SAFETY

The Equipment Safety subprogram is one of seven subprograms of the Track, Equipment and Personnel Safety Program and is a top priority of the Office of Research and Development. The equipment safety effort is dedicated to the development of new equipment, techniques, and performance specifications and guidelines to ensure that train locomotives and cars are as safe and efficient as possible. The equipment investigated in this area is used in both freight and passenger train operations.

There are seven projects organized under the Equipment Safety Subprogram. These projects include:

1) Hazardous Materials
2) Rail Vehicle Component Failure Prevention
3) Vehicle Structural Integrity/Occupant Protection
4) Rail Vehicle Control Systems
5) Truck Design Optimization
6) Braking Performance
7) Coupling and Braking Systems Optimization

Each project is carried out by the FRA through contracts with private and Federal research organizations. A description of each project area and associated contracts is followed by a bibliography of published reports.



HAZARDOUS MATERIALS PROJECT

Over the past few years, there have been derailments involving hazardous material tank cars. These derailments have resulted in mass evacuation, injuries, and fatalities.

In response to the seriousness of accidents involving hazardous materials, the FRA's hazardous materials project was established. The project was designed both to reduce the frequency of railroad hazardous material releases and to reduce the severity of accidents in which releases do occur. In researching the causes and deterrents to hazardous materials accidents, the safety project is geared to the development of performance specifications for the manufacture and repair of rail cars which will be transporting hazardous materials. The project is also establishing guidelines for priority routing of trains carrying hazardous materials and is developing procedures for railroad and emergency personnel to follow when responding to railroad accidents involving the release of hazardous materials.

Past research in the hazardous materials project concentrated on investigating and improving the structural safety of large (class 112/114) tank cars used to transport liquified petroleum gas and ammonia. These tank cars were singled out for study because of the relatively high frequency and severity of accidents involving the shipment of these highly volatile and toxic materials in the large tank cars. The FRA has sponsored research into the structural integrity of the large tank cars. This research has included full-scale fire tests and a series of full-scale impact tests simulating car-to-car impacts often occurring in switching operations.

A HAZARDOUS MATERIALS CLOUD RISES FROM BURNING TANK CARS DERAILED NEAR CRESTVIEW, FLORIDA. FOURTEEN PERSONS WERE INJURED AS A RESULT OF THE RELEASE OF POISONOUS GAS, AND 4,500 PERSONS WERE EVACUATED FROM THEIR HOMES.

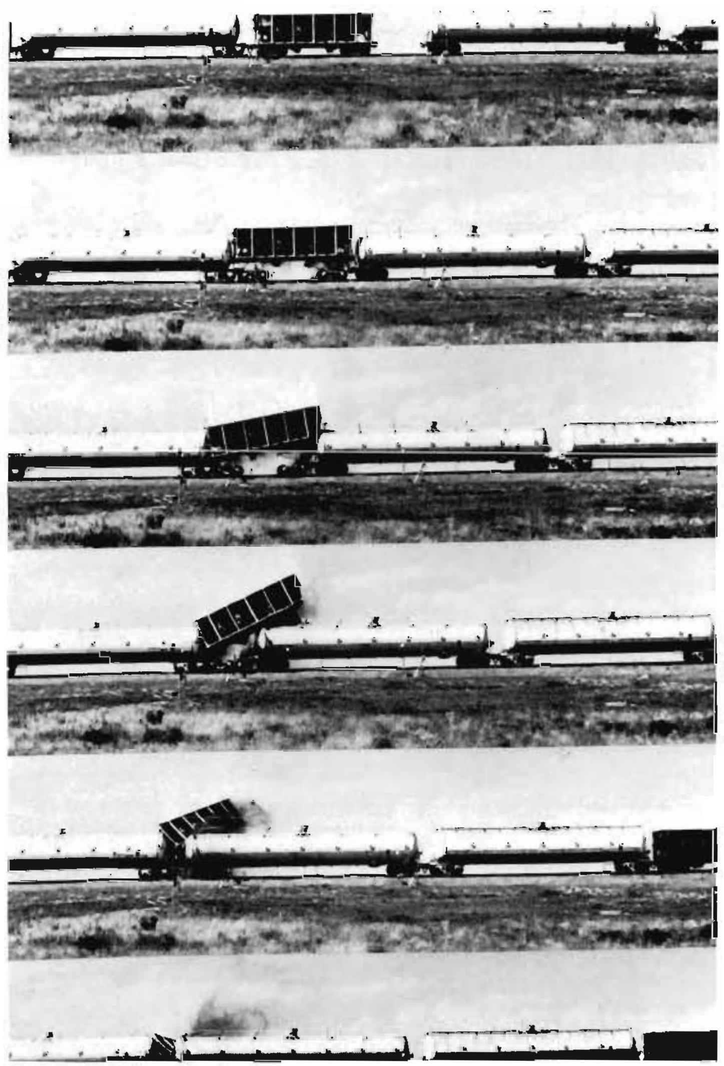
From this research, performance specifications calling for full steel jackets, thermal protection, head protection, and shelf coupler systems were developed for those tank cars. Tank cars with these performance specifications underwent 90,000 miles of testing at the Transportation Test Center (TTC). Following the test evaluations, regulations requiring the use of the new specifications were mandated for implementation by the railroad industry.

Subsequently, through a study conducted by the Transportation Systems Center (TSC), the FRA broadened the scope of the study to include additional tank cars. The urgency of addressing structural changes to smaller tank cars was highlighted by the consequences of a derailment and major hazardous materials release at Crestview, Florida in early 1979.

Additional research projects are now underway to ensure the safe transport of radioactive, explosive, and toxic cargoes. This research effort is designed to develop performance specifications for cars carrying such hazardous commodities, recommendations for the switching and placement of these cars in trains, and emergency response guidelines for Federal, state, and local officials to follow in the event of a railroad incident involving the release of a variety of hazardous materials, including spent nuclear fuel casks.

Specifically, these studies include investigations into determining the cost and benefits associated with special routing of spent nuclear fuel shipments, the development of performance specifications for safety relief valves for cars carrying hazardous materials, and the development of a plan to prevent, detect and extinguish fires on rail cars.

A great deal of effort has been undertaken to reduce the release of hazardous materials transported by rail. However, it is likely that some releases will still occur. Because of this probability, research is underway to determine evacuation guidelines in the event hazardous materials are released in an accident. The purpose of another ongoing effort is to develop guidelines for the emergency response and wreck clearance of accidents involving hazardous materials.



TANK CAR IMPACT TEST

CONTRACTS

A Study of Methods to Determine Dangerous States of Hazardous Cargoes During Transport
Contract No.: AR-8196
Funding: $125,000
Schedule: September 1978 – September 1981
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Army, Ballistics Research Laboratory

The U.S. Army's Ballistics Research Laboratory is conducting a research study for the FRA to develop a means of detecting the release and/or changed physical state of hazardous materials while cargo is in transport and before the release becomes a serious problem. Early detection of the release of hazardous materials will enable train crews to take appropriate action to prevent additional releases or to avoid dangerous situations.

The study includes the identification of those hazardous materials that require early detection and the development of laboratory tests of techniques that might be used to carry out that detection. A work plan will be developed for field testing prototypes of detection techniques.

U.S. DOT Hazardous Materials Program
Contract No.: RSPA/DTFR 53-80-x-00104
Funding: $50,000
Schedule: June 1980 – September 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: U.S. DOT/RSPA

The number, variety and possible combinations of hazardous materials carried on single trains is ever growing. This growing and changing situation makes the establishment of safety regulations, performance specifications, and emergency response measures difficult, at best.

In facing the ever-changing problems of transporting hazardous materials, research undertaken in this contract is designed to determine what research is needed to support the efforts of the Materials Transportation Bureau and other U.S. DOT administrations. The results of the research will allow regulations, specifications and requirements to be established with the confidence that they will solve the problems for which they are intended in the most efficient and beneficial way possible.

The study will 1) review past R&D in hazardous materials, 2) develop a multi-year advanced R&D plan, and 3) conduct preliminary research in some of the areas recommended for examination.

Anhydrous Ammonia Spill Test
Contract No.: AR-8207
Funding: $40,000
Schedule: September 1978 – April 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: U.S. Coast Guard

Anhydrous ammonia is one of the most often carried and potentially dangerous hazardous materials transported by rail.

The examination of the dispersal characteristics of anhydrous ammonia in the atmosphere is an important step in working out procedures to minimize harm downwind from a spill. An analytical methodology will be developed, based on monitoring 6-ton and 80-ton ammonia spills, to predict these downwind dispersion patterns.

Results from these tests will allow guidelines to be developed to aid in the evacuation of area residents in the event of an ammonia spill. The study will also develop guidelines for setting safe distances between populated areas and rail yards that handle anhydrous ammonia.

Safety Relief Valves for Hazardous Materials
Contract No.: FR-64181
Funding: $416,001
Schedule: August 1975 – May 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: University of Maryland

Many types of hazardous materials, particularly those in gaseous form, build up pressure while being transported in rail tank cars. Efforts are underway to ensure that levels of those pressures do not build to such a point that tank cars are ruptured.

An FRA research contract with the University of Maryland was established to develop a method to ensure that pressures in tank cars do not reach explosive levels. Work undertaken in this contract is designed to develop new safety valves which will provide the required pressure relief capacity without requiring extensive modifications to existing tank cars. The study is concentrating on the analysis and laboratory testing of scale-model two-phase flow-through valves.

Results of the study will be in the formulation of performance specifications for pressure relief valve systems on rail tank cars used to transport hazardous materials.

Munition Car Fire Tests
Contract No.: AR-9129
Funding: $90,000
Schedule: August 1979 – September 1980
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: Military Traffic Management Command

Under this contract, the Military Traffic Management Command has completed testing on the effectiveness of a water tank in inhibiting the progression of a detonation or fire from one box car to another and on the effectiveness of heat and smoke detectors and automatic fire suppression systems in box cars carrying munitions and other explosives.

The investigation included two full-scale fire tests. One test used a water tank to suppress a munitions detonation. The other test used heat and smoke detectors and an automatic fire suppression system to suppress the fire.

Fire Safety Concepts for Railroad Cars Carrying Class A Explosives
Contract No.: AR-8198
Funding: $125,000
Schedule: September 1978 – August 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: National Bureau of Standards

A fire in a rail car can create a disastrous situation both because the fire can spread from car to car, to other trains or to buildings, and because personnel, equipment and water needed are often not available to extinguish a blaze. A fire can pose even more of a threat if it breaks out in or near a rail car filled with such hazardous materials as Class A explosives.

Work undertaken in this contract by the National Bureau of Standards is designed to reduce the frequency and severity of fires involving munitions-carrying rail cars.

State-of-the-art technology will be evaluated for efficiency in improving the fire safety of this type of rail car. A cost-benefit analysis of alternative systems and devices which could contribute to the prevention, detection and suppression of fires will be performed. A test plan to improve cost effective technology utilizing both small-scale and full-scale tests will be established. Performance standards will be formulated.

Emphasis in the guidelines will be placed on improving, through a systems approach, fire safety of rail cars carrying explosives.

Hazardous Transportation of Radioactive Materials
Contract No.: AR-8178
Funding: $650,000
Schedule: August 1978 – August 1982
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Army, Ballistics Research Laboratory

Spent nuclear fuels must be transported from power plants, where they are used, to secure disposal areas. These fuels are still radioactive, although spent, and must be handled with extreme care.

The Ballistics Research Laboratory is conducting a study to determine the behavior of casks used to hold spent fuels in the event the casks are exposed to fire resulting from a rail accident. The study will be conducted using full-scale pool and torch fires of spent fuel casks.

The investigation will describe the relationship of temperature and burning time to the critical locations of the casks. Guidelines for responding to rail car and cask fires can then be developed from this research.

Statistical Modeling for Hazardous Materials in Rail Transportation
Contract No.: TSC-1607 (Managed by the Transportation Systems Center)
Funding: $209,177
Schedule: September 1978 – August 1980
TSC Technical Contact: T.S. Glickman
(617) 494-2621
Agency/Contractor: Arthur D. Little, Inc.

The prevention of railroad accidents and the resulting release of hazardous materials can begin only when the causes of the accidents are understood. A major step in understanding the causes is in determining common circumstances, high-risk situations and accident probability statistics.

This contract, in analyzing the risk of transporting hazardous materials by rail, was designed to develop computer models of rail car accident probability, accident impact, and track network linkages in high-risk areas. Results of the analysis will be presented as aggregated and track-related probability distributions and accident impact and high-risk area network models.

The study will be used as the starting point in investigating specific causes of accidents and in developing strategies to avoid or prevent accidents in the future.

Special Routing of Spent Fuel Shipments
Contract No.: FR-5380-C-00009
Funding: $107,197
Schedule: December 1979 – April 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: Systems Technology Laboratory

The transportation by railroad of casks containing spent nuclear fuel may pose, in the event of an accident, a threat to the residents of communities through which the train must pass. This research contract is designed to develop procedures to carry out risk and cost analysis for routing trains carrying those casks away from highly populated areas.

Three major tasks are included in this contract: First, a method will be developed for evaluating the risks and costs of fuel cask shipments. Second, seven origin-destination combinations will be selected to test the method of evaluation that is developed. Third, the evaluation method will be tested using the seven origin-destination combinations. The results of this work will be in the development of procedures for evaluating risks and costs for special routing of trains carrying casks with spent nuclear fuel.

Metallurgical Studies
Contract No.: AR-40008
Funding: $572,000
Schedule: October 1973 – July 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: National Bureau of Standards

The National Bureau of Standards is conducting detailed tests to determine the metallurgical and mechanical properties of steel used in tank cars which carry hazardous materials.

The study is using steels taken from the head plates of tank cars used in switchyard impact tests at the Transportation Test Center. The steels will undergo eight separate tests to determine such characteristics as changes under different temperatures and behavior of various shapes and forms during impact.

The study is designed to result in the development of performance specifications for steel used in the manufacture of tank cars. New specifications will help prevent hazardous materials releases by requiring impact-resistant tank cars.

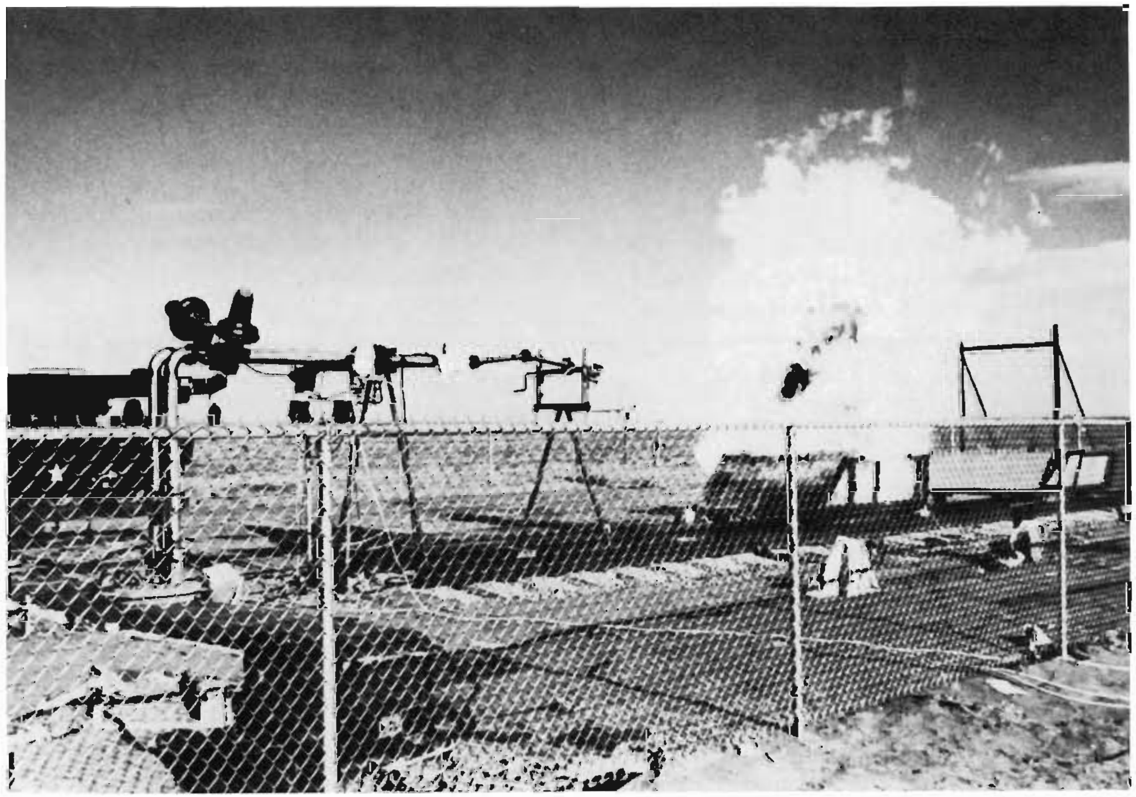
Thermal Shield Testing
Contract No.: AR-9134
Funding: $500,000
Schedule: September 1979 – September 1981
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Army, Ballistics Research Laboratory

Performance specifications are needed to ensure that tank cars, commonly used to carry hazardous materials, are able to withstand a degree of fire and heat before their contents are forced into the atmosphere.

This contract supports, in part, the development of performance specifications by upgrading the torch fire test facility at the Transportation Test Center so that simulated pool and torch fires of thermal shield systems on tank cars can be carried out.

Upgrading of the torch fire test facility center and studying fire protection afforded by existing insulation on Class 105 tank cars will assist the rail industry in improving fire protection and thermal shields of one of the most commonly used containers for the shipment of hazardous materials.

Results of this contract are directed toward the development of recommendations for improving the fire safety of munition-carrying box cars.



THERMAL SHIELD TESTING

Guidelines for Railroad Accident Emergency Response and Wreck Clearance

Contract No.: AR-9157
Funding: $450,000
Schedule: September 1979 – July 1982
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Air Force, Rocket Propulsion Laboratory

The response to the release of hazardous materials by local, state, Federal or railroad personnel may endanger those people or may create a situation more dangerous than the original problem. Emergency response personnel must be informed of the characteristics of the material(s) and combination of materials with which they are faced and the response that is most appropriate for the situation. This study is designed to prevent uninformed action by developing guidelines and recommended for use by emergency personnel in situations involving hazardous materials.

The study will include the investigation of current hazardous material wreck clearance procedures and will assess the risks inherent in each of those procedures. Recommendations and guidelines will outline the responses that are most appropriate in specific emergency situations. A handbook for emergency response personnel will be prepared which will contain recommendations and guidelines outlining responses that are most appropriate in specific situations.

Support of Fire Tests of Spent Nuclear Fuel Shipping Casks

Contract No.: AR-8189
Funding: $1,025,000
Schedule: September 1978 – September 1981
FRA Technical Contact: D. Dancer
(202) 426-1227
Agency/Contractor: U.S. Department of Energy

The transportation of casks containing spent nuclear fuel by rail is often a long and time-consuming journey. In the event of an accident, the trip may also pose a threat to the residents of communities through which the train must pass.

In an effort to mitigate the possibility of such a mishap, the U.S. Department of Energy is conducting a study for the FRA to evaluate the capability of spent fuel casks to withstand accidents and fires without releasing dangerous levels of radiation. The study will involve the design and fabrication of two small-scale casks and an examination of their behavior in fires. The study will also involve reconditioning two full-size casks and an examination of their behavior in fires.

Results of these fire tests, and results from other research contracts, will help the FRA in the formulation of performance specifications required for spent fuel casks.

RAIL VEHICLE COMPONENT FAILURE PREVENTION PROJECT

For the past 10 years, approximately 23 percent of accidents on the railways can be attributed to failures in the various components of rail vehicles. The major components experiencing failure are the wheels, truck components, coupler and draft system components, axles and bearings and brakes.

Many accidents could have been avoided if countermeasures for defective components had been available. Also, safety and performance testing of components should be regarded as a means of preventing accidents and improving the efficiency of the railway system.

The project not only looks at the structure of vehicle components and makes laboratory tests, but it also considers the operating environment to be an important consideration in appraising the performance of rail car parts. Many of the characteristics of railroad operations and surroundings cannot be simulated in a laboratory. Hence, this project determines the service environment experienced by vehicles and critical vehicle components and recommends changes in vehicles and their components where problems may arise. It also develops techniques to identify components in use which are about to fail.

This project also provides the industry, FRA and suppliers of components with guidelines on locomotive suspension systems, performance specifications for critical vehicle components and concepts for on-board component failure detection.

CONTRACTS

Overheated Bearing and Local Derailment Detector
Contract No.: AR-44061-54162
Funding: $1,309,000
Schedule: November 1974 – February 1982
FRA Technical Contact: J.C. Mould
(202) 426-1682
Agency/Contractor: Naval Surface Weapons Center (NSWC)

In the course of 30 billion miles traveled each year, the 2 million American railroad freight cars suffer thousands of derailment accidents. These derailments are due to numerous causes, but historically approximately half are due to failures of equipment or roadway. The cost of these derailments is not accurately known, but estimates for equipment and roadway-caused accidents total approximately $60-65 million for direct railroad losses, with total losses estimated at $180-330 million per year.

The largest single category of equipment-caused derailments is due to broken or overheated journal bearings (hotboxes), which accounted for $45-75 million in estimated total damages. Other major equipment-caused derailment sources are broken truck components and car dynamics. Similarly, the majority of roadway-caused derailments are attributable to broken rails, joints, or switches and to improper maintenance of the roadway.

This contract provides for special technologies developed at the Naval Surface Weapons Center to be adapted by designing, fabricating and testing a hot bearing and derailment detector system. The detectors are located on each wheel and, when activated, stop the movement of the whole train. These devices are installed on four cars of the DM&IR Railroad, and the system is undergoing a full operational test.

A Study of the Effects of the Physical Properties of Nonmetallic Materials on Rail Vehicle Dynamics
Contract No.: AR-8190
Funding: $246,000
Schedule: September 1978 – March 1981
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: National Aeronautics and Space Administration

This study focuses attention on the types of nonmetallic materials used in railway applications. Nonmetallic materials include natural and synthetic polymers such as fabric, paint, and glazing; fluids and lubricants; and composites exemplified by brake shoes and fiber-reinforced plastics. Nonmetallic materials represent a very small, but very essential, part of railway material use, and it seems likely that this will continue to be the case. Since railway equipment is engineered for a long life, the spread of new materials will be slow. The primary thrust for nonmetallic materials improvements will come from the reduction of maintenance requirements brought about by lengthened service life and predictable performance characteristics.

This study will determine the effects of varying the physical properties of certain visco-elastic materials used in rail vehicle suspension systems on the characteristics of the dynamic fatigue life of such systems. This work will be useful to the railroad industry. Amtrak, suppliers, the FRA, and the Office of Safety. It will allow improvements to be made in the design and performance of new suspension systems.

Track/Train Dynamics/Phase II
Contract No.: FR-64228
Funding: $2,291,582
Schedule: June 1976 – August 1981
FRA Technical Contact: D.M. Dancer
(202) 426-9252
Agency/Contractor: Association of American Railroads

The international Government/Industry Research Program on Track Train Dynamics is a 10-year, 3-phase, cooperative research effort directed towards the alleviation of the adverse effects of track/train dynamics. The placement of new equipment in revenue service and changes in train makeup practices have frequently led to operational situations involving complex dynamic interactions which have contributed to an increasing number of train accidents. Alleviation of the personal casualties, equipment damage, and lading damage which result from diverse dynamic interactions will allow the railroad industry to improve safety records, work at a higher efficiency, provide more dependable and reliable service, and supply continuing low-cost transportation services.

Phase II has as its goal the development of recommended performance specifications and relevant design guidelines to assure the safety of operations through compatibility of equipment, track structures, and their components with the operating environment. Part of this work investigates track stress and rail flaws, and part investigates rail vehicle components, especially for heat effects and wear.

Stress Relaxation Characteristics of Elastomeric Isolation Pads
Contract No.: AR-8193
Funding: $100,000
Schedule: September 1978 – May 1981
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: D.W. Taylor
Naval Ship R&D
Center

This contract is for the development of a predictive capability for determining the life cycle performance of elastomeric isolation pad materials currently being built for locomotive use. This task will: develop a test methodology for performing stress relaxation tests; prepare rigid steel fixtures capable of being loaded and locked under controlled conditions; evaluate test specimens of tensile dumbbell type in regards to its reaction to atmosphere, temperature, exposure time, and life cycle tests. This data will be analyzed and compared to other test specimen information.

The railroad industry, suppliers of equipment, Amtrak, and the National Transportation Board (NTSB) will be able to use this information to gain an understanding of the behavior of non-metallic materials in railroad service.

Wheel Failure Studies
Contract No.: FR-5380
Funding: $447,500
Schedule: April 1980 – December 1982
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: National Aeronautics and Space Administration

The wheel is one of the most critical components of a car or locomotive in that a failure often results in a major derailment causing significant damage and operational losses. Moreover, the railroads are operating today with trains that are longer, heavier and running at higher speeds on deteriorating track and structures. The dynamic loads imposed on the locomotive and car wheels have increased tremendously, thereby increasing the potential for wheel failures. Since a wheel failure can cause a serious derailment that may result in injury and huge nonproductive financial costs, a need exists for determining the extent to which the wheels can be expected to perform without failure.

This contract satisfies this need by the development of a test facility to evaluate new and existing wheel designs under simulated operating conditions. A test device, capable of subjecting wheels to high thermal inputs until failure occurs is currently being constructed. It will be fully instrumented to determine temperature-strains and metallurgical changes. The results of these tests will be useful in providing guidelines to industry, the FRA Office of Safety, and the National Transportation Safety Board (NTSB) for preventing wheel failure.

Locomotive Dynamic Performance Program
Contract No.: AP-64231
Funding: $1,085,000
Schedule: March 1976 – May 1981
FRA Technical Contact: J.V. Mirabella
(202) 426-1227
Agency/Contractor: National Aeronautics and Space Administration

This contract will obtain locomotive truck behavior characteristics at various temperatures to determine truck stiffness and properties data as part of an on-going program to understand truck dynamics. This will involve two-axle locomotive trucks and some truck components being tested at ambient temperature and at reduced temperature. The locomotive dynamic characteristics will be determined, and a simplified model will use this data to develop a methodology which can be used to compare performance of the locomotives. These characteristics will provide guidelines to the FRA Office of Safety and the railroad industry on locomotive suspension systems and the results should help in improving the safety of railroad operations.

Study Techniques to Distinguish Degraded Performance in Various Rail Vehicle Components
Contract No.: AR-8187
Funding: $175,000
Schedule: September 1978 – September 1982
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: Department of Army/
Ballistics Research
Laboratory

For the past 10 years, approximately 23 percent of the accidents sustained by the nation's railroads have been attributable to failures of various component parts of rail vehicles. Chief among these are failures of wheels, followed by truck components, coupler and draft system components, axles and bearings, and brakes. One approach taken to address this problem has been to investigate measures for preventing the failures before they occur. For example, wheel designs and alloying content have recently come under investigation in an effort to increase rail car wheels' ability to withstand high brake-induced thermal loads.

This approach has resulted in the development of some successful countermeasures. However, in order to implement a complete system engineering approach to the problem, investigations need to be made of concepts that will warn of impending degradation of the performance of various components.

The objective of this contract is to investigate a wide range of conceptual techniques for distinguishing abnormal or degraded safety performance in various rail car component parts. The range of concepts includes on-board vehicle and track-based systems. The purpose of these systems will be to signify, in the appropriate manner, that the operational performance of a given component is degraded to the point where replacement or repair is warranted. The present tasks include analysis and ranking of component parts which have failed and resulted in accidents; evaluation of the usefulness of various methods for detecting degraded performance in rail car component parts; and laboratory and field testing of those methods.

Small-Scale Investigation of Improved Wheels
Contract No.: FR-744-4301
Funding: $385,366
Schedule: September 1977 – June 1981
FRA Technical Contact: J.V. Mirabella
(202) 426-1227
Agency/Contractor: Illinois Institute of Technology

One major cause of train derailments has been the failure of wheels. This often results in costly damage to equipment and poses a serious threat to life, as in the case of freight trains hauling hazardous materials, or high-speed passenger trains. For example, a broken wheel derailed a freight train in Laurel, Mississippi in 1969. The train included tank cars carrying a liquefied petroleum gas. Most of these cars exploded following the derailment, igniting dwellings and buildings as well as inflicting mechanical damage. Several fatalities and over $3 million worth of damage resulted. With the current trends to greater vehicle capacity and higher speeds, the incidence of wheel failure may further increase unless remedial action is taken.

This contract involves the development of a number of design considerations which will later be combined into concepts for wheels with improved adhesion characteristics, reduced instances of derailments due to worn wheels and reduced instances of wheel failure due to causes associated with wheel wear. This will include a literature search for past and present work in the area; establishment of criteria for evaluating rail wheel improvements; development of a detailed experimental plan and the design and fabrication of model rail wheels; design, fabrication of, and evaluation of small-scale wheels employing the design features developed; development of new wheel concepts by combining design features recommended; design and fabrication of model rail wheels; test on wheels; combination and analysis of best designs and recommendations for concepts for full-scale wheels with improved characteristics. These concepts for improved wheel designs will provide performance guidelines for wheel manufacturers, railroads, and the FRA Office of Safety.

Quick Response Safety Research
Contract No.: FR-718-4261
Funding: $1,153,850
Schedule: March 1977 – December 1980
FRA Technical Contact: J.V. Mirabella
(202) 426-1227
Agency/Contractor: Arthur D. Little

The contractor developed performance specifications, safety guidelines, and testing techniques in support of the Office of Rail Safety Research. Previous outputs have included guidelines for the testing of FRA rear end marking devices and a conceptual design of a Wheel Testing Facility.

The output of this contract has been used in supporting FRA rulemaking and responding to National Transportation Safety Board recommendations.

Testing and Analysis Support
Contract No.: AR-74340
Funding: $400,000
Schedule: August 1977 – August 1980
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Army, Ballistics Research Laboratory

The tasks assigned under this contract were limited to seven specific functional areas of R&D: Experimental Planning and Design; Development of Test Procedures; Instrumentation Design/Installation; Calibration of Instrumentation/Measurement Systems; Data Acquisition, Reduction & Analysis; Testing (laboratory and field); and Feasibility Studies.

This research was beneficial for the FRA Office of Safety, the operating railroads, NTSB, Amtrak, and the railroad supply industry.

VEHICLE STRUCTURAL INTEGRITY/OCCUPANT PROTECTION PROJECT

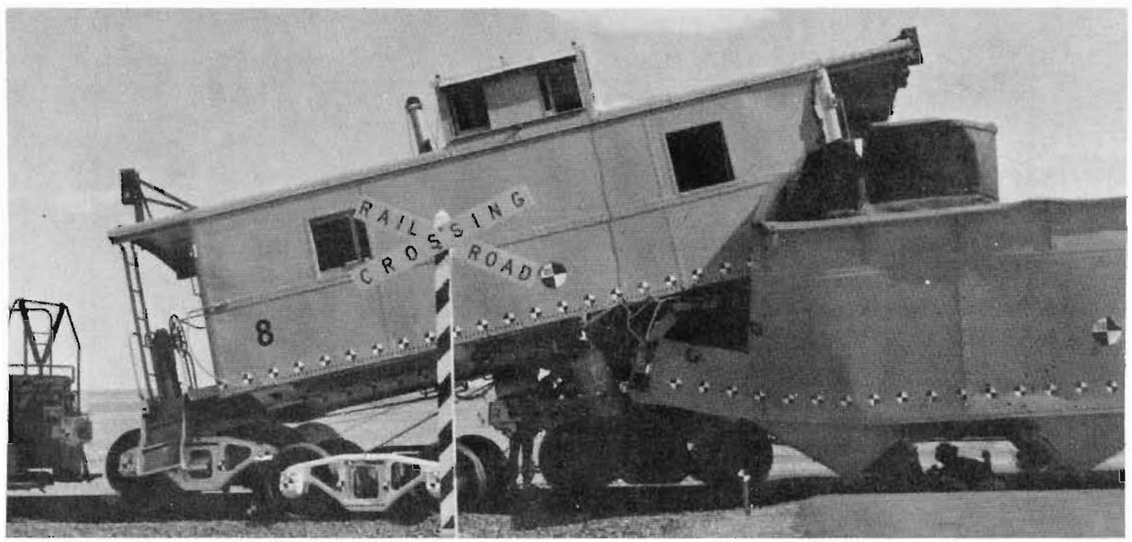
The Vehicle Structural Integrity/Occupant Protection Project was established to ensure that the high degree of safety enjoyed by railroad employees and passengers continues. In FY80, full-scale impact and fire testing was initiated on both passenger and crew rail vehicles. The purpose of the testing is to verify the small-scale testing and analytical work conducted in prior years. In addition, the research results will be used to develop guidelines for vehicle structural integrity and crashworthiness and for vehicle interior design.

Growing public awareness and concern with all areas of consumer safety, coupled with the increased use of synthetic fibers and plastics for vehicle interior components, have also prompted DOT to consider establishing fire safety standards for rail passenger vehicles. The majority of the materials used for interior applications are combustible, to a certain degree. However, a proper selection and use of interior materials can reduce the potential fire hazards to which rail passengers are exposed. The principal concern is that in the event of a fire, the source of ignition be localized, thus allowing adequate time necessary for the complete evacuation of the vehicle.

The evaluation of combustible material in terms of fire hazard is an extremely difficult problem. Sufficient data to precisely quantify the degree of hazard represented by burning interior materials does not exist. Test methods now available measure only the flammability and smoke generation of individual materials and do not explore the *total* interaction and fire behavior of materials involved in a total vehicle fire.

Significant factors which must be investigated include ignition temperature, rate of flame spread, heat transfer, etc. Moreover, the behavior of a burning material may vary in a specific situation because of the particular use and location of the material within the vehicle. Environmental conditions such as air supply, venting and turbulence should also be taken into account.

It has been recognized by the FRA that additional data is needed to provide the basis for development of reasonable fire performance requirements for interior materials. A major research effort currently underway is intended to produce this necessary data.



CRASHWORTHINESS TESTING

CONTRACTS

Fire-Flammability of Materials Used in Rail Passenger Cars
Contract No.: AR-8179
Funding: $675,000
Schedule: August 1978 — August 1982
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: U.S. Army, Ballistics Research Laboratory

Despite the enviable safety record possessed by intercity rail passenger travel, the occurrence of an onboard fire within the rail vehicle interior presents the potential threat of injury or death to passengers.

The Department of Transportation is considering the development of fire safety standards for materials used within the interior of the vehicles.

Information describing rail interior fires will be collected as well as pertinent Federal, state, and local fire prevention regulations and codes. Existing flammability test methods will be reviewed to select methods which are applicable to vehicle interior materials. Flammability of current interior materials in various categories of use will be measured using suitable fire testing methods.

A full-scale test of a typical rail passenger vehicle interior will be conducted. This test will allow the evaluation of the complete interaction between burning materials within the entire vehicle.

The output of the research effort will be used in developing fire performance requirements for materials used within rail passenger vehicle interiors.

Scale Model Support for Assessment of RR Structural Safety Options
Contract No.: TSC-8086 (Managed by the Transportation Systems Center)
Funding: $463,442
Schedule: June 1980 — June 1983
TSC Technical Contact: O. Orringer
(617) 494-2419
Agency/Contractor: Southeast Research Institute

Engineering support will be provided in the area of scale model testing for assessment of railroad structural safety options.

The efforts of the contractor are expected to support TSC in conducting rapid evaluations of the crashworthiness capabilities of the structural concepts identified by parallel studies as potentially viable options.

Locomotive Crashworthiness Safety Options Study
Contract No.: TSC-RA-7914
Funding: $825,000
Schedule: July 1979 — October 1980
TSC Technical Contact: O. Orringer
(617) 494-2419
Agency/Contractor: U.S. Army, Ballistic Research Laboratory

Support for the Railroad Crashworthiness Program was provided in this contract through the identification of locomotive characteristics, the review of design practices, impact analysis, the evaluation of existing locomotive cab structures and performance guidelines for the solution of locomotive caboose override.

RAIL VEHICLE CONTROL SYSTEMS PROJECT

The objective of the Rail Vehicle Control Systems Project is the reduction in frequency and severity of railroad accidents caused by control systems and procedure failure. Research efforts are concentrated in the areas of railroad signals, communications, and control systems.

The safe and efficient movement of hundreds of freight and passenger trains daily is dependent on the correct functioning of signals along the railroad right-of-way and constant communication between the train crew and dispatcher control points.

Although all signal and communications failures cannot be realistically eliminated, FRA is developing a safety research and development plan to identify areas in which potential changes in equipment or procedures could contribute to an improved level of safety.

Development of Safety Research and Development Plan for Railroad Signals, Communications and Control Systems
Contract No.: FR-9025
Funding: $49,978
Schedule: February 1979 – March 1980
FRA Technical Contact: J. Mould
(202) 426-1682
Agency/Contractor: OAO Corporation

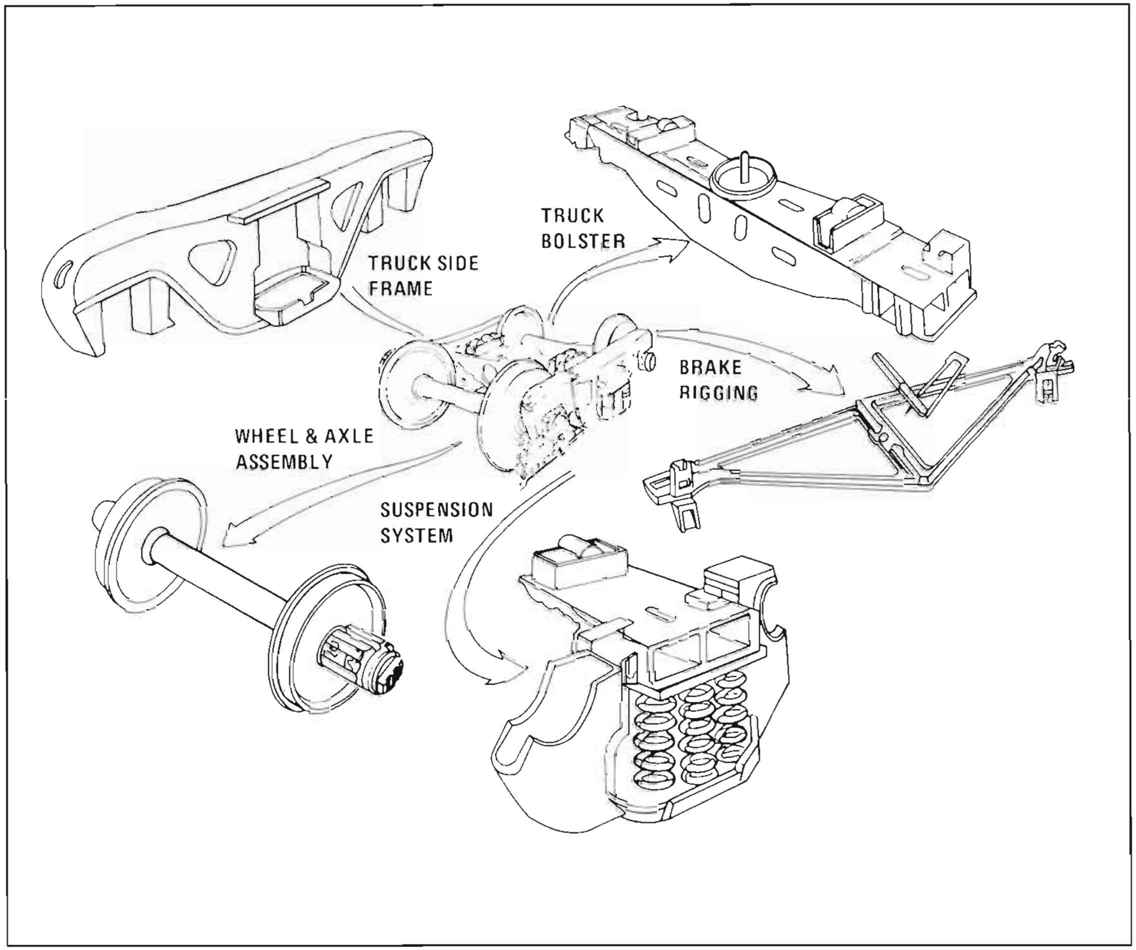
The safe and efficient operation of freight train movements within the limited range of a railroad yard or across the entire country is dependent on the correct functioning of track and vehicle signal control and communications system and procedures. The results of the work undertaken for this contract were intended to serve as the basis for the development of a research and development program plan which contributes to safer operations and reduces the probability of human injury and/or property damage.

The outputs are the identification of hazardous conditions which can develop and possibly result in accidents and the identification and evaluation of specific remedies to counteract each type of failure.

TRUCK DESIGN OPTIMIZATION PROJECT

As the major component between the lading and the track, the freight car truck performs the essential functions of guidance, support, and vibration absorption to the freight car. In performing these functions in a dynamic environment, the standard three-piece truck has performed remarkably well since its introduction in the early 1900's. However, increasing demands on the rail transportation system, in the form of heavier car weight, higher center of gravity, and increasing speed, coupled with deteriorating maintenance of equipment and track, have indicated that improvements to the standard truck are required.

In response to the need of the rail industry for a better freight car truck design, the FRA is sponsoring a broad-based research program: the Truck Design Optimization Project (TDOP). Its purpose is to characterize the behavior of existing trucks and to generate performance and test specifications for new truck designs. Using quantitative performance indices defined by operational and economic information, these specifications will not only provide the technical base for design innovation, but also facilitate its easy correlation with the cost of such design improvements.



ASSESSMENT OF TRUCK DESIGN CHARACTERISTICS

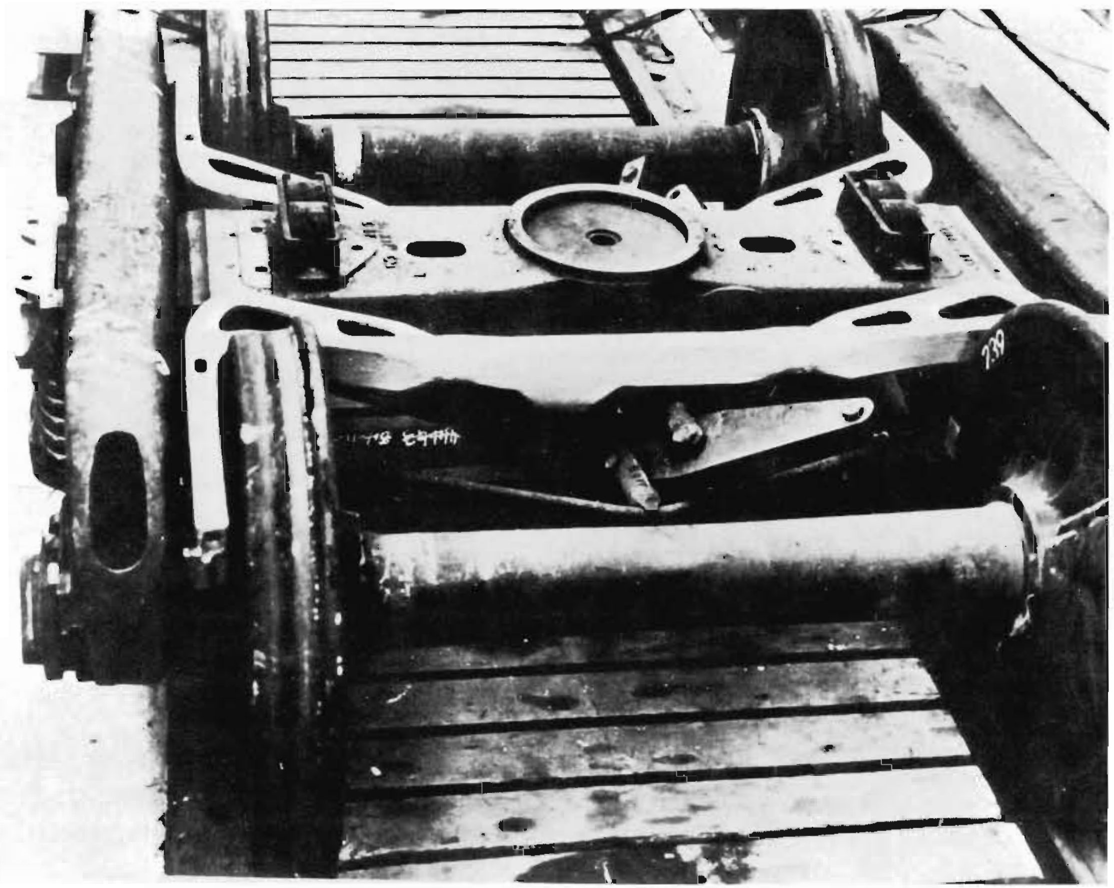
Phase I of the TDOP was a study of the Type I, general purpose, three-piece truck. The standard, three-piece freight car truck, or its modified versions with basically similar configurations, is defined in TDOP as the "Type I" truck. The "improved" or Type II truck is defined as a truck whose design features bring about functional differences in truck and carbody behavior. In the context of TDOP, the main restriction placed on a Type II truck is that it preserve coupler height, but the method of mounting the wheelsets on the frame and of supporting the carbody are not specified. In Phase I, two standard, three-piece trucks (the American Steel Foundries' Ride Control truck, and the Standard Car Truck Company's Barber S-2 truck) were tested under 70- and 100-ton carbodies. The data from Phase I constitute the main basis for characterizing the performance of the Type I truck.

The TDOP project is now in Phase II, having as its objectives:

- Defining the performance of both Type I and Type II trucks in quantitative terms, represented by performance indices;
- Establishing a plan to collect economic data on the cost of acquiring, operating, and maintaining the standard, Type I truck;
- Determining a quantitative basis to evaluate the economic benefits to be derived from Type II trucks; and
- Generating performance characterizations for Type I trucks and performance and test specifications for Type II trucks.

These objectives are being met through several approaches that include:

- Road testing several Type I and Type II trucks;
- Mathematical modeling of freight car trucks to augment and complement the comparison of test results;
- Determination of wear of Type I and Type II trucks in unit train service over an extended period of time;
- Collection of economic data on truck maintenance and operation, and correlation of such data with information on truck performance; and
- Engineering interpretation including effect on performance of eventual wear and deterioration of truck components.



DRESSER DR-1 RADIAL TRUCK (TYPE II TRUCK EXAMPLE)

Most of these are concurrent activities, for example: developing and refining a methodology; field testing of the trucks; economic data collection and analysis; and assessment, validation, and use of computer models. Those activities will soon culminate in the establishment of a Type I truck performance characterization document. A Type II performance specification, a test specification for Type I and II trucks, a cost/benefit analysis, and a final report will be produced at the conclusion of the project.

In order to accomplish TDOP goals, a project methodology was established in which key terms have been defined in order to develop performance characterizations and performance specifications for the Type I and Type II trucks, respectively. Secondly, the methodology shows how testing, data acquisition/reduction, computer modeling, and engineering analysis will be used to develop the performance characterization/specifications.

In addition, the truck performance must be defined with respect to the truck's operating conditions. These conditions may differ considerably from one railroad to another. For example, a railroad operating primarily in mountainous territory at relatively low speeds may be concerned with reducing wear of wheels and rails in curves. On the other hand, a railroad operating in flat terrain at high speeds will require that its trucks have high lateral stability. Railroads handling fragile cargo may be concerned with the ride quality aspect of performance. Safety and stability of the vehicle system, e.g., harmonic roll, is the concern of all operators.

A useful characterization of truck performance thus requires the identification of specific performance regimes which may be defined as sets of conditions associated with predominant features that distinguish one regime from another. Besides being distinct and non-overlapping, the set of performance regimes should be inclusive, i.e., identify all aspects of truck behavior.

In order to make possible the quantitative evaluation of truck performance, both absolute and comparative, each performmance regime must be associated with performance indices, by which is meant measurable quantities typical of that regime. Examples are critical speed of hunting, lateral wheel load in curves, and minimum dynamic vertical wheel load.

Common terms used in the TDOP are defined below.

Lateral Stability (Hunting)

Hunting is a self-excited lateral and yaw oscillation of the truck and carbody that occurs above a certain speed (the "critical speed").

Curve Negotiation

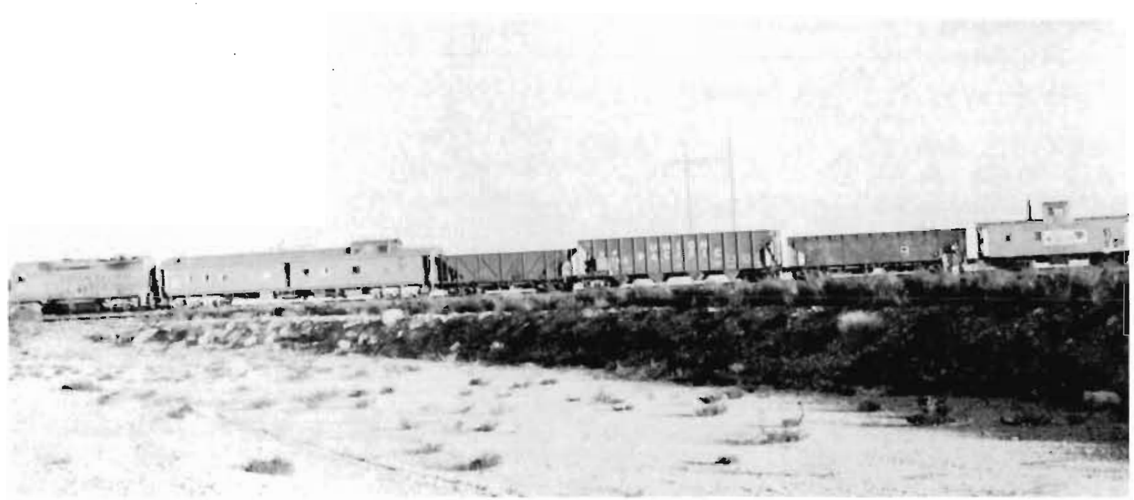
The ability of a freight car truck to negotiate a curve with minimum resistance is treated in this regime.

Trackability

Trackability refers to the ability of the truck to maintain an adequate load on all four wheels under a range of track conditions, and the dynamics of the vehicle resulting from transient or periodic changes on these conditions.

Ride Quality

Ride quality denotes a standard of performance rather than a performance regime. It is generally taken to refer to the acceleration environment in the carbody and thus reflects the capability of the truck to isolate the carbody from track irregularities.



TRUCK DESIGN TESTING ON UNION PACIFIC RAILROAD WITH DIFFERENT TRUCKS

CONTRACTS

Truck Design Optimization Project (TDOP), Phase II
Contract No.: DOT-FR-742-4277
Funding: $4,006,244
Schedule: September 1977 — March 1981
FRA Technical Contact: N. Tsai
(202) 426-0855
Agency/Contractor: Wyle Laboratories

Wyle Laboratories is conducting a study for the FRA in response to the need of the rail industry for a better freight car truck design.

The objectives of this study are to:

1) Provide a truck evaluation methodology, including benefit/cost analysis;
2) Characterize the dynamic and wear behavior of existing trucks; and
3) Develop performance and test specifications of new freight car trucks.

To achieve the aforesaid objectives, TDOP is conducting engineering analysis, field testing and economic data collection and analysis for both existing and seven improved truck designs. The first two objectives have been completed. The performance specification of the new truck designs will be prepared upon the completion of the performance and wear testing programs.

The outputs of this project are the technical reports on truck characterization and an economic-based performance specification. To inform the users of these reports, TDOP has conducted four industry-wide in-progress review meetings where reports of project progress were discussed.

TRUCK DESIGN OPTIMIZATION PROJECT

OBJECTIVE

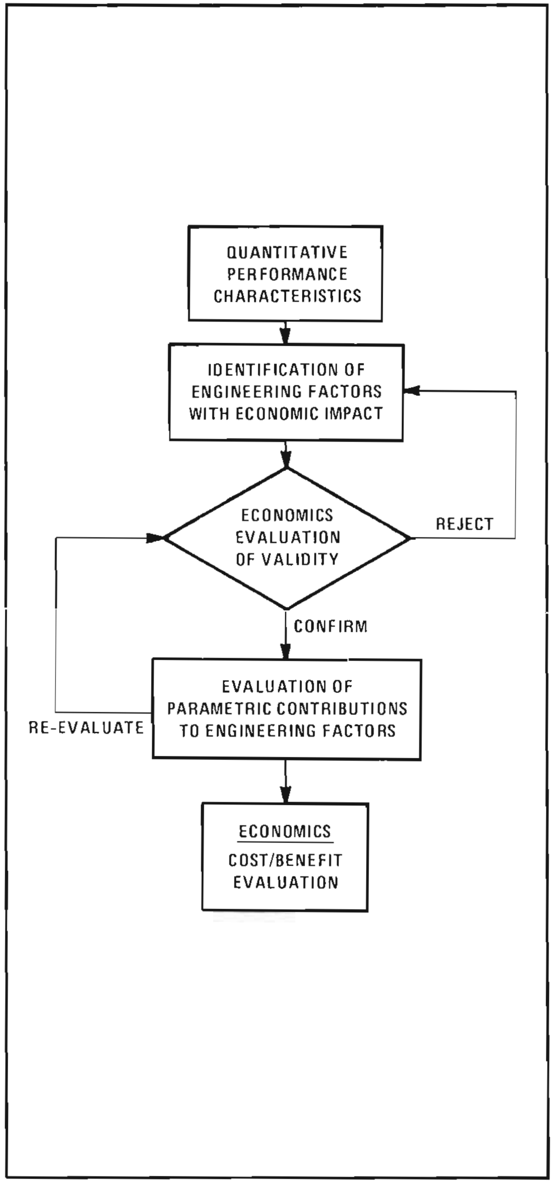
- IMPROVE FREIGHT CAR TRUCK PERFORMANCE THROUGH THE DEVELOPMENT OF SYSTEM-TYPE SPECIFICATIONS THAT INCLUDE ENGINEERING, ECONOMIC AND OPERATIONAL CONSIDERATIONS

APPROACH

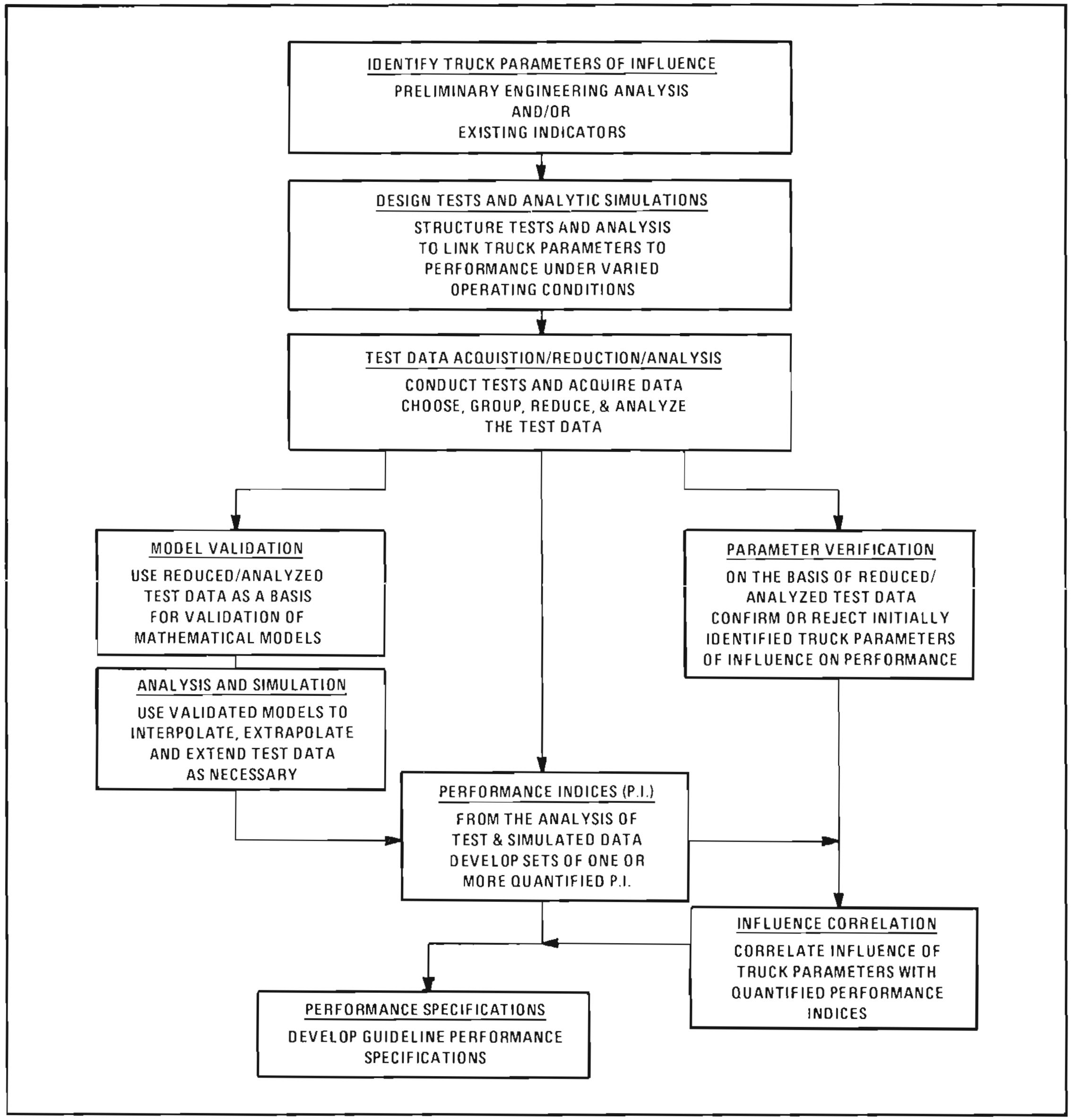
- MULTI-PHASE PROGRAM
- CHARACTERIZATION OF GENERAL PURPOSE AND SPECIAL SERVICE TRUCKS THROUGH TESTING AND ANALYSIS
- ECONOMIC ASSESSMENT AND ESTABLISHMENT OF METHODOLOGY FOR DETERMINING TRUCK COSTS AS RELATED TO TECHNICAL PERFORMANCE INDICES
- DEVELOPMENT OF MATHEMATICAL MODELS FOR INDUSTRY USE AND DATA ANALYSIS
- DEVELOPMENT OF PERFORMANCE AND TESTING SPECIFICATIONS
- INDUSTRY PARTICIPATION TO INSURE IMPLEMENTATION OF RESULTS

PAYOFFS

- HIGHER LEVEL OF IN-SERVICE PERFORMANCE
- EQUIPMENT THAT IS LESS COSTLY TO PROCURE, OPERATE AND MAINTAIN
- DECREASED LADING DAMAGE
- MORE PROFITABLE OPERATION



ENGINEERING/ECONOMICS INTERFACE



METHODOLOGY FOR TRUCK EVALUATION

BRAKING PERFORMANCE PROJECT

The objective of the Braking Performance Project is to investigate the total behavior of a freight train brake system in order to develop performance guidelines to support Freight Car Safety Standards.

The primary tool for the safe control of train operation is the brake system, which is responsible for controlling both the speed of the train as well as the dynamic forces within the train. Brake action also has a pronounced effect on wheels and the dynamics of the wheel/rail interface.

Freight trains have an automatic brake system which is a pneumatic control system with a dual-purpose brake pipe supplying power to the brake valves and transmitting commands to the brake valves on individual cars. Brake valves must correctly interpret pressure signals transmitted by the brake pipe. Difficulties occur due to leakages existing throughout the length of the train. Furthermore, faulty brake applications occur, resulting in casualties, derailments, and equipment damage.

While the train air brake system has achieved maturity of design, it has yet to gain from the technical understanding we have today. The National Transportation Safety Board (NTSB) has expressed the need for brake system research in the area of brake shoe composition, forces, and environmental variations. In addition, the FRA Office of Safety has requested that the Office of Rail Safety Research provide a basis for the development of brake system performance standards by considering such components as propagation of air, valve operation, rigging efficiency, brake shoe variations, and environmental considerations.

Eight tasks have been identified for research in order to achieve precise understanding of the train air brake system for improvement of train safety:

Task 1 – Assessment of Safety Benefits for Implementation. Analyze accidents that might have been avoided by achieving shorter stopping distances and identify human errors.

Task 2 – Fluid Mechanical Analysis. Analyze pressure/flow characteristics for a comprehensive picture of the brake pipe.

Task 3 – Leakage Detection/Location. Develop procedures to locate concentrated leakage in the brake pipe.

Task 4 – Brake Rigging Efficiency. Design and perform a series of experiments to determine dynamic brake rigging efficiency.

Task 5 – Net Braking Ratio. Analyze relationship of variations in Net Braking Ratio as related to in-train forces and their potential to cause accidents.

Task 6 – Brake Shoe Materials. Review brake shoes in current use to provide inherent characteristics and associated problems of each; also, assess brake shoe materials with reference to life and safety of commonly used wheel and evaluate safety implications of off-tread braking.

Task 7 – Environmental Considerations. Examine the cumulative effects of prolonged temperature extremes and prolonged application (e.g., snow brake, drag brake).

Task 8 – Brake Performance Standards. Develop a set of criteria for performance requirements of train brake systems.

CONTRACTS

Freight Train Brake Systems Safety/Study A
Contract No.: DTFR53-80-C-00088
Funding: $181,512
Schedule: June 1980 – June 1983
FRA Technical Contact: D.A. Vaugh
(202) 426-1227
Agency/Contractor: Illinois Institute of Technology Research Institute

The objectives of this contract are to develop concepts for improved stopping distances for freight trains, to study effect of irregular car brake forces on in-train forces, and to evaluate brake shoe characteristics and the effect of shoes on wheel life.

An assessment of the safety benefits that would accrue by achieving shorter stopping distances will be done. Brake rigging efficiencies will be measured. Data developed under other contracts will be used to assess the inherent characteristics and associated problems of each type of brake shoe.

The results and recommendations of the study will be used for subsequent work to develop braking systems performance guidelines in support of Freight Car Power Brake Regulations.

Freight Train Brake Systems Safety/Study B
Contract No.: DTFR53-80-C-00103
Funding: $238,205
Schedule: July 1980 – July 1983
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: Bolt, Beranek and Newman, Inc.

The objectives of this contract are to formulate characterization of brake pipe air flow, to develop comprehensive computer models of the air brake system to be used as a tool to address outstanding NTSB brake questions, and to develop brake shoe data to be used in brake shoe evaluations.

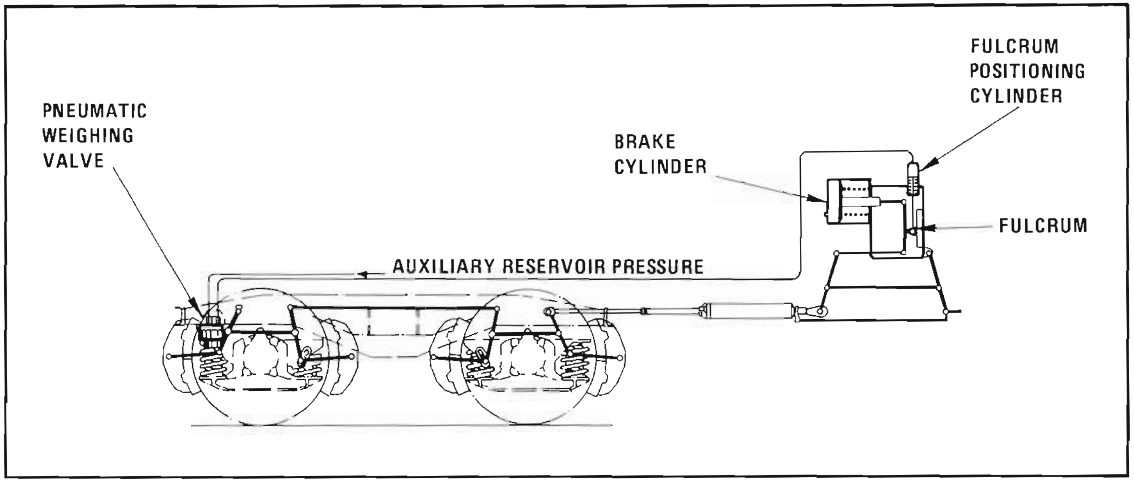
The air flow through the brake pipe will be analyzed mathematically to determine pressure/flow characteristics. Tests of a simulated freight train brake pipe will be conducted. Brake shoes will be tested on a dynamometer to determine the coefficient of friction under environmental conditions.

The outputs of this contract will include train brake testing techniques to assure adequate brake force, and recommendations concerning brake shoe operation in various environments.

COUPLING AND BRAKING SYSTEMS OPTIMIZATION PROJECT

Whether an advanced railroad component or system is suitable for implementation, development, or research depends on whether it shows sufficient promise to be cost-effective. Determining this involves a multi-stage process. First, a realistic assessment must be made of the future stream of anticipated costs and benefits. Costs are usually assessed in terms of monetary outlays, but benefits will tend to appear as reduced time for crews to perform certain functions, greater safety of operation, or extended component life times. To facilitate a comparison of costs and benefits, these factors must all be reduced to the same financial basis. However, these costs and benefits occur unevenly over time (costs invariably precede benefits) and must also be reduced to common terms through a net present value technique to discount future cash flows. Once this has been done, costs and benefits can be compared as a ratio which provides a measure of the attractiveness of a particular candidate system.

The Coupling and Braking Systems Optimization Project was initiated to develop systems that will improve railroad efficiency, productivity and, concomitantly, profitability. Emphasis is therefore placed on evaluating, strictly in monetary terms, the costs and benefits of a broad range of possible systems. Underlying much of the study is the recognition that recent advances in electronics, communication, and control technologies could be applied to braking and coupling systems with dramatically beneficial results. Indeed, combined benefits on the order of a billion dollars a year may ultimately be realized.



SCHEMATIC DIAGRAM OF A LOAD-PROPORTIONAL BRAKING SYSTEM

The purpose of this project is to determine a future course of R&D for railroad braking and coupling systems. The systems investigated in this study are classified as mechanical or electrical and according to whether their principal function is to improve operating efficiencies (mainly in yards) or the dynamics of train performance (mainly over the road).

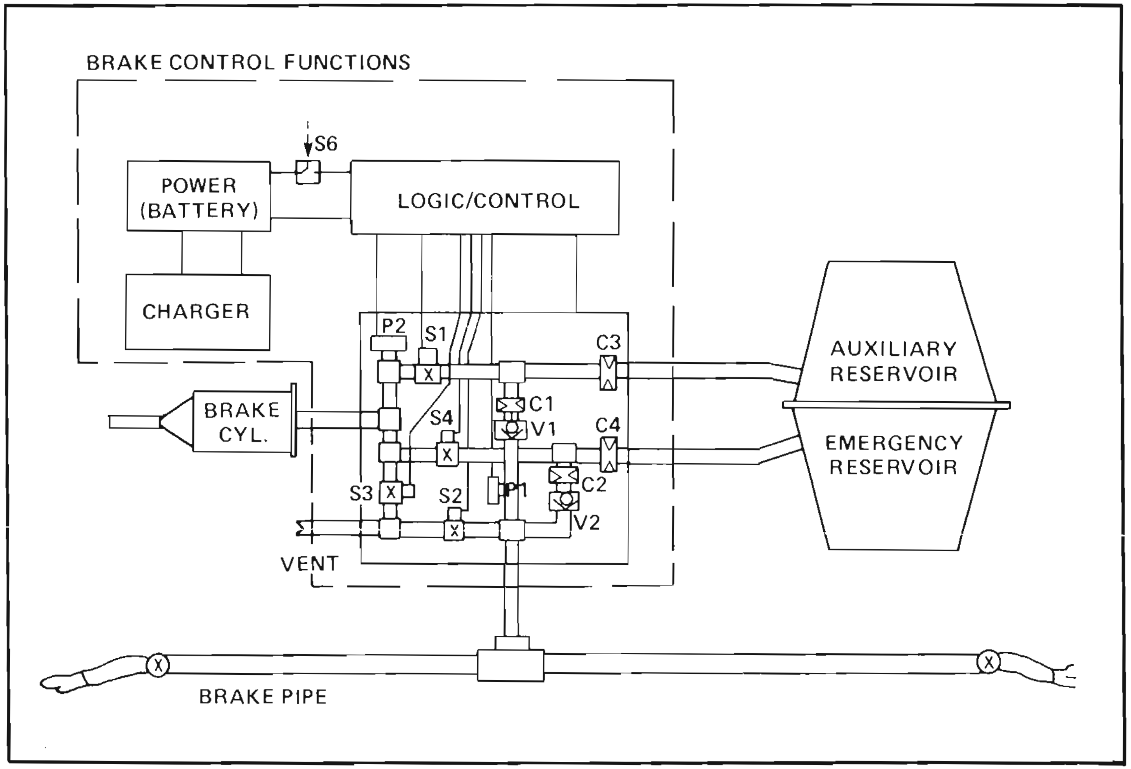
The methodology for evaluating the costs and benefits of each system involves estimation of incremental equipment costs per car, and the estimation of maximum allowable costs per car. Financial analysis of these estimates is based on a specified implementation scenario in which the future stream of costs and benefits is to be realized, and on such financial parameters as discount rate, depreciation schedule, and tax rate.

The resulting cost/benefit figure of merit is expressed as the ratio of the estimated cost to the allowable cost. When this ratio is less than unity, it indicates that the system is favorable; when it is greater than unity, the return on investment is insufficient to justify its cost.

The results of this study lead to several important conclusions. Of the nine mechanical systems evaluated, only wide-range couplers and high strength knuckles appear promising. The coupler could have a particularly large impact, primarily because it speeds the assembly of trains in classification yards.

Most of the electrical systems show promise of substantial financial benefits. The connectors and wiring are the framework upon which other systems are to be built. Remote-controlled couplers are very attractive if their implementation is accompanied by a crew-size reduction of one member. Remote-controlled brake locks replace the use of hand brakes in many situations and can result in significant annual savings. The ultrasonic brake control system, applied to cars requiring special handling (about 5 percent of the fleet) can save significant classification time and an undetermined amount of loading damage. The train condition monitor, by speeding the power brake test, could potentially save considerable amounts of expenditure in labor and equipment utilization.

Of the remaining electrical systems (those designed to improve dynamics), only the electronic brake system shows much potential. It can probably be made for less cost than the conventional pneumatic system. Even at $120 per car set, electronic load sensors do not appear ready for fleetwide use, but may be appropriate for cars with unusually high gross/tare weight ratios.



HYBRID ELECTRONEUMATIC BRAKING SYSTEM SHOWING DETAILS OF THE ELECTROPNEUMATIC SWITCHING SUBSYSTEM

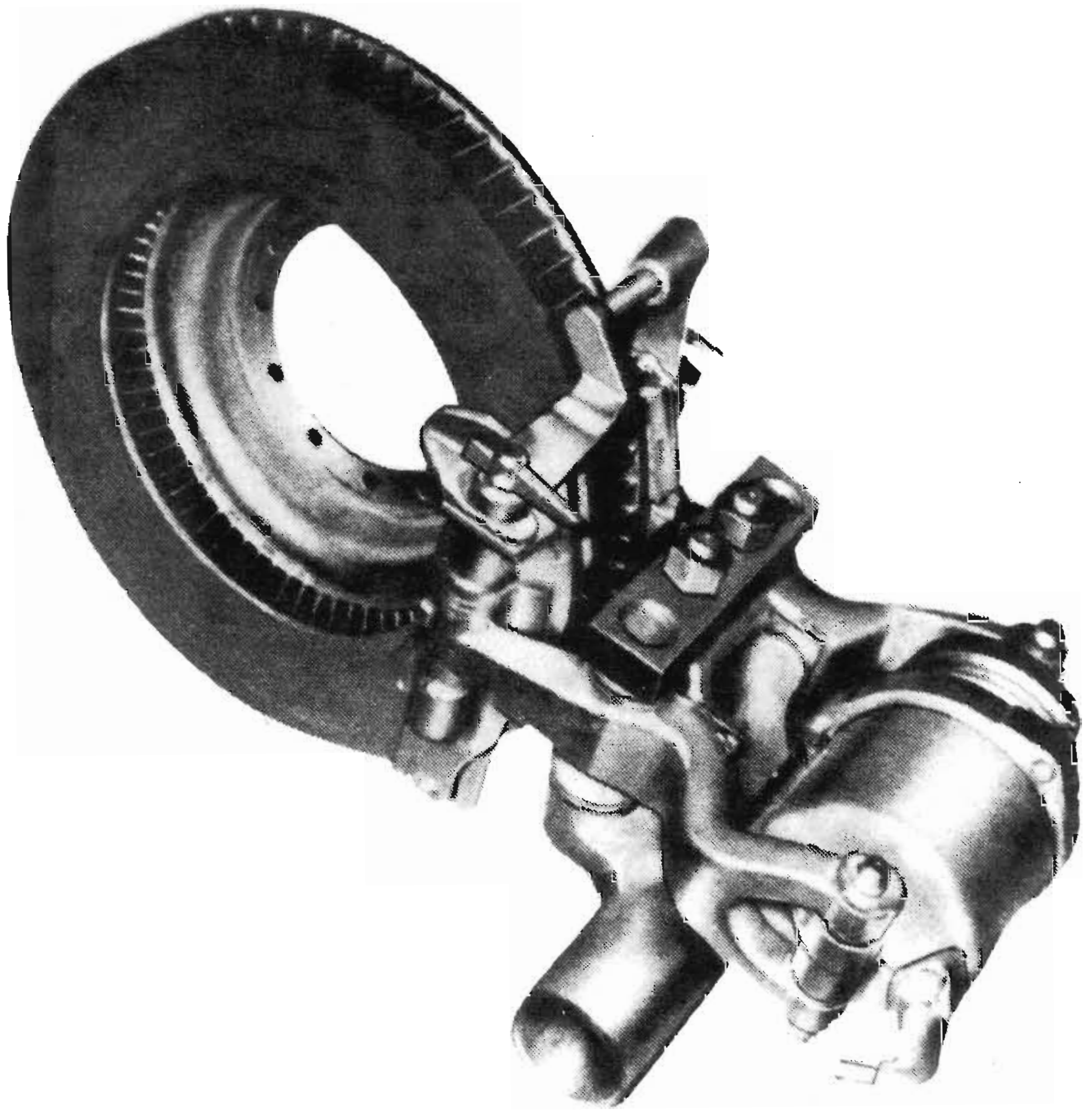
CONTRACTS

Braking and Coupling Systems Design Optimization – System Engineering
Contract No.: DOT-FR-8091
Funding: $291,782
Schedule: August 1978 – March 1981
FRA Technical Contact: N. Tsai
(202) 426-0855
Agency/Contractor: Bolt, Beranek and Newman, Inc.

The objectives of this contract are to assess the likelihood that advanced braking and coupling systems will ultimately be incorporated by the railroad industry and to develop recommendations for further research in the most promising areas for improvement in contemporary systems.

A cost/benefit analysis methodology and data base will be developed to evaluate existing and innovative concepts. As a result of this evaluation, systems for further development will be recommended, and a plan for implementing an R&D program will be developed.

Sixteen advanced railroad braking and coupling systems have been evaluated in terms of costs and benefits. Most of the benefits result from improved classification yard efficiencies, with secondary benefits accruing through reduced accident rates, road delays, and maintenance related to component wear and failure. The most promising systems are couplers with wide gathering ranges, a brake condition monitoring system, and a remote-controlled brake locking system. In addition, ultrasonic brake control on cars presently requiring special handling and direct electronic brake control all show promise of improving railroad productivity.



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The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

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CHAPTER 2
IMPROVED TRACK STRUCTURES

The Improved Track Structures subprogram is designed to reduce track-related accidents on existing structures and to improve the performance of track systems by increasing track life and developing better maintenance practices.

The underlying challenge of track research activities is to develop a level of understanding and knowledge base which can lead to the development of improved track structures that can safely tolerate longer periods of heavier utilization before requiring costly maintenance.

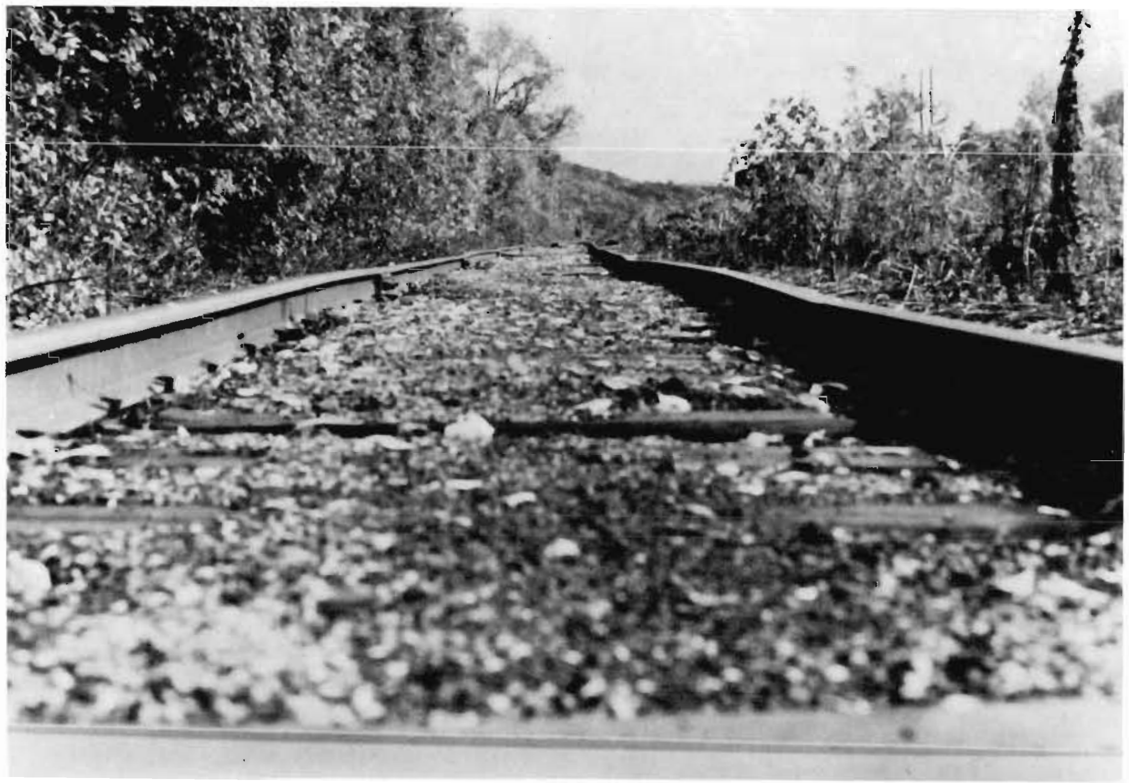
To date, the major accomplishments of the Federal Railroad Administration's Improved Track Structures subprogram have been in the areas of:

1) Analyzing service loads and rail capacity;
2) Understanding rail failure behavior; and
3) Identifying critical vehicle/track interaction processes.

The six projects included in the Improved Track Structures subprogram are:

1) Track Standards Development;
2) Track System Safety Studies;
3) SAFE Development Support;
4) Track Performance and Safe Life;
5) Performance Standards Maintenance Requirements; and
6) MOW Equipment and Techniques Evaluation.

Each project is carried out by the Federal Railroad Administration (FRA) through contracts with private and Federal research organizations. Descriptions of each project area, supporting contracts and a bibliography of published reports follow.



TRACK STANDARDS DEVELOPMENT PROJECT

In order to minimize the potential threat to public safety and reduce the costs of track and equipment damage resulting from derailments and other accidents, the FRA has initiated the Track Standards Development project.

In 1972 and 1973, the FRA established specific classifications for the various kinds of track within the national rail network. These classifications were based on industry maintenance standards. As a result, the track requirements were written, to a large extent, in design language.

The current Track Standards Development project was established to develop performance-based track safety standards reflecting what the track needs to do rather than what the track should look like. The thrust of the standards development research is therefore directed at quantifying the demands of train operations and defining the lower bounds on tolerable track functions. The potential for safety improvement resulting from these performance standards is significant and would allow the rail industry more flexibility in meeting safety requirements. The key aspect of functional performance standards is their direct derivation from the essential elements of the mechanics of track structural and vehicle-track interaction dynamics. Each major mode of track-caused derailment can be related to one of the principal proposed performance standards of functional track specifications.

The four major areas for these performance standard applications are 1) rail integrity, 2) rail vehicle dynamics, 3) rail restraint, and 4) track panel restraint. Work on these areas is progressing at this time. Research underway for the rail integrity standard emphasizes the development of techniques and strategies for preventing rail service failures. The basic approach of the rail/vehicle dynamics

TYPICAL THERMALLY-INDUCED LATERAL TRACK SHIFT (BUCKLE) standard development is to view the interaction of rail vehicles and track as a dynamic system. Safe limits of this dynamic interactive system are being formulated in terms of track deflection under load, track geometry and the speed-affected response of certain car types. The emphasis of the rail restraint performance standard development is the evaluation of the structural capacity required of the track to reliably and safely restrain the service loads which train operations produce. Track panel restraint research is addressing the ability of the rail/tie system to be held in place by the ballast when the track is subjected to thermally-induced longitudinal forces and to train loads.

A spectrum of research will be used to ensure that the proposed standards are on a technically sound basis and that the intended users are convinced of their validity and effectiveness. The requirements for each standard are being established through an analysis of both the failure mechanism associated with each major cause of derailment as well as the degree to which the failure mode is identifiable in current FRA railroad accidents/incident reports for the last 3 years. Emphasis on standards, in general, parallels the rank order of these causes, first by number of reported accidents and secondly by damage potential.

CONTRACTS

Analysis of Service Stresses in Rail
Contract No.: TSC-1663 (Managed by the Transportation Systems Center)
Funding: $326,819
Schedule: March 1979 – November 1980
TSC Technical Contact: O. Orringer (617)494-2419
Agency/Contractor: Battelle Memorial Institute

Track failure, due to rail fatigue or other rail defects, has caused a significant number of freight train derailments. The purpose of this contract was, therefore, to provide data on rail stress cycles necessary to compute the growth behavior of rail defects in service in order to prevent such failure. An evaluation of the sensitivity of flaw growth behavior, under varying load support conditions and rail properties, was conducted.

The results of this research will be used in formulating the Rail Integrity Standard.

Rail System Dynamics Parametric Study
Contract No.: TSC-1302 (Managed by the Transportation Systems Center)
Funding: $804,840
Schedule: December 1976 – January 1981
TSC Technical Contract: H. Weinstock (617) 494-2459
Agency/Contractor: Analytic Sciences Corp.

The dynamic interaction between a locomotive or rail car and the track can cause the derailment of a train. The main objective of this research effort was to gain a clear understanding of track/train dynamics which will permit the development of track and vehicle response specifications relating to different levels of track geometry and quality, and vehicle speed. Another desired output was the identification of track pertubation limits to avoid service-related track, vehicle and lading damage.

Track geometry variations were investigated to determine their effects on vehicle safety, wear, levels of riding comfort, and damage to vehicle components, track, and lading.

Track Structural Testing
Contract No.: TSC-1541 (Managed by the Transportation Systems Center)
Funding: $316,190
Schedule: January 1979 – May 1981
TSC Technical Contact: J. Herlihy (617) 494-2579
Agency/Contractor: Association of American Railroads (AAR)

A test program is required to evaluate the structural capacity required of the track to reliably and safely restrain the service loads which train operations produce.

The controlled-environment facilities of the AAR Track Laboratory are being utilized to investigate the mechanics of track lateral and vertical restraint and rail restraint.

Evaluation of Factors Influencing Rail Load Capacity
Contract No.: TSC-1575 (Managed by the Transportation Systems Center)
Funding: $55,370
Schedule: July 1978 – September 1980
TSC Technical Contact: D. McConnell (617) 494-2596
Agency/Contractor: Tufts College

The formulation of a clear relationship of rail defect initiation to the track environment is necessary for the success of rail and track restraint tests. This contract was designed to provide an evaluation of structural loading trade-offs to determine the load capacities of track. A pilot fatigue-based evaluation of rail life was included.

Track/Vehicle Systems Structure Support
Contract No.: TSC-80110 (Managed by the Transportation Systems Center)
Funding: $485,003
Schedule: June 1980 – June 1982
TSC Technical Contact: A. Kish (617) 494-2649
Agency/Contractor: Battelle Memorial Institute, Inc.

This contract will provide short-notice response to the demand for engineering support services in the areas of quantification of service environment, analysis of track/vehicle system and components, experimental validation and feasibility assessment.

Track Structures Metallurgy Support
Contract No.: TSC-1708 (Managed by the Transportation Systems Center)
Funding: $420,056
Schedule: May 1979 – June 1982
TSC Technical Contact: O. Orringer (617) 494-2419
Agency/Contractor: Battelle Memorial Institute, Inc.

The objectives are to: 1) establish, by use of metallurgical analyses, the characteristics of selected metallic track components which influence safety and serviceability; 2) using fatigue damage criteria and concepts of cumulative damage, make life predictions of track components under service environments considering both the initiation and growth, and based on these, conceive of one or more effective inspection rationales; and 3) design and implement experiments and/or studies related to material behavioral characteristics (and analyze data therefrom) generating information supporting improved track component safety and serviceability.

Vehicle Derailment Studies
Contract No.: TSC-8062 (Managed by the Transportation Systems Center)
Funding: $488,123
Schedule: May 1980 – April 1982
TSC Technical Contact: H. Weinstock (617) 494-2459
Agency/Contractor: The Analytic Sciences Corp.

Engineering support will be provided in the areas of car component characterization, track geometry and structure characterization, computer simulation of rail/car dynamic response characteristics, and analysis and simulation of track/train dynamic interaction.

Fabrication of a Track Strength Measuring Vehicle
Contract No.: FR-30051
Funding: $627,259
Schedule: June 1973 – February 1983
FRA Technical Contact: W. O'Sullivan (202) 426-4377
Agency/Contractor: Battelle Columbus Laboratories

Originally, the effort supported by this contract was intended to develop equipment capable of continuously measuring the dynamic mechanical impedance of the track structure. This proved to be an extraordinarily difficult technical task, a fact now recognized in the U.S. and abroad. While FRA and the contractor were wrestling with impedance measurement system design problems, it became apparent that very useful information could be obtained by investigating the gross strength properties of the track structure, rather than dwelling on frequency-related track evaluation. After observing preliminary, confirmatory tests, the thrust of the effort was re-directed toward obtaining a vehicle-borne system that will assess the lateral and vertical strength characteristics of railroad track at speeds of up to 50 mph.

Track Structure Failure Studies
Contract No.: TSC-1595 (Managed by the Transportation Systems Center)
Funding: $604,760
Schedule: September 1978 – September 1980
TSC Technical Contract: D. McConnell (617) 494-2596
Agency/Contractor: Battelle Memorial Institute

The contractor was responsible for providing quick-reaction, rapid turn-around investigations of specific problems in track safety and performance.

Longitudinal Rail Force Measurement
Contract No.: DTFR53-80-C-00043
Funding: $66,000
Schedule: February 1980 – August 1981
FRA Technical Contact: W. O'Sullivan (202) 426-4377
Agency/Contractor: National Academy of Sciences (National Materials Advisory Board)

Measurement of track strength includes an evaluation of the imminence of lateral track buckling or the probability of rails pulling apart at welds or other junctures. Buckling is generally associated with warm temperatures and wheel/rail interaction particularly related to uni-directional traffic. Conversely, pull-aparts usually occur in cold weather. Both effects involve longitudinal rail force, either compressive or tensile. No means exist today to conveniently measure the absolute longitudinal force level in the rails at a location of interest.

At the request of FRA, the National Materials Advisory Board assembled a panel of experts familiar with the various techniques for non-destructively assessing stress levels in metals. From the continued deliberations of this panel will come recommendations that can guide future FRA development of one or more techniques specifically applicable to railroad environment use.

Track Buckling Test Support
Contract No.: TSC-8076 (Managed by the Transportation Systems Center)
Funding: $35,195
Schedule: May 1980 – March 1981
TSC Technical Contact: A. Kish (617) 494-2649
Agency/Contractor: Southern Railway Co.

The necessary field support will be provided to implement the track buckling tests designed to develop the relationship between buckling load and safe temperature increase.

Track Structure Failure Studies
Contract No.: TSC-1596 (Managed by the Transportation Systems Center)
Funding: $399,025
Schedule: September 1978 – September 1980
TSC Technical Contact: D. McConnell (617) 494-2596
Agency/Contractor: Foster-Miller Associates, Inc.

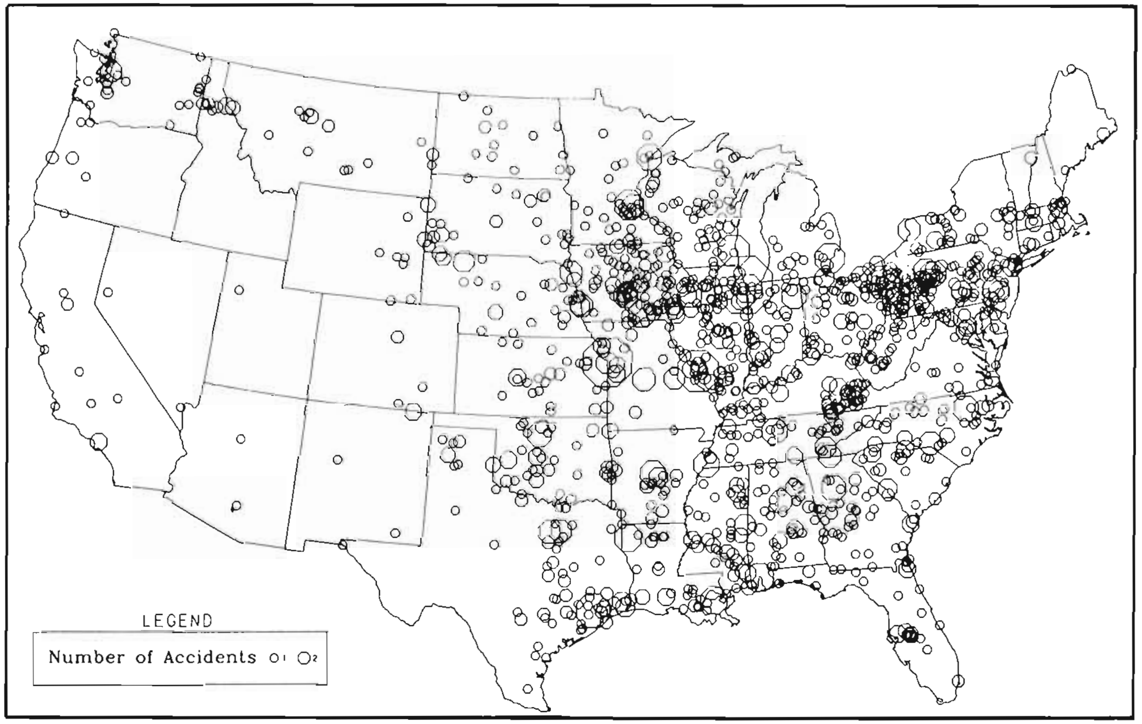
The contractor was responsible for providing quick-reaction, rapid turn-around investigations of specific problems in track safety and performance.

The railroad industry and FRA have shown strong, sustained interest in the development of track performance rather than design standards. The present effort will produce equipment, the use of which can establish procedural guidelines for determining one aspect of track performance: the ability to contain applied wheel loads.

TRACK SYSTEM SAFETY STUDIES PROJECT

The Federal Railroad Administration (FRA) is completing the research needed to create new track standards for use by the railroad industry based on performance requirements rather than physical design specifications. One aspect of this research is to provide the ability to assess the impact on the rail industry of implementing these standards and/or other Federal government policy options concerning track and inspection requirements.

The results of the research effort will be the development of an analytical capability to assess industry impact, a requisite data base and the understanding of industry decision processes in determining maintenance-of-way expenditures.



RAIL ACCIDENTS DUE TO TRACK GEOMETRY – 1978

CONTRACTS

Development of Systems Dynamic Model of Railroad Industry
Contract No.: TSC-1561 (Managed by the Transportation Systems Center)
Funding: $113,849
Schedule: June 1978 – September 1980
TSC Technical Contact: R. Smith (617) 494-2155
Agency/Contractor: Pugh-Roberts Associates, Inc.

Many railroad systems are finding it extremely difficult to maintain track to government and industry standards or correct year-to-year wear resulting from freight traffic.

A computer simulation model has been developed to assist in understanding the broad range of influences on track wear and maintenance costs. Factors considered include freight volume, revenues, numerous categories of expenses, operating practices, and the various government policies which affect all of them.

An improved understanding of the nature and influences of the interaction between railroad track maintenance and the safety, operational, and financial characteristics of national freight service will result.

Analysis of Railroad Maintenance-of-Way Expenditures
Contract No.: TSC-1675 (Managed by the Transportation Systems Center)
Funding: $85,098
Schedule: April 1979 – January 1981
TSC Technical Contact: M. Hollyer (617) 494-2599
Agency/Contractor: Pennsylvania State University

Current track safety standards, implemented in 1973, set forth minimum safety requirements for specific track conditions. The effectiveness of these standards in reducing track-related accidents was examined in terms of the selection of operating speeds and maintenance-of-way (MOW) costs. The decision making process used to determine MOW expenditures was investigated and quantified. How this process may or may not be affected by Federal safety regulations and procedures in existing or proposed forms was explored.

User's Manual for a Computerized Track Maintenance Simulation Cost Methodology
Contract No.: TSC-1594 (Managed by the Transportation Systems Center)
Funding: $79,000
Schedule: July 1979 – September 1980
TSC Technical Contact: R. Smith (617) 494-2155
Agency/Contractor: Shaker Research Corp.

The actual cost of maintaining a segment of railroad track is extremey difficult to quantify. Materials used for track repair represent only a small fraction of overall maintenance expenses. Costs of delivery, installation and operations delays are all other important factors which must be considered in order to evaluate track maintenance costs. Moreover, the costing of an existing or proposed maintenance policy or practice is complicated by the fact that there are almost as many maintenance practices as there are railroads which perform them.

The work completed under this contract produced a methodology for computer simulation of track maintenance procedures and costs.

The simulation model provides for the graphic representation of the maintenance system under examination, the costing of proposed alternate maintenance plans or procedures, the listing of all annual track maintenance costs and the ability to output maintenance costs at any desired instant during the time simulation. An important feature is the capability to choose the specific kinds of maintenance costs to be included depending on the particular requirements of a particular railroad.

Railroad Maintenace-of-Way Data Profile
Contract No.: TSC-1704 (Managed by the Transportation Systems Center)
Funding: $28,688
Schedule: April 1979 – September 1981
TSC Technical Contact: M. Hollyer (617) 494-2599
Agency/Contractor: Boston and Maine Railroad

Sufficient information is not available at this time to analyze the complex decisions used by rail carrier managers in allocating funds for maintenance-of-way (MOW). This contract was designed to define typical allocation procedures for MOW expenditures, develop average unit costs for labor, materials and equipment, and explore the priorities perceived between top-down and bottom-up oriented personnel.

Track Safety and Maintenance Data Base Analysis
Contract No.: TSC-1664 (Managed by the Transportation Systems Center)
Funding: $119,263
Schedule: June 1979 – December 1980
TSC Technical Contact: R. Smith (617) 494-2155
Agency/Contractor: Association of American Railroads

The purpose of this contract was to review the data requirements of the Federal government and railroad industry to determine what data are needed, whether common data needs exist, and if these requirements can be met by a coordinated data collection effort with a minimum cost and imposition to the nation's railroads.

Analysis of the Behavioral Relationship of Rail-Road Maintenance Spending
Contract No.: TSC-1679 (Managed by the Transportation Systems Center)
Funding: $101,384
Schedule: April 1979 – July 1980
TSC Technical Contact: M. Hollyer (617) 494-2599
Agency/Contractor: Dynatrend, Inc.

The extent of impact on maintenance-of-way (MOW) expenditures of existing or future Federal regulations was investigated under this contract. A hypothesis of MOW expenditure behavior was developed and tested. A statistical study was performed and a series of hypothetical decision problems were designed and solved.

The output of this effort will help predict the impact of changes in Federal track safety regulations on overall MOW expenditures by Class I railroads.

Industry Impact Assessment of Rail Safety Regulations
Contract No.: TSC-1802 (Managed by the Transportation Systems Center)
Funding: $169,822
Schedule: September 1979 – September 1981
TSC Technical Contact: R. Smith (617) 494-2155
Agency/Contractor: Dynatrend, Inc.

Investigative support and data will be provided to TSC technical staff by accomplishing individual task specifications which in turn support the objectives of:

a) Quantifying the impact that regulations have upon the economics of the railroad industry;
b) Measuring the expected effectiveness of proposed safety alternatives;
c) Describing the level of funding that would be required to accomplish specific programs; and
d) Developing a rank ordering of R&D alternatives, based upon their influence on the reduction of track-related accidents.

Technical Support for Rail Related Analysis Tasks
Contract No.: TSC-8085 (Managed by the Transportation Systems Center)
Funding: $999,024
Schedule: April 1980 – April 1983
TSC Technical Contact: R. Smith (617) 494-2155
Agency/Contractor: Dynatrend, Inc.

This is a task-order contract to provide support in the form of studies and analysis for rail-related tasks.

Characterization of Rail Distribution in the National Track System
Contract No.: DTFR53-80-C-00119
Funding: $74,300
Schedule: September 1980 – October 1981
FRA Technical Contact: W. O'Sullivan (202) 426-4377
Agency/Contractor: Texas A&M Research Foundation

As part of developing a new recommendations for track performance safety standards, it is necessary to assess future impact were such standards to become effective. In the case of a proposed requirement affecting the inspection, detection and disposition of defective rail, it would be of use, for example, to know how rail is distributed throughout the national running track network in terms of size, age, authorized train speed, occurrence on curves or grades of varying severity, etc. From such a characterization it would be possible to determine the impact on the railroad industry were a certain rail class to become a candidate for specific regulatory treatment due to a hypothetical proneness to defect.

The contractor has access to track charts and operating time-tables from most Class I railroads. The information that will enable the expression of rail quantities by track-mile, in terms of the distribution factors cited above, is being extracted from this data base.

The contents of the FRA Office of Safety track inspection reports will be correlated to track segments of Section 503 of the 4R Act. Network abstractions will be demonstrated. Main line track defects can then be discretely located within the national railroad system.

Data files containing the above-described correlations will be provided.

SAFE DEVELOPMENT SUPPORT PROJECT

The objective of this project is to support the development and construction of the Stability Assessment Facility for Equipment (SAFE) at the Transportation Test Center (TTC). This facility, intended for research testing of vehicles and track, will benefit both the railroad industry and the government.

SAFE will be developed as both an assessment process and a permanent facility incorporating the capabilities of the Rail Dynamics Laboratory (RDL) and a new dedicated track layout. The dedicated track loop will have various representative track sections (e.g., tangents, spirals, curves, etc.) with superimposed geometric perturbations. Vehicles to be tested will be operated on the track to collect data on actual response to pre-established track perturbations. SAFE will thus coalesce a combination of analytical modes, laboratory testing, and track operations to assess the dynamic response characteristics of a railroad vehicle.

The problems and costs encountered in over-the-road derailment tests of the E-8 and SPD-40 locomotives emphasized the need for a dedicated facility to assess the dynamic response characteristics of railway vehicles. The track/vehicle interaction derailments, whether caused by the track being unable to contain the vehicle-imposed loads or by excessive vehicle motion, can be investigated by using a set of known track perturbations superimposed on a variety of track geometry conditions.

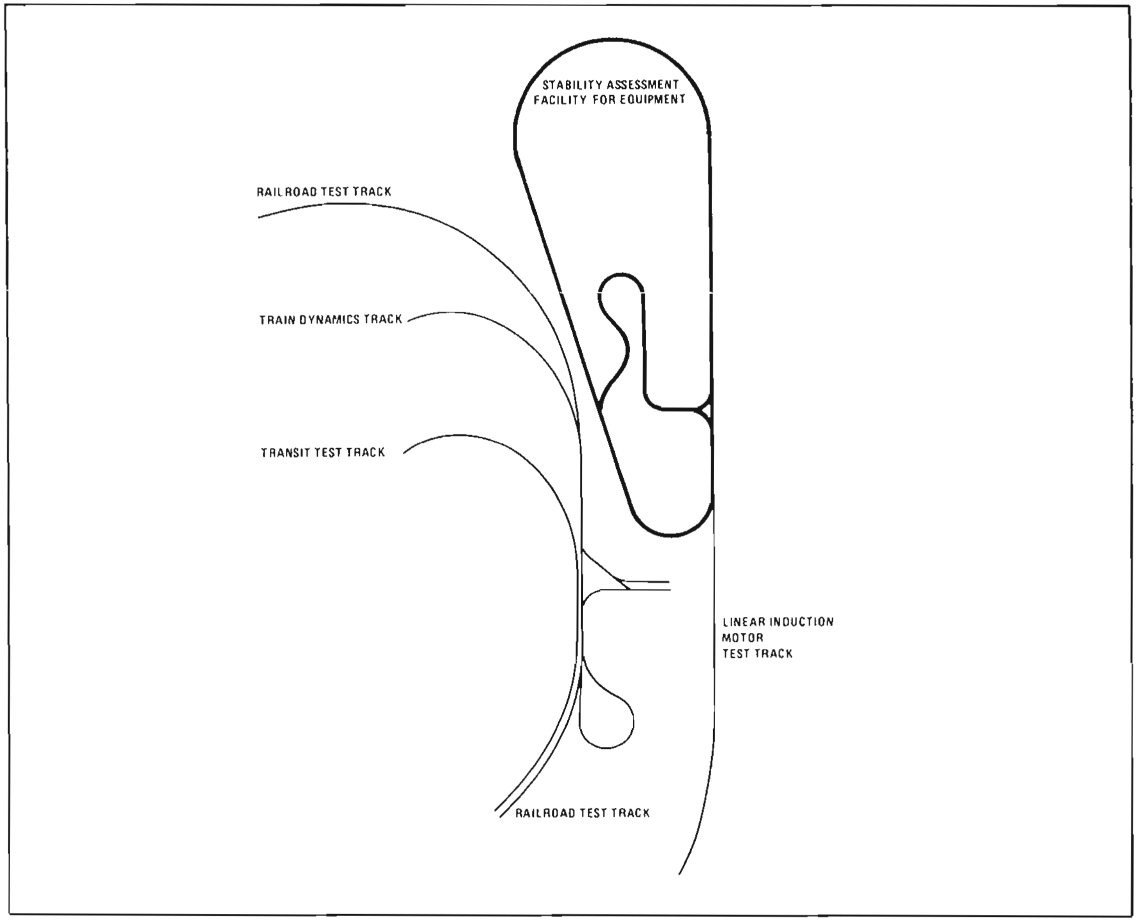


DIAGRAM SHOWING LOCATION OF SAFE TEST TRACK AT TTC

A temporary pilot test version of SAFE was conducted during late 1978 and early 1979 at the TTC. The Perturbed Track Test used the Train Dynamics Track and Railroad Test Track at TTC to test the SDP-40 and E-8 locomotives and a part of the Facility for Accelerated Service Testing (FAST) freight consist. The test demonstrated the technical feasibility of the concept of SAFE.

A coordinated program has been established with the appropriate parts of industry. The program uses the Track Train Dynamics Steering Committee for industry participation in the program management and for industry-supported working groups for technical design inputs.

The scope of the activity includes: the establishment of a SAFE Program Office at TSC for the day-to-day management of the development activities; the support of the various technical areas with in-house or contractor expertise; the definition of the technical and programmatic requirements for SAFE to allow the architectural and engineering design to progress; the monitoring and coordinating of the architectural and engineering design and facility construction; the development of test and data analysis/management requirements; and the conducting and/or sponsoring of checkout, acceptance and demonstration tests of the completed facility. After acceptance, the facility will be turned over to the TTC to operate. The Track Research program will then become a potential user of the facility.

CONTRACTS

Perturbed Track Test Data Analysis
Contract No.: TSC-1671 (Managed by the Transportation Systems Center)
Funding: $274,443
Schedule: January 1979 – September 1980
TSC Technical Contact: R.P. Brantman (617) 494-2210
Agency/Contractor: Arthur D. Little, Inc.

The SDP-40F locomotive was introduced into Amtrak passenger service during the period June 1973 to August 1974. Since then, 150 of these locomotives have been used in all parts of the country. It is one of the heaviest locomotives in use today and is similar to the SD-40-2, which is used for freight. By January 1978, passenger trains powered by the SDP-40F locomotive had been involved in 21 derailments at speeds of 30 mph or greater. This derailment record caused concern among various safety interests. Various tests were performed on operating locomotives and these after-the-fact tests of a perceived safety problem demonstrated the need for before-the-fact guidelines for assessing new equipment prior to introduction into the revenue service. In the after-the-fact tests, different methodologies were employed and it also became apparent that standardized test and analysis methodology should be developed. To achieve this objective the SAFE test facility was proposed. The perturbed track test demonstrates the feasibility of such a concept and provides data and guidelines for the further design of such a facility.

This contract was designed to evaluate existing and alternative data collection systems, particularly as they can be applied to SAFE. Post-test data analysis was included to assess the dynamic performance of the locomotives being tested and to develop pilot testing and design specifications for SAFE.

Support for the Perturbed Track Test of Locomotives at the Transportation Test Center
Contract No.: DOT-FR-64113 (Task 642)
Funding: $1,762,075
Schedule: June 1978 – September 1980
FRA Technical Contact: R.T. Liang (202) 426-1682
Agency/Contractor: ENSCO, Inc.

This contract demonstrated the capability of controlled, perturbed track testing to determine vehicle safety-related performance and provide design data for SAFE; established a basis for simulating revenue service track responses; obtained information for the validation of locomotive dynamic performance analytical models; and provided data for the validation of analysis specifying track safety standards.

Test series have been conducted at TTC since August 1978 as a cooperative industry/FRA effort. Investigations have covered the behavioral response of track containing a series of different instrumented perturbations types and the responses of two locomotive types and a baggage car negotiating the perturbed zones at speeds between

PERTURBED TRACK TESTING AT THE TRANSPORTATION TEST CENTER

35 mph and 75 mph. Also studied was the input to the perturbed track zones of a freight consist of 4 locomotives and up to 30 loaded cars, mostly 100 ton net, operating between 30 and 65 mph.

Extensive data collections were made and analyses conducted. Preliminary findings of interest include the occurrence of lateral track shift on a curved track test zone under a locomotive at 75 mph. It was determined from the data collected using the fully-instrumented wheels of one truck, a first use instance in the U.S., that the total truck force required to move what was essentially excellent track several inches laterally approximated 1100,000 lbs.

Two technical reports will be published. The first is an organized data base of test results with a user's manual that describes how to apply this data base to future evaluations. The second will consist of a series of test planning documents, operational test plans and data analysis procedures that will be used to evaluate the dynamic response of railroad rolling stock. Both of these will be directly implemented in the design and operation of SAFE.

Support for TTC Committee for SAFE
Contract No.: TSC-RA-7910 (Managed by the Transportation Systems Center)
Funding: $100,000
Schedule: July 1979 – July 1981
TSC Technical Contact: E. Sarkisian (617) 494-2485
Agency/Contractor: Federal Railroad Adm., Transportation Test Center

The objective is to obtain TTC support for planning and developing the SAFE program. The contractor will perform a short-term mini-experiment, test and calculations.

Engineering & Management Support for SAFE Program
Contract No.: TSC-1797 (Managed by the Transportation Systems Center)
Funding: $131,619
Schedule: September 1979 – September 1981
TSC Technical Contact: M. Hazel (617) 494-2651
Agency/Contractor: The Analytic Sciences Corp.

Engineering support services will be provided on demand in the areas of rail vehicle and track dynamic characterization, safety assessment test development, and track facility design.

Engineering & Management Support for SAFE Program
Contract No.: TSC-1799 (Managed by the Transportation Systems Center)
Funding: $126,523
Schedule: September 1979 – September 1981
TSC Technical Contact: M. Hazel (617) 494-2651
Agency/Contractor: Kaman Sciences Corp.

Engineering support services will be provided on demand in the areas of rail vehicle and track dynamic characterization, safety assessment test development, and track facility design.

Engineering & Management Support for SAFE Program
Contract No.: TSC-1798 (Managed by the Transportation Systems Center)
Funding: $133,861
Schedule: September 1979 – July 1981
TSC Technical Contact: M. Hazel (617) 494-2651
Agency/Contractor: Ensco, Inc.

Engineering support services will be provided on demand in the areas of rail vehicle and track dynamic characterization, safety acceptance test development, and track facility design.

Test Requirements, Data Reduction and Analysis for SAFE
Contract No.: TSC-80111 (Managed by the Transportation Systems Center)
Funding: $438,640
Schedule: June 1980 – June 1984
TSC Technical Contract: R. Ehrenbeck (617) 494-2233
Agency/Contractor: Arthur D. Little, Inc.

The objectives are to provide quick response, to develop test requirements, reduce and analyze data from multiple instrumented rail/vehicle inputs and produce dynamic and operational characterization of normal and degraded vehicles by analysis of test data.

TRACK PERFORMANCE AND SAFE LIFE PROJECT

The objective of this project is to conduct research needed to achieve increased safe life and productivity from the track system with reduced maintenance and rehabilitation requirements. The approach being used is to identify the most important requirements based on government and industry expert perceptions, and to conduct research on the highest priority projects identified. A recently completed study has resulted in the identification of 20 ranked areas of needed research and development. Programs are being initiated in response to this study.

During fiscal year 1980, in conjunction with a National Science Foundation grant, an investigation into the use of a large pulsed electrical power supply for the field welding of railroad rails was initiated. This process is known as Homopolar Pulse Resistance Welding (HPRW). If this study is successful, it will have a significant impact on the identified needs in maintenance and rehabilitation.

CONTRACTS

Failure Characteristics of Rail Joint Welds
Contract No.: TSC-1567 (Managed by the Transportation Systems Center)
Funding: $34,998
Schedule: April 1979 – August 1981
TSC Technical Contact: J. Morris (617) 494-2011
Agency/Contractor: University of Arizona

An increasing percentage of track segments within the national rail network is being replaced with continuous welded rail. The elimination of conventional rail joints contributes to lower maintenance costs.

However, weld failures can occur and cause derailments. The purpose of this contract is to establish the optimum thermite welding procedures applicable to premium rails being tested at the Facility for Accelerated Service Testing (FAST).

Improved Track Structures Information Dissemination and Conference Support
Contract No.: DOT-FR-9044 Task 2
Funding: $43,475
Schedule: September 1979 – January 1981
FRA Technical Contact: N. Ahmed (202) 426-0955
H. Moody (Technical Monitor) (202) 426-4377
Agency/Contractor: Unified Industries, Incorporated

Support was provided to Improved Track Structures Research Program managers in the areas of planning, report preparation, information dissemination and other associated tasks.

A report of proceedings of a conference on Nondestructive Techniques for Measuring the Longitudinal Force in Rail has been prepared. Assistance was provided in preparation for and preparing conference proceedings on Symposium on Railroad Electromagnetic Compatibility.

Homopolar Pulse Resistance Welding Process
Contract No.: DTFR53-80-x-00099
Funding: $35,000 (Total grant $343,345)
Schedule: June 1980 – March 1982
FRA Technical Contact: H. Moody (202) 426-4377
Agency/Contractor: National Science Foundation

In 1974, the Center for Electromechanics was formed at the University of Texas at Austin to develop large pulsed electrical power supplies for use in experiments concerned with thermonuclear fusion. The center was able to build a homopolar generator as proof-of-principle experiment. This generator operates on a principle of first storing rotational kinetic energy in a spinning rotor and then developing that energy in the form of a large electrical current pulse. It has been found that such a generator could have a number of possible industrial applications, among them the resistance welding of large cross sections of metal.

The Federal Railroad Administration (FRA) contracted the National Science Foundation to develop this process for use in welding railroad rails. To date a rail-welding fixture design has been made. This project is also scheduled to determine the cost of making in-track rail welds using the homopolar pulse resistance welding process. Additionally, weld samples will be made and evaluated microstructurally and mechanically for several types of joint designs.

PERFORMANCE STANDARDS MAINTENANCE REQUIREMENTS PROJECT

The Federal Railroad Administration (FRA) is presently formulating new track standards which will be based on functional performance rather than design requirements. This work is described within the Track Standards Development project.

An important result of these standards will be the increased flexibility of the rail industry in addressing safety concerns while at the same time maintaining track in a cost effective manner. In order to ensure the practical implementation of these standards, supporting cost effective maintenance-of-way information must be developed.

The work undertaken for this project will allow the rail industry to make informed and cost effective decisions relative to track maintenance requirements. A set of guidelines will be produced to provide an understanding of the standards, compliance measurement techniques, remedial actions and cost/performance trade-off information on acceptable design, and maintenance intervals and requirements.

In order to evaluate railroad embankments and obtain necessary data on which to base cost effective maintenance-of-way decisions, information must be obtained on subsurface conditions, foundation response to loads and history of loading. Traditional approaches to subsurface exploration have proven time-consuming and expensive. A research effort is underway to develop alternative methods which will allow extensive field surveys at greatly reduced costs.

The design and maintenance of the track substructure components are crucial to assuring reliable, safe operations.

THE WES'S TRAILER-HOUSED VIBRATOR ON-SITE ON THE ROCK ISLAND RAILROAD IN ARKANSAS

CONTRACTS

Evaluation of Techniques to Improve Subgrade Support to Rail Systems
Contract No.: TSC-RA-7641 (Managed by the Transportation Systems Center)
Funding: $880,000
Schedule: September 1976 – December 1980
TSC Technical Contact: P. Mattson
(617) 494-2431
Agency/Contractor: U.S. Army Corps. of Engineers, Waterways Experiment Station

The Transportation Systems Center is investigating innovative rational techniques for assessing potential maintenance and safety problems for existing roadbeds and embankment structure. This contract with the U.S. Army Corps. of Engineers was established to develop non-destructive test methods and equipment for use on rail embankment evaluation.

The output is intended as a means to quickly and inexpensively identify real or potential problem areas in the subsurface and foundation conditions.

Ballast and Subgrade Requirements Study
Contract No.: TSC-1527 (Managed by the Transportation Systems Center)
Funding: $326,000
Schedule: July 1978 – April 1981
TSC Technical Contact: J. Lamond
(617) 494-2544
Agency/Contractor: Goldberg, Zoino and Associates

The purpose of this contract is to develop a sound engineering basis for improving the safety, reliability and integrity of the railroad track support structure. A framework of track substructure criteria will provide opportunities to reduce maintenance costs and increase the safety and reliability of track ballast, subgrade, and foundation. Alternative technologies and engineering practices utilized for the design and construction of airfields and highways will be reviewed for potential railroad applicability. A similar review will be performed to determine whether related subgrade stabilization methodologies can also be utilized. Review of soil and ballast material testing and acceptance methods applicable to the railroad environment will be provided.

Railway Construction Systems Engineering Data
Contract No.: TSC-1539 (Managed by the Transportation Systems Center)
Funding: $250,703
Schedule: May 1978 – June 1980
TSC Technical Contact: A. Sluz
(617) 494-2431
Agency/Contractor: Haley & Aldrich, Inc.

Engineering data services were provided in the multi-disciplinary areas of geotechnical engineering, instrumentation, railway design analysis, soil stabilization, roadway drainage, construction and maintenance of elevated structures, maintenance-of-way planning and equipment, and cost estimation and economic analyses.

Contractor efforts supported all phases and aspects of railway design, construction, and maintenance.

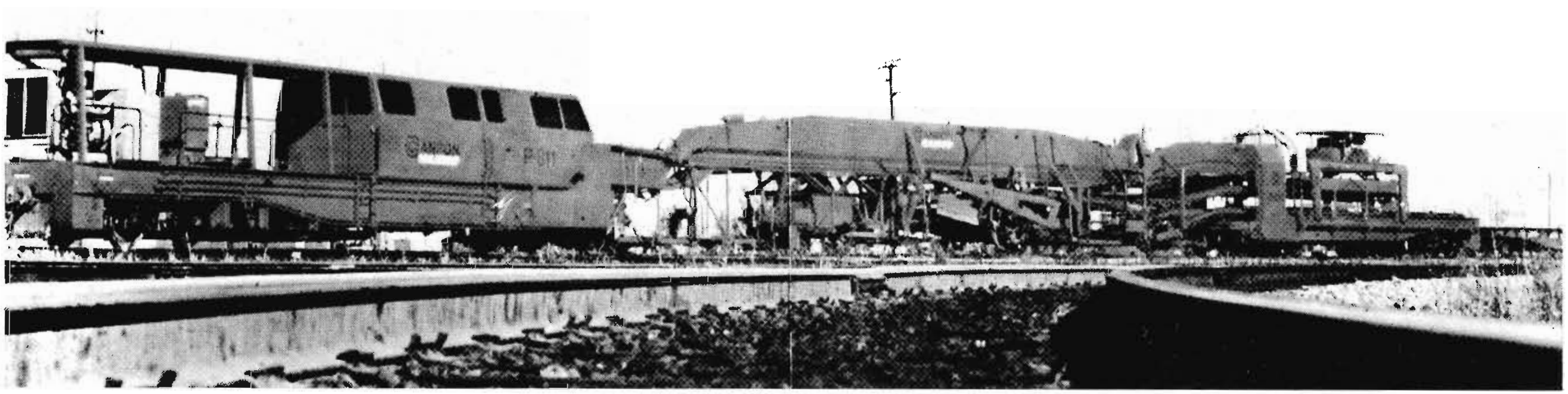
MOW EQUIPMENT AND TECHNIQUES EVALUATION PROJECT

The objective of this project is to develop long-range maintenance-of-way (MOW) requirements and techniques so as to achieve improved performance and safety. An analytical model will be developed utilizing a track geometry car, physical track information, and traffic data. Also, improved MOW equipment and techniques will be reviewed and analyzed.

A cooperative program with Conrail has resulted in the development of five Track Quality Indices, and a predictive track degradation equation. Other efforts have produced a study of track renewal machines and the economics of re-using wooden railroad ties.

Every railroad must decide where to utilize its limited MOW budget to perform basic maintenance and programmed or rehabilitation maintenance in the most cost-effective manner without allowing deterioration of track into unproductive and unsafe conditions. The Office of Research and Development of the Federal Railroad Administration has been sponsoring research to develop analytical techniques to aid railroad MOW planning and thereby utilize the MOW resources in the optimum manner, as well as reduce deferred maintenance and slow orders and thereby improve the quality of rail service and overall safety.

This project is comprised of two separate research and development contracts. The first deals with MOW Model Development Using Track Geometry Cars, and the second is investigating the economics of track renewal maintenance.



CANRON P-811 TRACK RENEWAL MACHINE

CONTRACTS

Research and Technology Sharing Support Service – Task 4 Track Equipment
Contract No.: FR-9044
Funding: $177,747
Schedule: August 1979 – April 1981
FRA Technical Contact: C. Orth
(202) 755-1877
Agency/Contractor: Unified Industries, Inc.

The objective of this research was designed to investigate the major operational and economic advantages and disadvantages associated with the track renewal method (TRM) of railroad track maintenance. TRM is being compared to conventional, selective track maintenance in North America. Under favorable conditions, benefits of the track renewal method include a major reduction in track time required for maintenance, reduced labor requirements, improved track structures, safe track maintenance operations at night, reduced long-term maintenance costs, completely rebuilt track for low additional first-year cost, savings for concurrent ballast cleaning and a capability for special applications.

The disadvantages of this method seem to include an increase in the long-range planning required by the maintenance of way department, carefully coordinated logistics requirements, improved personnel training, investment in expensive equipment, changing of rails concurrent with tie replacement, and in most cases, an additional cost during the first year.

While the full range of favorable conditions is not known, it appears that most large railroads and at least some smaller railroads could benefit from adopting the track renewal method for at least some of their lines.

MOW Model Development – Using Track Geometry Cars
Contract No.: FR-64113, Task 437
Funding: $469,215
Schedule: March 1978 – October 1980
FRA Technical Contact: A. Gross
(202) 755-1877
Agency/Contractor: ENSCO, Inc.

The objective of this contract was to develop techniques for long-range track maintenance planning that will better utilize the limited MOW resources and improve the quality of rail service and overall track safety. This FRA/Conrail cooperative research and development program utilizes data from FRA's track geometry cars operating on part of two Conrail division test tracks. Tonnage, speed data, track structure, and maintenance data are to be obtained together with statistical and engineering analysis to develop techniques and tools for track maintenance planning.

The final objective of this contract was to show the feasibility of using automated track geometry cars along with other track-related data in long-range track maintenance planning. Track Quality Indices (TQI) figures of merit have been established that objectively quantify the conditions of the track. Additionally, it has been found that there exist well defined relationships between TQI's and certain physical parameters which affect track condition.

SOUTHERN MOW DRIVING SPIKES

IMPROVED TRACK STRUCTURES BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the sub-program shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

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CHAPTER 3
DYNAMIC ANALYSIS

The objective of the Dynamic Analysis subprogram of the FRA is to ensure a more effective U.S. rail transportation system through the safe, reliable and effecient performance of its rail vehicles and their components.

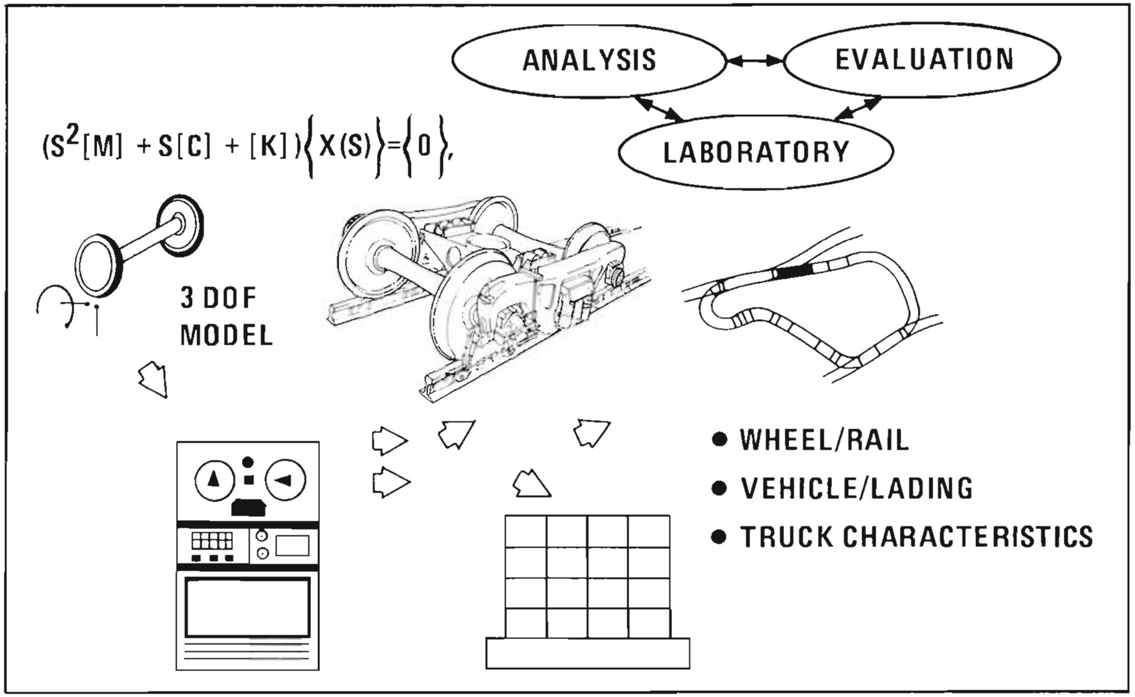
Large increases in freight car size and train weight over the last 10 years have tended to increase the wear and maintenance expenses on freight cars and tracks, as well as the amount of lading damage and number of train accidents experienced by railroads. The Dynamic Analysis subprogram is developing the basic information needed to predict and, if economically justified, reduce the forces exerted on vehicles, track, and lading.

Excessive rocking and bouncing of rail cars and erratic behavior of locomotives are problems which limit the nation's railroad and urban transit systems. Poor interaction between wheel and rail not only causes rough rides for passengers, but is also responsible for accidents, derailments, lading damage, and excessive maintenance costs.

The Rail Dynamics Laboratory (RDL), located in Colorado at the Transportation Test Center (TTC) is investigating the many dynamic factors affecting vehicle performance and safety through the use of two highly advanced test machines: the Roll Dynamics Unit (RDU) and the Vibration Testing Unit (VTU). Both machines recreate the effect of rails under a vehicle and include features to accommodate a wide variety of vehicle sizes and weights for testing purposes.

There are four projects organized under the Dynamic Analysis subprogram. These projects include:

1) Rail Dynamics Laboratory;
2) Equipment Analysis;
3) Equipment Evaluation; and
4) Lading Loss and Damage.



DYNAMIC ANALYSIS AND EVALUATION

RAIL DYNAMICS LABORATORY PROJECT

The Rail Dynamics Laboratory (RDL) Project began in 1974, at the Transportation Test Center (TTC) at Pueblo, Colorado. The TTC, established in 1971, is a facility where research is conducted to develop and improve railroad and transit technology. The newest railroad and transit vehicles and the latest ideas in railroad technology are tested here. As a result, many rail-related problems have been solved through performance and reliability testing on the Center's major tracks.

However, track tests cannot provide all the answers. Consequently, a controlled environment designed to test rail vehicle dynamics under laboratory conditions became necessary to conduct vehicle research efficiently. The RDL provides two highly advanced test machines, the Roll Dynamics Unit (RDU) and the Vibration Test Unit (VTU). The RDU is applied in studies of acceleration, adhesion, braking, and the hunting phenomenon — the tendency for trucks to swivel, yaw, and/or warp excessively. It simulates forward vehicle motion on rollers rather than on conventional rails. The RDU can also apply rotating forces to or absorb forces from the wheels of a powered vehicle. Vehicle speeds in excess of 140 mph can be simulated. Four advantages of RDU testing of railway vehicles are: 1) test conditions can be accurately controlled and measured; 2) surface contamination can be reduced to a minimum, or controlled; 3) parameters may be easily changed and their effect studied; and 4) random road bed disturbances including rail profile variations are eliminated.

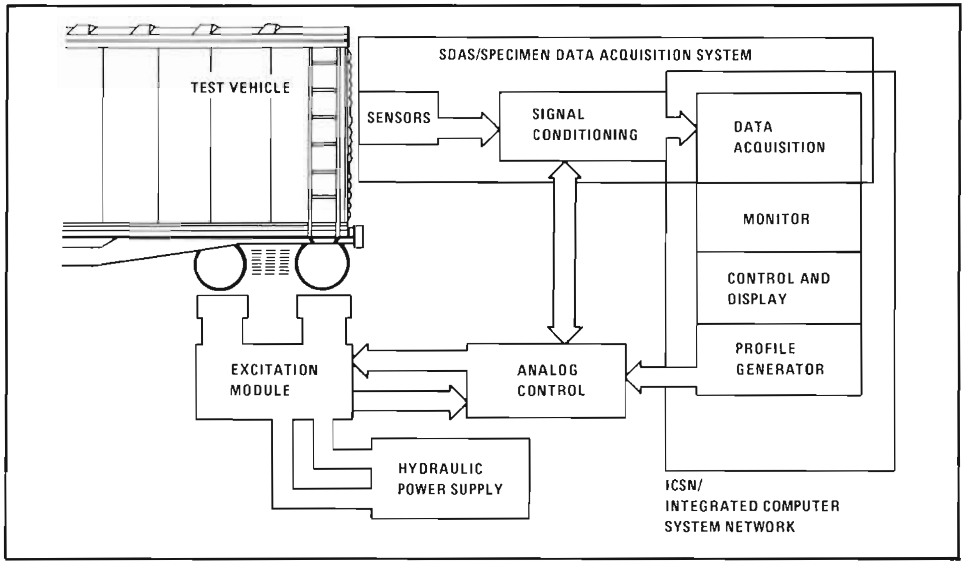
THE RAIL DYNAMICS LABORATORY (RDL) AT THE TRANSPORTATION TEST CENTER. THE RDL CONTAINS TEST RIGS WHERE RESEARCHERS CAN OBSERVE THE REACTIONS OF RAILROAD AND RAIL TRANSIT VEHICLES IN PLACE AS IF THE VEHICLES WERE MOVING ALONG RAILROAD TRACK. THE ROLL DYNAMICS UNIT RECREATES THE EFFECT OF A RAILCAR MOVING ALONG NEAR-PERFECT TRACK, WHILE THE VIBRATION TEST UNIT RECREATES THE EFFECT OF A RAILCAR ON PERTURBED TRACK.

The VTU provides the capability of subjecting a stationary 320,000-lb rail vehicle to controlled vertical and lateral vibration inputs on the wheels, creating the dynamic effects of perturbed track on a vehicle. The VTU is designed to vibrate a railcar to simulate the action of rail misalignment by using a hydraulic shaker system. Suspension characteristics and rock and roll tendencies of rail vehicles, component and vehicle natural frequencies, and component fatigue can be studied on the VTU.

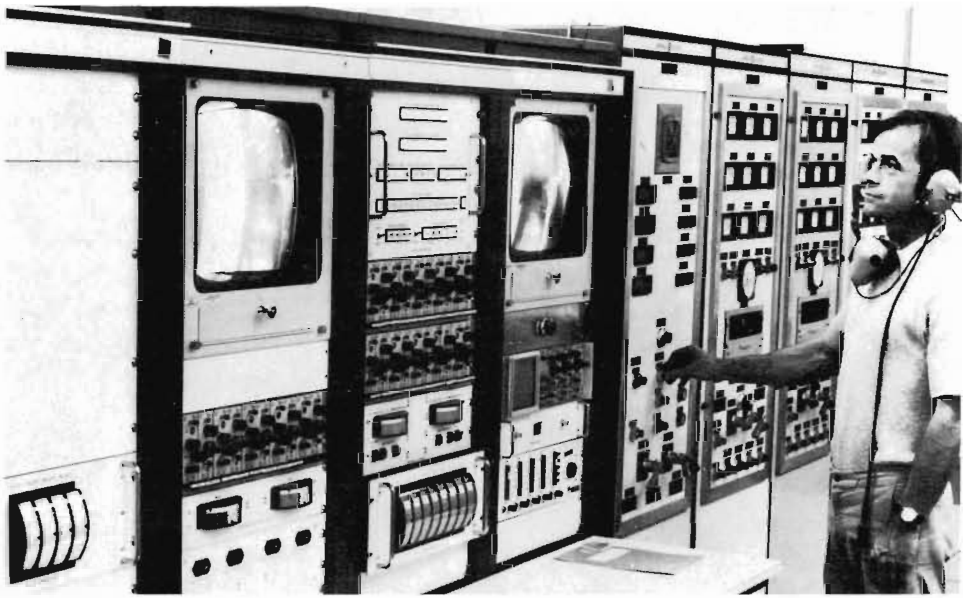
The RDL has begun testing under a demonstration program, funded by the Office of Research and Development and the Association of American Railroads Track/Train Dynamics Program, to test the dynamics of a 100-ton high-side gondola car on the VTU and a 70-ton TTX 89-foot flatcar on the RDU. The RDL will then be used to test the state-of-the-art transit car for the Urban Mass Transportation Administration (UMTA), a high-cube boxcar lading damage program, and a Metropolitan Atlanta Rapid Transit Authority (MARTA) subway car.

The RDL is available for use by government and private organizations, such as railroads (both domestic and foreign), car builders, locomotive manufacturers, trade associations, and universities. The objective of safe, reliable and efficient performance of rail vehicles can be realized through investigation of the dynamic factors affecting vehicle safety. The RDL provides testing to identify improvements for railroad and transit systems in order to assure safety, ride quality, and stability.

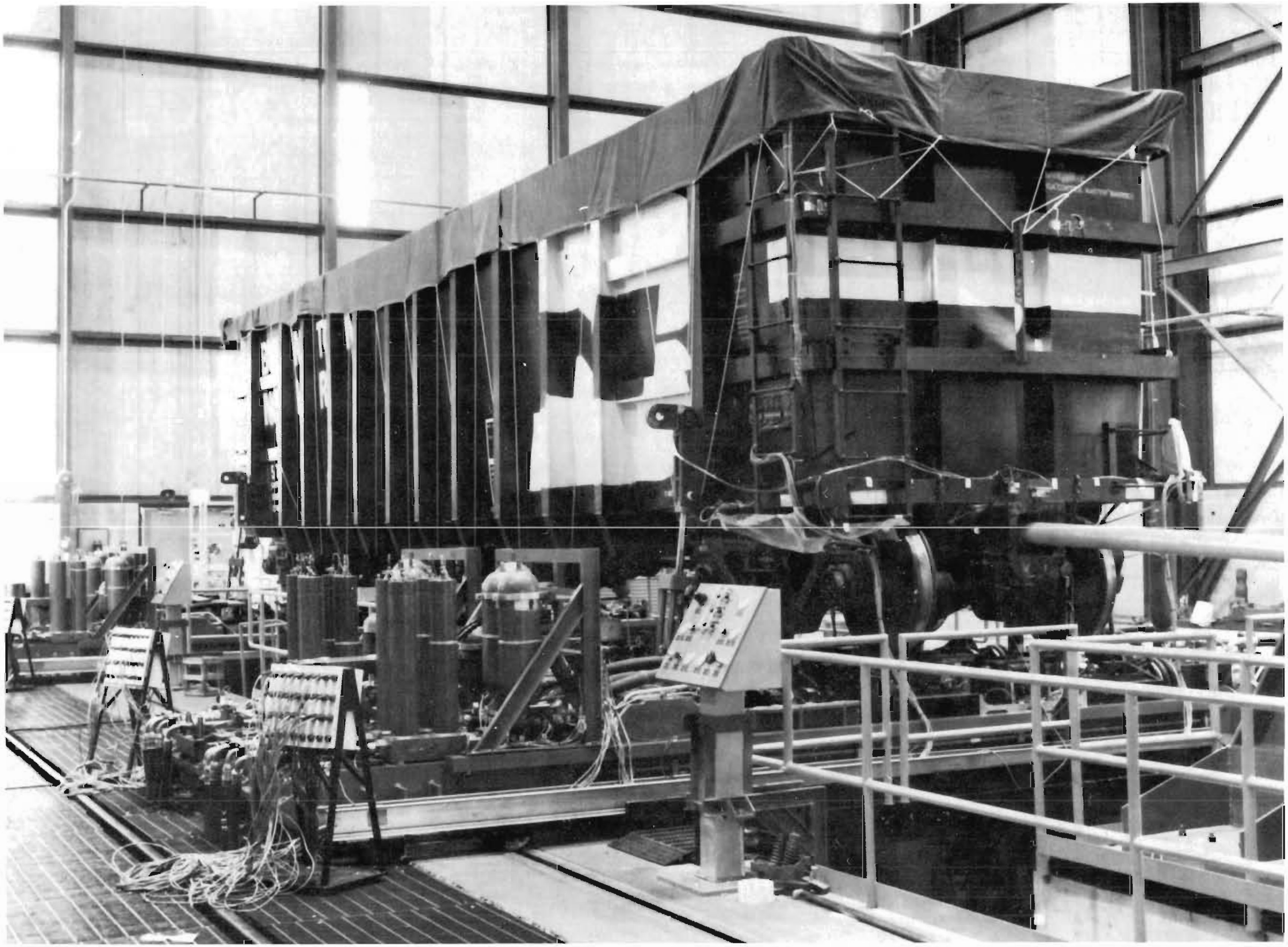
Three contracts for FRA research and development efforts at the RDL are described.



THE VIBRATION TEST UNIT



A TECHNICIAN MONITORS THE PROGRESS OF A TEST ON A RAILCAR FROM THE CONTROL CONSOLE OF THE ROLL DYNAMICS UNIT (RDU). OBSERVING THE REACTION OF TEST VEHICLES WILL ENABLE RESEARCHERS TO DETERMINE HOW RAILCARS, LOCOMOTIVES AND TRANSIT CARS CAN BE GIVEN INCREASED RIDE QUALITY, STABILITY AND SAFETY.



RDL – VIBRATION TEST UNIT

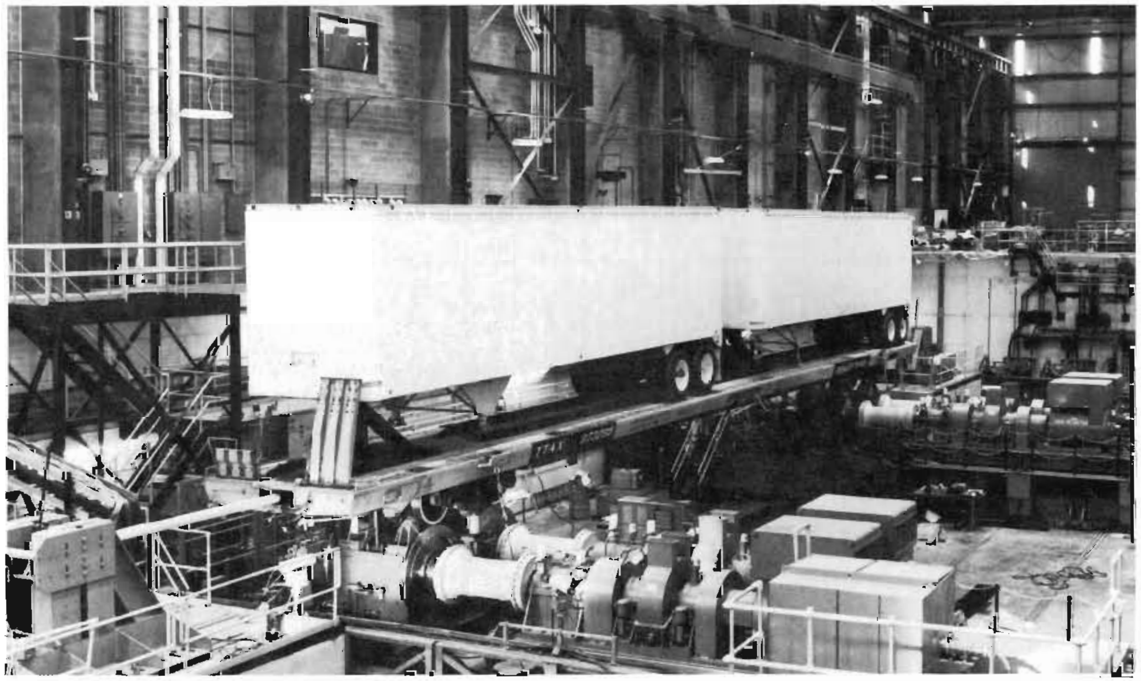
CONTRACTS

Rail Dynamics Laboratory (RDL)
Contract No.: FR-64200
Funding: $10,984,236
Schedule: July 1975 – September 1980
FRA Technical Contact: A. Gross
(202)755-1877
Agency/Contractor: Wyle Laboratories, Inc.

The TTC in Pueblo, Colorado was established in 1971 to conduct research for the development and improvement of railroad and transit technology. Since it is necessary to test rail vehicle dynamics under controlled laboratory conditions, a Rail Dynamics Laboratory (RDL) was developed for the FRA. RDL has facilities to perform tests on full-scale locomotives, passenger and freight trains, and transit vehicles, under computer-controlled conditions.

The Roll Dynamics Unit (RDU) and the Vibration Test Unit (VTU) machines, which comprise the RDL, result in the most technically advanced railroad and transit research laboratory in the world.

The RDL program provides controlled conditions in a track-related in-service environment to isolate causes and determine the solution of dynamic operating problems encountered in the railroad and transit industry.



AN 89-FOOT TOFC (TRAILER-ON-FLATCAR) IS POSITIONED ON THE ROLL DYNAMICS UNIT (RDU) FOR TESTING. THE RDU RECREATES TRACK MOVEMENT FOR RAILCARS, LOCOMOTIVES AND TRANSIT CARS BY ROLLING THEM IN PLACE UNDER CAREFULLY CONTROLLED LABORATORY CONDITIONS.

Roll Dynamic Unit (RDU) Wheel/Rail Correlation Study
Contract No.: Purchase Order 9116
Funding: $7500
Schedule: July 1979 – September 1980
FRA Technical Contact: A. Gross
(202)755-1877
Agency/Contractor: Arizona State

Arizona State is conducting an analysis for the FRA of the dynamic behavior of a test vehicle on the RDU. The RDU is used to investigate the wheel/rail dynamics of acceleration, adhesion, braking, and truck-hunting.

This study will investigate the contact conditions existing between the RDU roller and vehicle wheel, or rail creep/force theories, with regard to their applicability for use in RDU analysis as well as comparisons when a wheel set runs on track.

RDL/RDU and VTU Demonstration Program
Contract No.: PR4498
Funding: $74,533
Schedule: December 1979 – May 1981
FRA Technical Contract: A. Gross
(202)755-1877
Agency/Contractor: Transportation Test Center

The TTC in Pueblo, Colorado will examine the capabilities of the RDL/RDU and VTU to test and evaluate the dynamic stability characteristics of a typical freight vehicle.

The RDU test program will have four objectives: 1) to demonstrate the use of the RDU facility for determining hunting characteristics of a TTAX flatcar; 2) to provide data for correlation of a truck hunting mathematical model developed by Track Train Dynamics (TTD)/AAR personnel with test data; 3) to explore the effect of operating and design parameters on truck hunting behavior; and 4) to obtain track test data for comparison of truck hunting dynamics on tangent track verses RDU.

The VTU test program will have three objectives: 1) to demonstrate the use of the VTU facility for determining the dynamic characteristics of a freight car (100-ton high side gondola car) and to reduce the experimental data for design purposes; 2) to provide test data for comparison with responses obtained with mathematical models developed by the track/train dynamics (TTD) program, and with selected field tests; and 3) to establish the range of strains occurring during dynamic conditions for estimates of the fatigue life of critical structural elements.

Upon completion of the RDU/VTU tests, TTC will prepare technical test reports and a short color movie on testing. At contract completion, TTD will prepare final test/analysis reports.

EQUIPMENT ANALYSIS PROJECT

Large increases in freight car size and train weight over the last 10 years have tended to increase the wear and maintenance expenses on freight cars as well as the amount of loss, damage and number of train accidents experienced by railroads. This project addresses some of the problems found by examining freight car behavior, with actual testing taking place at the Union Pacific Railroad and the Transportation Test Center (TTC).

The equipment analysis attempts to develop analytical techniques to determine the freight car parameters that contribute to derailments, increased vehicle maintenance, loss, and damage. Several analytical models have already been developed and validated to provide simple and accurate predictive methods to analyze freight car behavior under various operational conditions. Six of these describe freight car truck hunting and two, freight car lading response. In addition, surveys and evaluations have been completed on all current railroad-related analytical models.

CONTRACTS

Review and Summary of Computer Programs for Railway Vehicle Dynamics
Contract No.: FR-8076
Funding: $30,000
Schedule: August 1978 – September 1980
FRA Technical Contact: N. Tsai
(202)426-0855
Agency/Contractor: University of Virginia

All available rail/vehicle dynamics computer program were identified and classified as Lateral Stability; Curving Dynamics; Vertical Dynamics; Freight Dynamics and Analog/Hybrid Simulations.

Suitable authorities on each of these were chosen to evaluate available programs, and user's responses were obtained to provide recommendations regarding validation of selected programs.

Improved Wheel Measurement Instruments
Contract No.: PR-4505 & PR-4521
Funding: $37,000
Schedule: February 1980 – September 1980
FRA Technical Contact: D.E. Gray
(202)755-1877
Agency/Contractor: Transportation Test Center

Wheel wear is one of the key research topics under study at the FAST track. Based on analysis of previous data it became evident that measurement inaccuracy was contributing significantly to the unexplained variability in the data and, in particular, to the limited value of analysis of the rim wear data.

The FRA determined that one way to reduce inaccuracy would be to develop a more accurate instrument to replace the standard Association of American Railroads (AAR) finger gage currently in use. This instrument could result in more comprehensive and reliable data analysis and could provide considerable savings over the costs associated with the prevailing practive (using relatively large wheel samples and extensive test periods).

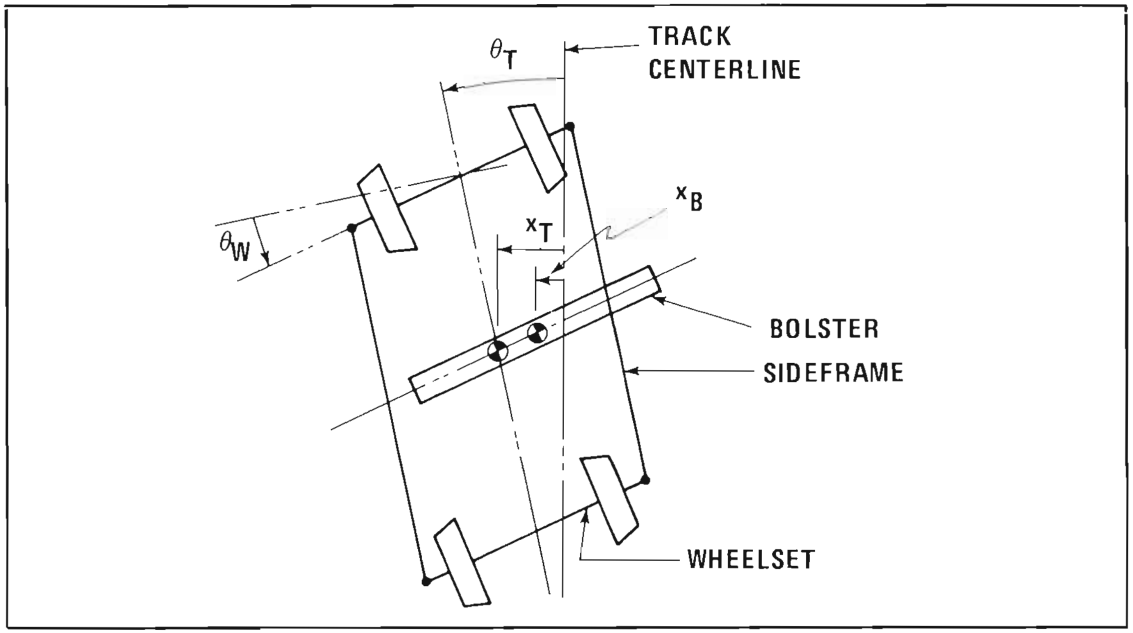
Unified Industries, Incorporated developed a prototype wheel instrument that measures flange thickness, rim thickness and flange height to a thousandth of an inch. Validation tests were carried out at the Transportation Test Center and the instrument is replacing the AAR finger gage at FAST.

This project also investigated the adaption of existing wheel profilometer designs for future use at FAST.

Freight Car Dynamics
Contract No.: OS-40018
Funding: $342,067
Schedule: June 1977 – August 1980
FRA Technical Contract: N. Tsai
(202)426-0855
Agency/Contractor: Clemson University

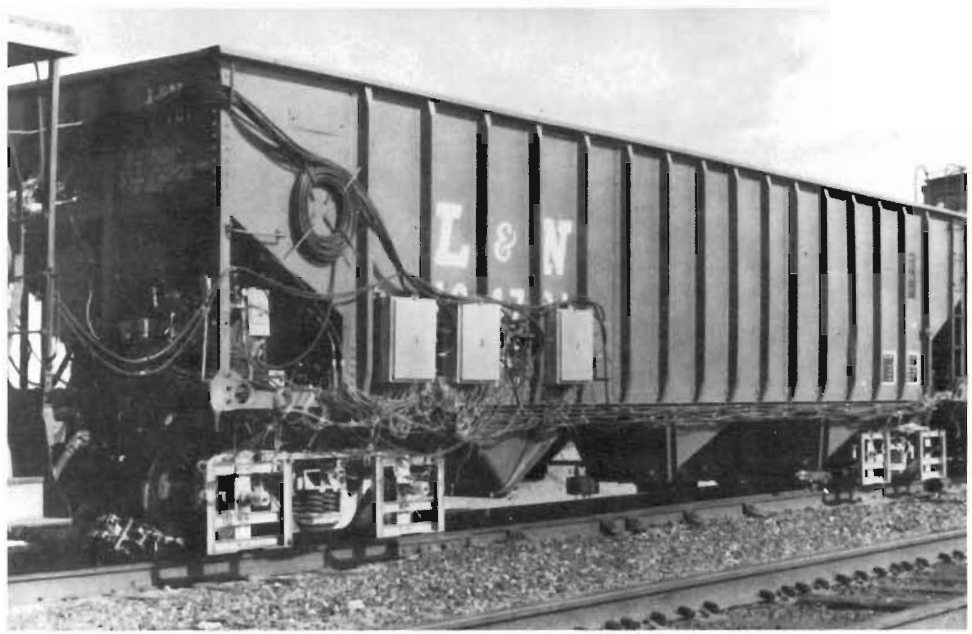
Clemson University conducted the Freight Car Dynamics Study in order to develop mathematical models to understand the dynamic behavior of freight cars and the effects on various truck, car, and track design parameters.

This study developed computer programs to simulate freight car dynamics, prepared user's manuals, and documented six computer programs for submission to the National Technical Information Service.



THREE DEGREE OF FREEDOM FREIGHT TRUCK MODEL

EQUIPMENT ANALYSIS USING COMPUTER MODELS



FREIGHT CAR-DYNAMIC TESTING VEHICLE

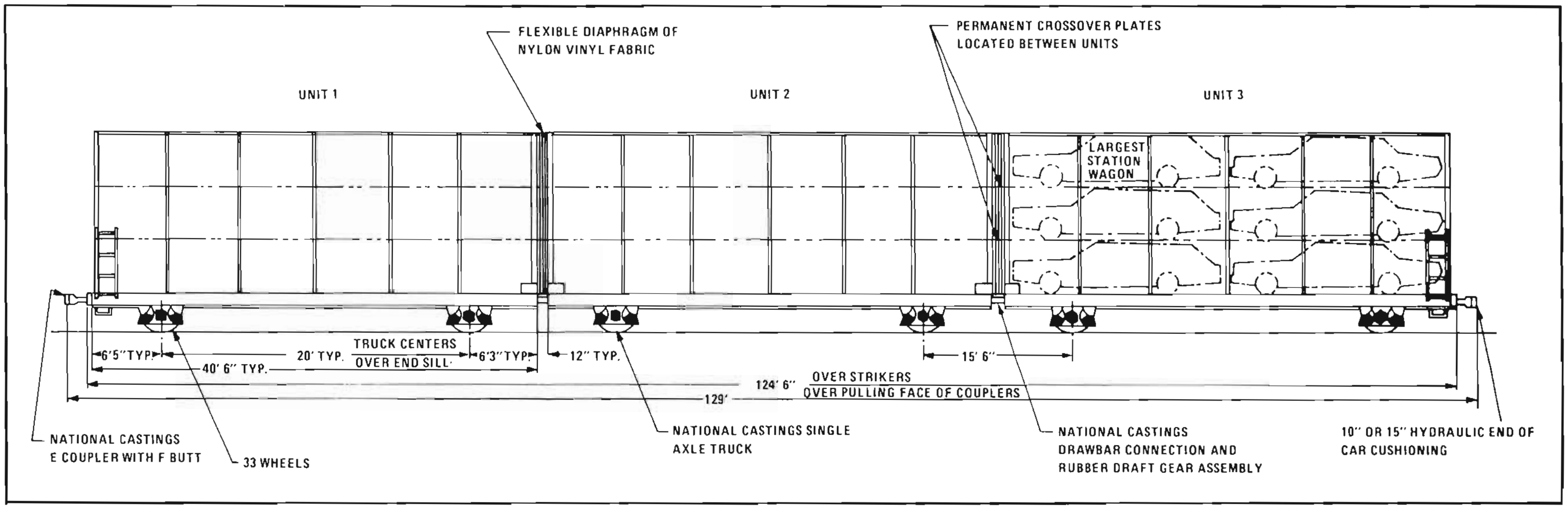
EQUIPMENT EVALUATION PROJECT

Freight car truck performance research has been conducted for several years by the Office of Freight Systems. Phase I of the Truck Design Optimization Project (TDOP) was a study of the Type I, general purpose, three-piece truck. Performance characterization of the Type I truck was completed in Phase II. A study was begun of the Type II, special purpose or premium truck, with the objective of developing performance and testing specifications for the Type II truck.

The Equipment Evaluation Project has as its objective the assessment of the relative service performance characteristics of single-axle trucks and trucks under an articulated connector joining two railcar sections.

Work on single-axle trucks and trucks under an articulated connector (railcar) was delayed for two reasons: 1) the complexity and variety of two-axle trucks falling into the category of the Type II truck, and 2) lack of equipment at the outset of Phase II for the single-axle trucks and trucks under an articulated connector.

Because recent developments have made available to FRA single-axle and articulated-connector equipment for study on a limited scale, a study project is being planned as an adjunct to TDOP. One autoguard car will be made available to FRA by the Southern Railway System for the study of single-axle truck performance. A six-



SINGLE AXLE AUTO CARRIER (3 UNIT DESIGN) section, articulated, intermodal railcar prototype to be provided by the Budd Company, Railway Division will make it possible to study the performance of a standard American Steel Foundries (ASF) three-piece truck under an ASF articulated connector.

In the above two studies, the cars will be equipped with instrumented wheelset and other measurement devices to measure wheel/rail load, displacement and truck/carbody motions during the field testing over the mainline track of Richmond, Fredericksburg and Potomac Railroad (RF&P). Data will be analyzed and compared with conventional freight car truck performance data. The Equipment Evaluation project will develop data and test requirements and methodologies to meet TDOP basic data needs and special requirements of other project participants.

Charcterization of Articulation and Single-Axle Suspension Systems
Contract No.: DOT-FR-64113
Funding: $315,000
Schedule: June 1980 – June 1981
FRA Technical Contact: N. Tsai
(202)426-0855
Agency/Contractor: ENSCO, Inc.

ENSCO, Inc. is conducting a research study for the FRA to determine the performance characteristics of innovative, single-axle trucks and trucks under an articulated connection joining two railcar sections.

Data obtained in Phases I and II of the Truck Design Optimization Project (TDOP) will be augmented by the knowledge acquired from the study. Road tests conducted during this study and analysis of test data will prove helpful in comparing the performance of the innovative systems with more contemporary suspension systems.

LADING LOSS AND DAMAGE PROJECT

Damage to goods during transit can result in various costs. There are the raw claims costs, the costs of litigation, claims processing costs, insurance costs, delayed sales and lost future sales, cost of larger inventories, and the interruptions to the production process resulting from unreliable shipments.

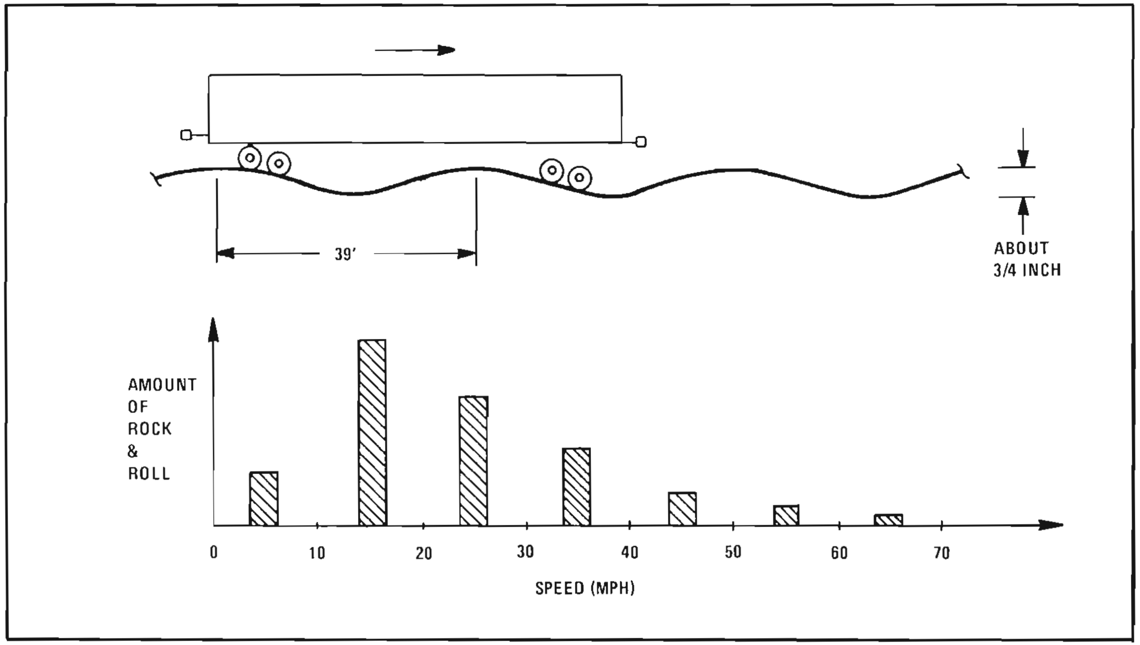
The costs of preventing such damage often seem high when compared to just the claims costs, but many of the costs of damage are subtle and hidden. To reduce these costs over the long period, the Federal Railroad Administration (FRA) has a continuing program to investigate the causes of damage to goods. This program has examined many facets of damage and now has developed complex simulation models to provide a relatively inexpensive method of providing solutions to the causes of damage in shipments. In addition, special research facilities have been developed at the Rail Dynamics Laboratory (RDL) to test, under laboratory conditions, the effects found on actual track.

TESTING FOR "FRATE" MODEL VALIDATION

It is easy to visualize the types of vibrations and shocks that packages experience while traveling along a railroad, and it is obvious how much damage can occur. There is the general sliding of cargo as a train accelerates or decelerates, the end-to-end collision of cars during coupling and slack and buff train action, the ambient vibration from movement, the rock and roll motion of traveling over jointed track, and the shifting of the car carriage along the wheel axles as the body follows the movement of the gage. These, and other causes of damage can be treated as continuous or single vibrations and these can cause packages to walk, bounce or vibrate in sympathy. The science of packaging attempts to provide methods of loading, stacking and protecting that work with or against these forces to prevent damage to the contents. In addition, engineers attempt to improve the ride quality and reduce some of these forces by improved rail geometry, different types of suspension mechanisms, couplers, etc. All this work is oriented toward reducing the costs of damage in transportation and preventing accidents.

The packaging will also be different for different types of products. For some causes of damage certain speeds must be maintained to avoid damage. As an example, the type of cushioning required for a particular product will vary with the product, depending on how the product responds to vibrations. The amount of cushioning will also vary with the route being traversed. Depending on the type of vibration problems being encountered, a certain amount of cushioning can damp vibrations making for a more comfortable ride or, under different conditions, can exaggerate the bounce being felt within a car and consequently cause more damage.

The complexity of this subject has required the setting up of tests to check on the vibrations actually found in different types of vehicles and, because of the expense of this type of testing and the costs of constructing alternatives, a computer simulation program has been extensively used and is continually being redesigned to account for different types of load configurations and vehicle types. This type of analysis allows for theoretical testing of new design or lading features before any actual model or full-scale test prototype need be developed. All this work should help to reduce shipping damage and therefore will improve the service quality of the railroads.



RAILROAD ROCK AND ROLL

CONTRACTS

Rail Freight Dynamics
Contract No.: FR-54090
Funding: $371,000
Schedule: March 1977 – August 1979
FRA Technical Contact: C.L. Orth
(202)755-1877
Agency/Contractor: MITRE Corp.

Physical damage occurs to railroad freight during transit. It is possible to reduce this damage by reducing the forces experienced by the freight. A computer program (FRATE) has been developed to study the dynamic response characteristics of freight cars. It assumes that freight car motion causes wear on the car, the track and the roadbed, causes damage to commodities carried, and can result in derailment. Today, it costs in excess of $10 billion annually to maintain rolling stock, track and roadbed and to defray the cost of lading damage settlements. A small increase in the ride quality can create large savings.

The use of computer analysis techniques helps innovation in car design and lading protection techniques. They can be performed more quickly and at less cost than development testing. This saves time and money and results in a better final product.

This contract has examined various track and car characteristics that result in car motion which could cause vehicle, track and lading damage. These include a rock and roll analysis (the response of the car to joints between rails), a hunting analysis (the movement of the car between the gage as the car body follows the wheel movement) and a vertical pulse analysis (movement resulting from irregularities in track profile such as uneven settling of the roadbed or elevated hard spots found at road crossings or switch blocks). It concludes with a series of recommendations for improving ride quality.

Railcar Lading Damage
Contract No.: FR-54090
Funding: $334,295
Schedule: February 1978 – March 1981
FRA Technical Contact: C.L. Orth
(202)755-1977
Agency/Contractor: MITRE Corporation

This contract is a continuation of the "Rail Freight Dynamics" contract and is part of the "Lading Model Validation Test/Evaluation" being conducted at the TTC. The FRATE model previously developed for a trailer-on-flatcar (TOFC) has been modified for a boxcar with compliant lading.

Vibration tests will be performed on a 70-ton boxcar with lading on the RDL vibrations test unit to validate the revised FRATE model. Analyses will be performed to obtain the response of boxcar elements and compliant lading to several track profile and body hunting conditions.

Packaging Dynamics of Freight Lading Study
Contract No.: FR-76-74323
Funding: $122,753
Schedule: September 1977 – September 1980
Technical Contact: C.L. Orth
(202)755-1877
Agency/Contractor: Rutgers University

Proper packaging and stacking of products can reduce transport damage. Proper packaging can vary from product to product depending on its density. This contract has been pursued to determine the responses of certain product/package ladings to a range of shock and vibration. Various tests were made on cans of three products (with different densities) packed in corrugated cardboard shipping containers and under several

PACKAGE DYNAMICS TESTING–RUTGERS UNIVERSITY stacking and palleting configurations. Attempts were made to simulate the lading conditions found on freight cars, trailer-on-flatcars, and container-on-flatcars.

Rail Car Performance Based Track Geometry Descriptors
Contract No.: FR-54090
Funding: $35,000
Schedule: July 1980 – March 1981
FRA Technical Contact: A. Gross
(202)755-1877
Agency/Contractor: MITRE Corporation

Reduced track maintenance usually results in increases in the number of severity of derailment and lading loss. The profitability of railroad operations can be determined by the balance between these two costs. This contract provides a set of criteria for evaluating the performance levels of track and a sound basis for budgeting track maintenance expenditures.

Criteria of track geometry and quality have been redefined to account for the response of various types of moving vehicles. These new indices can be used to provide a list of critical defects requiring immediate maintenance. Track quality indices related to specific levels of performance can be used to assign priorities in a maintenance budget.

Descriptors of track geometry and quality based on vehicle performance levels are to be derived from a computer graphics program and were then tested with actual data. They are to be defined so that track areas not exceeding the threshold values had little derailment risk and areas flagged as high-risk exceeded the threshold values. A statistical computer package of track quality indices is to be generated to examine existing track geometry. These future vehicle indices can then be usefully incorporated into a maintenance-of-way budget strategy.

Lading Package Materials Evaluation
Contract No.: PR-4531
Funding: $25,000
Schedule: August 1980 – June 1981
FRA Technical Contact: C.L. Orth
(202)755-1877
Agency/Contractor: Michigan State University
School of Packaging

Boxes of cans resonating in boxcars often result in damage to both the cans and the car. Work is currently underway to identify the causes of lading damage in railcars, and as part of this program tests will be made to compare the currently used corrugated fibreboard boxes and on alternative material.

Lading Model Validation Test/Evaluation
Contract No.: PR-4513
Funding: $108,112
Schedule: March 1980 – September 1981
FRA Technical Contact: C.L. Orth
(202)755-1877
Agency/Contractor: Transportation Test Center

This contract provides funds to obtain a 70-ton boxcar and to set up the Vibration Test Unit for tests on lading damage and validation of the FRATE model. These tests are described in the contracts for "Lading Package Material Evaluation" and "Railcar Lading Damage."

MITRE Corporation has modified the Freight Car Response Analysis and Test Evaluation (FRATE) computer simulation model to simulate a 70-ton boxcar with rigid and compliant lading. This project will validate the modified model. Tests will take place on the Vibration Test Unit at the Rail Dynamics Laboratory (RDL) in Pueblo, Colorado. The results will be useful in reducing transportation damage to shipments of canned goods.

Support Services – Rail Freight Systems

The objective of the tasks described is to accumulate information from a wide variety of sources to aid to Office of Freight Systems in R&D activities.

The following contracts provide support to all of the subprograms: Equipment Safety, Safety Testing, Improved Track Structures, Dynamic Analysis, Energy/Environment, and Freight Systems Technology in the Office of Freight Systems.

As a result, the final reports, test plans, etc. will be related to the specific subprogram for which each task order is issued.

FRA Technical Contact: C.L. Orth
(202) 755-1877

Task I
Contract No.: FR-9082
Funding: $181,484
Schedule: May 1979 – May 1983
Agency/Contractor: SRI International

System definition, feasibility, and technology assessment studies associated with the formation of research plans will be provided.

Task II
Contract No.: FR-9048
Funding: $270,817
Schedule: April 1979 – April 1982
Agency/Contractor: Dynamic Science, Inc.

Test and evaluation criteria for test plans and procedures will be developed.

Task III
Contract No.: FR-9049
Funding: $322,716
Schedule: April 1979 – April 1983
Agency/Contractor: IIT Research Institute

Instrumentation, data collection, processing and management systems will be established.

Task IV & V
Contract No.: FR-9050
Funding: $303,370
Schedule: May 1979 – May 1983
Agency/Contractor: Systems Control, Inc.

Technical assistance in developing modeling and simulation tools for ground vehicle mechanics and dynamics will be provided.

Technical assistance in conducting various technical and operational studies requiring specialized expertise in the engineering and systems sciences will also be provided.

Task VI
Contract No.: FR-9051
Funding: $145,830
Schedule: April 1979 – April 1983
Agency/Contractor: A.J. Kearny, Inc.

The purpsose is to aid the Government in transferring R&D research to private industry and encourage implementaton of feasible results.

DYNAMIC ANALYSIS BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

TOFC Lading Response Analyses for Several Track Profile and Hunting Conditions
MITRE Corp.
George Kachadourian
Report No. FRA/ORD-80/3 April 1980
PB 80-178171

Analog and Digital Computer Simulations of Coulomb Friction
Clemson University
R. Heller, J. Tuten, P. Kadala, and E. Law
Report No. FRA/ORD-78/07 Dec. 1977
PB 279-465

Analytical and Experimental Determination of Wheel-Rail Constraint Relationships
Clemson University and Arizona State University
N.K. Cooperrider, et al
Report No. FRA/ORD-76/244 Dec. 1975
PB 252-290

Contact Stresses on Bodies with Arbitrary Geometry, Applications to Wheels and Rails
University of Pennsylvania
B. Paul and J. Hashemi
Report No. FRA/ORD-79/23 April 1979

Contact Stresses for Closely Conforming Bodies — Application to Cyclinders and Spheres
University of Pennsylvania
B. Paul and W. Woodward
Contract No. DOT-TST-77/46 Dec. 1976
PB 271-033

Dynamic Hopper Car Results Report, FAST
ENSCO Corp.
M. Kenworthy, Jones, Kessler
Report No. FRA/ORD-78/61

FRATE (Freight Car Response Analysis and Test Evaluation) Vol. 1, User's Manual
MITRE Corp.
G. Kachadourian, N.E. Sussman, and J.R. Anderes
Report No. FRA/ORD-78/59 Sept. 1978
PB 291-206

General Models for Lateral Stability Analyses of Railway Freight Vehicles
Arizona State University, Tempe, Dept. of Mechanical Engineering
E.M. Law, et al
Report No. FRA/ORD-77/36 June 1977
PB 272-371

General Models for Lateral Stability Analyses of Railway Freight Vehicles
Clemson University
E.H. Law, J.A. Hadden, and N.K. Cooperrider
Report No. FRA/ORD-77/36 June 1977
PB 272-371

An Improved Numerical Method for Counter-formal Contact Stress Problems
University of Pennsylvania
B. Paul
Report No. FRA/ORD-78/26 July 1977

An Investigation of Techniques for Validation of Railcar Dynamic Analysis
Arizona State University, Tempe, Dept. of Mechanical Engineering
W.J. Fallon, N.K. Cooperrider and E.H. Law
Report No. FRA/ORD-78/19 March 1978
PB 279-996

Mathematical Modeling Report for DODX Railcars
ENSCO, Inc.
C.J. Jones
Report No. FRA/ORD-77/47 Aug. 1978

Response Analyses of a Boxcar with Compliant Loading for Several Track Profile and Hunting Conditions
G. Kachadourian and E. Sussman
Report No. FRA/ORD-80/4 April 1980
PB 80-177637

A Review of Rail-Wheel Contact Stress Problems
University of Pennsylvania
B. Paul
Report No. FRA/ORD-76/141 April 1975
PB 251-238

User's Manual for Asymmetric Wheel/Rail Contact Characteristics Program
Arizona State University and Clemson University
R. Heller and N. Cooperrider
Report No. FRA/ORD-78/05 Dec. 1977
PB 279-707

User's Manual for Kalker's "Exact" Nonlinear Creep Theory
Clemson University
J.G. Goree
Report No. FRA/ORD-78/50 Aug. 1978
PB 287-472

User's Manual for Kalker's Simplified Nonlinear Creep Theory
Clemson University
J.G. Goree and E. Law
Report No. FRA/ORD-78/06 Dec. 1977
PB 279-503

User's Manual for Lateral Stability Computer Programs for Railway Freight Car Models
Arizona State University, Dept. of Mechanical Engineering
E.H. Law and N.K. Cooperrider
Report No. FRA/ORD-80/30

User's Manual for Program for Calculation of Kalker's Linear Creep Coefficients
Clemson University and Arizona State University
I. Hague, E.H. Law, and N.K. Cooperrider
Report No. FRA/ORD-78/71 March 1979

User's Manual for Program CONFORM (CONFORMal contact stress problems)
University of Pennsylvania
B. Paul and J. Hashemi
Report No. FRA/ORD-78/40 June 1978
PB 288-927

User's Manual for Program CONTACT (COUNTer-formal contACT stress problems)
University of Pennsylvania
B. Paul and J. Hashemi
Report No. FRA/ORD-78/27 Sept. 1977
PB 288-927

Vertical Shaker System Demonstration Project Part I, System Performance Evaluation
Wyle Laboratories
Report No. FRA/ORD-78/43 July 1978

Vertical Shaker System Demonstration Program Part II, Model Development and Data Analysis
Wyle Laboratories
D. Gibson and M. Healy
Report No. FRA/ORD-78/43A Feb. 1979

CHAPTER 4
INSPECTION AND TEST SUPPORT

The number of derailments resulting from defective vehicle and track components and unsafe train/track dynamics is a major concern of the FRA. Derailments account for the vast majority of significant accidents and related losses, including the costs associated with track, vehicle and lading damage, site cleanup, and repairs. Improved inspection and testing are needed to locate defects before they cause catastrophic accidents.

The goal of Inspection and Test Support is to improve the quality and capability for inspection, test and assessment of track and rolling stock for defective conditions. The major objectives are: 1) development and evaluation of track inspection devices, 2) development of improved concepts and techniques for rolling stock and components inspection, and 3) development of a plan for safety life cycle testing of rolling stock components and systems.

Four project areas have been defined to accomplish these objectives:

1) Rail Vehicle Inspection Systems;
2) Track Inspection Systems;
3) Safety Life Cycle Testing; and
4) Automated Wayside Inspection Systems.

To ensure that defect detection sensor systems and concepts for evaluation will be responsive to railroad industry needs, the FRA coordinates its research activities with railroads, industry groups, other researchers, and rail equipment suppliers.

Each project is carried out by the FRA through contracts with private and Federal research organizations. Descriptions of each project area, supporting contracts and bibliography of published reports follow.

RAIL VEHICLE INSPECTION SYSTEMS PROJECT

Under legislative authority established in 1970 and 1974, the Federal Railroad Administration (FRA) was charged with formulating and enforcing a set of safety standards for railroads. A critical element of safety improvement is the reduction of rail vehicle-caused accidents. In order to achieve accident rate reduction in this area, the FRA initiated research to support the development of inspection equipment and techniques which can be used by FRA and railroads in performing more extensive inspections and in increasing their thoroughness and reliability. The use of these techniques and equipment throughout the life cycle of the rail vehicle will result in significantly improved safety and economic benefits. These will be realized by minimizing premature replacement of components and assemblies and by timely replacement of critically defective components.

To date, there are no reliable inspection programs which can effectively detect problem areas existing throughout the life cycle of a rail vehicle. As a result, the following objectives were established for the rail vehicle inspection project:

- Plan and implement R&D projects to support the development of new and/or improved rail vehicle inspection systems;
- Demonstrate and evaluate the utility, technical and economic attractiveness of new and/or improved rail vehicle inspection systems;
- Establish a data base to support policy development;
- Provide an integrated structured program to support, evaluate and demonstrate continuing research and development activities; and
- Identify and characterize various types of safety systems and devices beneficial to railroad operating safety.

To achieve these objectives, four project areas of inspection were chosen to cover the life cycle inspection effort: 1) Components, 2) Yards, 3) On-Board, and 4) Wayside. The fourth effort, automated wayside inspection, a separate project activity, will be discussed later in this report. A brief description of the first three project areas follows:

"Component Inspections" seek to provide improved and new inspection methods, hardware and software for the inspection of vehicle components at the manufacturers, in repair shops and on repair tracks. A primary objective of this effort is to perform inspections on components in operational assemblies and operating in a dynamic mode.

"Yard Inspections" uncover more than 50 percent of defects and irregularities which do not conform to established standards. It is believed that a higher percentage of defects and irregularities can be detected by updating present procedures and including more and better handheld or portable inspection equipment. Evaluation and improvement efforts for yard inspection have been initiated to establish automated methods for inspecting roller bearings as a part of Yard Inspections.

"On-Board Inspection" is intended to provide information directly to the consist crew or consist safety systems as to the "safe conditions" of the vehicle and vehicle components functioning under full operational conditions of loads, speeds and environments.

TRACK INSPECTION SYSTEMS PROJECT

In 1978, track-caused accidents resulted in over $100 million in direct damage which corresponded to nearly 40 percent of all railroad-related direct damage. This cause of accidents has consistently exceeded all other major causal factors both in number of accidents and resulting dollar damages. For this reason, the FRA's Office of Research and Development has, for the last 6 years, carried out intensive efforts to:

1) Improve FRA's capability (speed and accuracy) to inspect track structures;
2) Improve the state-of-the-art in track inspection methods and systems; and
3) Develop systems capable of inspecting additional track parameters.

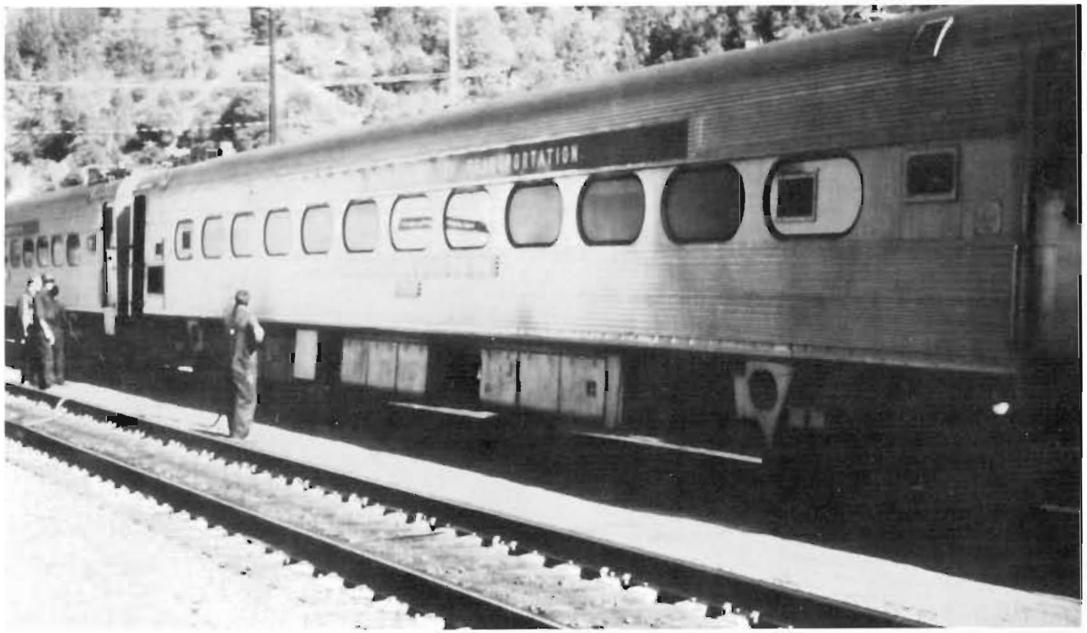
These efforts share a common objective: to reduce the number and severity of track-caused accidents through improved inspection of track structures and improved detection of critical track defects.

Work in the track inspection project to date addresses two major areas: Inspection for 1) track geometry defects and 2) rail flaws. These two areas accounted for 16.7 percent and 14.1 percent, respectively, of all train accident damages in 1978.

The track inspection project has developed track geometry inspection methods to measure gauge, crosslevel, alignment and profile within the accuracy constraints imposed by the Federal Track Safety Standards at regular track speeds. These methods are in use on the FRA Office of Safety's Automated Track Inspection cars. In the future, geometry inspection improvements may be required to improve inspection through improved reliability, and to extend the measurement range as required by the expected change to more comprehensive track standards.

FY80 efforts in the track geometry area were directed in the following areas:

1) Development of a self-propelled heavy rail inspection vehicle capable of main line, track-speed geometry inspections was underway for the FRA's Office of Safety's Automated Track Inspection Program (ATIP);



TRACK GEOMETRY SURVEY VEHICLES ARE NOW OPERATED OVER EVERY MAJOR RAILROAD IN THE RAIL NETWORK BY THE FRA OFFICE OF SAFETY TO DETERMINE TRACK SAFETY BY COMPARING ACTUAL TRACK MEASUREMENTS AGAINST FEDERAL TRACK SAFETY STANDARDS.

2) Further development of highway-rail (hy-rail) vehicles (already deployed) with both geometry and rail flaw detection systems for use in ATIP. (These hy-rail vehicles are designed for use on low-speed, lower class track, where the largest amount of accident damage is concentrated); and

3) Development of a low-cost, locomotive-mounted track geometry monitoring system, the Locomotive Track Hazard Detector (LTHD). This will provide immediate warning of track geometry conditions which threaten safe train operation, and will also record the geometry data for future review.

The second major area addressed in the Track Inspection Project is detection of rail flaws. Existing inspection methods to detect hazardous rail flaws such as transverse fissures, vertical and longitudinal split heads, and weld and bolt hole cracks have been the subject of continual development. Magnetic, induction, and ultrasonic technologies have been applied to this inspection area. Typically, inspection cars in use today can inspect up to a maximum speed of 15 mph, and because of the requirement to stop and verify each defect indication, the average speed ranges from 2 to 8 mph. Current technologies and operating practices do not consistently find all dangerous rail flaws.

FY80 efforts to improve rail flaw detection included assessment of existing and potential methods of detection including ultrasonic, magnetic, and induction test methods. An Electromagnetic Acoustic Transducer (EMAT) system which can detect flaws without contacting the rail surface is also under development.

Planned efforts in the track inspection area include the development of a system to inspect wayside track signal systems from a moving vehicle.

Major outputs of the track inspection project to date include the three consists of heavy track inspection vehicles: T-1/T-3, T-2/T-4, and T-6 and hy-rail R-2 used by the Office of Safety. These vehicles were developed and initially operated under this project. Hy-railer R-1 is in use to monitor track geometry and rail flaws at the Transportation Test Center. Hy-railer R-3 is in use as a test bed for new systems development. The LTHD was tested in late 1980, and will be made available to the railroad industry in the future.

In conclusion, the successful completion of the Track Inspection Systems project will provide FRA with a modern, efficient fleet of high-speed rail bound and low-speed hy-rail track inspection vehicles. In addition, the improved technology will provide a direct economic benefit by reducing accident frequency and improving inspection productivity. This higher productivity is expected to have a direct positive impact on the viability of rail transportation.

HY-RAIL RAIL FLAW DETECTION VEHICLE

CONTRACTS

Track and Inspection Research: Rail Flaw Detection System; and Loran-C Automatic Vehicle Positioning Monitoring
Contract No.: DOT-FR-64113
Funding: $1,071,000
Schedule: April 1978 – September 1980
FRA Technical Contact: R.J. McCown
(202) 426-1227
Agency/Contractor: ENSCO, Inc.

This contract is divided into two task areas, as described below.

Rail Flaw Detection System: The objective of this effort is to develop an automated rail flaw detection system suitable for operation at medium speeds.

The effort began with an extensive study of rail flaw detection systems used by the railroad industry. The study revealed that the average inspection speed of these systems was about 5 mph, limited by the requirement to stop and hand verify all defects detected by the system. It was determined that improvements were needed to provide the type of performance and utility needed to support FRA inspectors in performing their regulatory duties.

To satisfy both near-term requirements and long-term objectives, the FRA turned to a two-system approach: first, a hy-rail system to meet the immediate needs of the FRA Office of Safety; and second, the development of an automated rail flaw detection system to provide a rapid, uniform inspection capability in the future. To accomplish this automated rail flaw detection capability, efforts were directed toward three areas: improved sensor performance, automated control, and the addition of automated data processing.

Loran-C: The purpose of this task was to evaluate automatic rail vehicle position monitoring using LORAN-C in order to determine its utility in the railroad environment. A test program was conducted to exercise the system in the railroad environment and compare LORAN-C position fixes with known locations along the test route.

This study has found that the concept of locating railroad vehicles by means of LORAN-C radio navigation is feasible, but technical problems associated with receiver design and with radiowave propagation must be addressed if the LORAN-C system is to be placed in widespread use.

Development of Electromagnetic Acoustic Transducers (EMAT) for Rail Flaw Detection
Contract No.: DTFR53-80-C-00121
Funding: $944,000
Schedule: September 1979 – April 1980 (Phase A)
FRA Technical Contact: R.J: McCown
(202) 426-1277
Agency/Contractor: Rockwell International

This contract was designed as an investigation of the application of electromagnetic acoustic transducers (EMAT) to detection of flaws in railroad rails. The FRA's Track Safety Standards define rail defects and conditions which inspections must detect. The work in this contract used samples of flawed rails and laboratory EMAT equipment to determine whether the EMAT technology is capable of detecting critical rail defects with sensitivities comparable to those of existing piezoelectric systems. EMAT has the advantage of not requiring surface contact or a fluid coupling agent between the sensor and rail, which the existing systems require. Sperry Rail Service assisted Rockwell International in defining requirements for operational inspection systems, and in supplying flawed rails with piezoelectric analysis data for comparison with EMAT results.

The EMAT devices used in this work consist of a flat electromagnetic coil suspended in a strong static magnetic field close to the rail to be inspected. Radio frequency pulses in the EMAT coil generate eddy currents in the rail surface. The interaction of the eddy currents and the static magnetic field generates ultrasonic energy which can be beamed within the rail, and produces echo signals from cracks and other irregularities in the rail. The returning echoes interact with the magnetic field at the rail surface, creating an echo pulse in the EMAT coil which can be used to determine the presence and magnitude of defects encountered by the beam.

If interim goals are accomplished, a prototype system will be constructed and tested on an inspection car.

Development of Locomotive Track Hazard Detector, Track Signal Inspection System and Engineering Support on TX Development
Contract No.: DOT-FR-54090
Funding: $1,020,000
Schedule: March 1977 – January 1981
FRA Technical Contact: R.J. McCown
(202) 426-1227
Agency/Contractor: MITRE Corp.

This contract was divided into three task areas. Each will be described as a separate effort.

Locomotive Track Hazard Detector (LTHD): The objective of the LTHD task was to develop a low-cost, locomotive-mounted system capable of automatically monitoring track geometry and identifying conditions which threaten safe operation. The LTHD concept was designed to utilize a relatively simple and inexpensive set of accelerometers to obtain data related to track geometry conditions. A preprogrammed on-board data processing package was developed to monitor the data to identify conditions which threaten the safe operation of the train. The operating crew can be notified immediately of severe conditions; less severe conditions can be recorded for later attention by maintenance-of-way forces.

Track Signal Inspection System (TSIS): The objective of the TSIS task was to develop a system capable of monitoring and evaluating the in-track electronic signals transmitted by wayside block signal and crossing protection systems. The TSIS will allow FRA inspectors to determine the operability of the wayside electronic systems automatically from a moving vehicle.

Track Geometry Measurement Vehicle (TX) Development Support: The objective of the TX engineering support task was to supply the Office of Rail Safety Research with the necessary engineering resources to monitor and evaluate the progress of the TX prime contractor in completing the TX Program. Engineering support on the TX Program included review of complex designs and analyses, and independent projections of cost and schedule estimates to assist the Office of Rail Safety Research in monitoring the TX Program completion.

Track Geometry Measurement Vehicle T-10
Contract No.: DOT-FR-9112
Funding: $1,773,000
Schedule: August 1979 – March 1981
FRA Technical Contact: R.J. McCown
(202) 426-1227
Agency/Contractor: ENSCO, Inc.

The objective of this contract is to design, fabricate and test a self-propelled track geometry measurement vehicle for FRA.

The basic vehicle is an SPV-2000 manufactured by The Budd Company. The vehicle is equipped for operation in either direction at speeds up to 80 mph. Structural modifications to the vehicle were required to provide track inspector and crew support facilities and track geometry instrumentation installation.

The T-10 Track Geometry Measurement System (TGMS) is designed to measure track gage, curvature, cross level (superelevation), profile and alignment. Provisions are incorporated for measurement of distance, automatic location detection, and manual entry of supplemental information. The T-10 TGMS is equipped with a computer to analyze the track data and to immediately produce printed reports of exceptions to the FRA Track Safety Standards (TSS) at speeds up to 70 mph.

The T-10 system will be delivered to the FRA Office of Safety in March, 1981, to begin service in the Automated Track Inspection Program.

TRACK GEOMETRY INSPECTION INSTRUMENTATION SYSTEM

BUDD SPV-2000 DESIGNATED FRA T-10, THE FIRST SELF-PROPELLED ATIP VEHICLE, WILL STREAMLINE THE TRACK GEOMETRY MEASUREMENT PROCESS WHILE ADDING A REDUNDANT DATA PROCESSING SYSTEM AND ENHANCING SYSTEM RELIABILITY.

SAFETY LIFE CYCLE TESTING PROJECT

The objective of the Safety Life Cycle Testing Project is to apply safe life methods to rail vehicle operations in order to control the risk of accidents. Safe life methods involve the development of life cycle prediction techniques based on the identification of critical parameters in the system operating environment; determining system component capabilities; determining probable failure mechanisms; and determining the consequences of single or multiple failures on system operation over the entire system life cycle. Primary concern has been given to innovative vehicle or component designs which have no service history, where analysis and prediction techniques are the only available means of projecting system performance. When properly applied, this process allows the estimation, with reasonable confidence, of the period during which the system will continue to function properly without endangering the safety of operations. An outgrowth of this testing was to develop appropriate safety life cycle prediction techniques. These techniques are now undergoing validation. Although this approach to safety research is applicable to any vehicle, this project is applying it specifically to locomotives.

Safety Life Cycle Methodology Development/ AEM-7 Assessment
Contract No.: AR-74316
Funding: $1,591,000
Schedule: April 1977 – October 1981
FRA Technical Contact: R.J. McCown
(202) 426-1227
Agency/Contractor: Aerospace, Inc.

The research under this contract was designed to study the applicability of safe-life methods to railroad vehicle systems and components in order to develop a methodology for determining the safe-life of rail vehicle systems.

This work is being conducted in three phases: development of the methodology, development of safety-life guidelines, and application of the methods of a prototype locomotive. In the first phase, the activities included a study of rail vehicle component integrity, an assessment of the applicability of the Facility for Accelerated Service Testing (FAST) for safety life cycle testing, and general methodology development. The second phase activities included a failure analysis of the SD series of locomotives using actual accident data, preparation of safety life cycle prediction models based on fracture mechanics and locomotive dynamic performance considerations, and preparation of guidelines for safety life monitoring and testing of rail vehicles. The third phase activity, now underway, is to obtain performance data on the "break-in" period of the new Amtrak AEM-7 locomotive, and to use the data to initiate validation of the prediction models developed in the project.

AUTOMATED WAYSIDE INSPECTION SYSTEMS PROJECT

The Federal Railroad Administration is currently engaged in research directed toward development of improved inspection techniques to enhance railroad safety through reduction of derailments and inspection costs. The Automated Wayside Inspection Systems effort, begun in 1977, addresses detection of railcar component defects and load problems which account for approximately 20 percent of all derailments and 25 percent of the associated total costs.

Existing inspection techniques are mostly manual/visual with limited application of the few sensor systems currently available (primarily hotbox detectors and dragging equipment detectors). As used, the installations are mostly stand-alone and are, for the most part, incompatible with each other. As employed, this not only makes each installation expensive, but the techniques are not adequate to address the spectrum of derailment-causing defects, and are deficient for identifying unsafe dynamics and improper loading. The Wayside effort is therefore focused on the application of existing technologies and equipment for detection of the most significant causes of derailment. These major causes of derailment were identified in the 1977 report, "Wayside Derailment Inspection Requirements Study for Railroad Vehicle Equipment," which investigated broken and cracked wheels, worn flanges and loose wheels, defective brakes, overheated bearings, and dynamics (including overload and load imbalance problems). These defects cause deterioration of track and roadbed, thus contributing indirectly to derailment conditions.

The specific objectives of the FRA Automated Wayside Inspection Systems effort are to:

- Improve safety of railroad personnel, equipment, and movement of hazardous materials through populated areas;
- Develop practical solutions to railroad safety problems by maximizing the use of existing and new defect detection sensors;
- Reduce cost, frequency, and complexity of inspection;
- Improve range and accuracy of defect detection techniques;
- Improve timeliness of defect identification and reporting; and
- Provide capability which can be adapted to individual user needs.

In order to meet these objectives, the approach adopted for development of a wayside detection capability includes:

- Utilization of existing sensor technology and equipment to minimize unnecessary development time and cost;
- Incorporation of sensor capabilities into an overall system to provide integration of defect detection capabilities and consolidated defect reporting;
- Development of new real-time inspection capabilities by combining and assessing data from various sensor combinations;
- Physical integration and shared utilization of components common to various sensor systems to reduce procurement and operating costs;
- Development of modular design to permit system capabilities to be added as user and site requirements dictate; and
- Coordination with the railroads and the railcar equipment supply industry to ensure that development is compatible with user needs.

The Wayside Detection effort will accomplish its objective of improving inspection techniques by applying existing technologies in three phases.

Phase I (in three stages — feasibility, expansion and standardization; device evaluation; and data base expansion) — Development of an Automated Wayside

Detection Research Facility (WDRF) to evaluate the automated, integrated modular approach to component fault detection, and to serve as an eventual testbed for evaluation of detection technologies and equipments.

Under this phase it is necessary to conduct exploratory development of concepts for braking inspection, cracked plate detection and wheel size/flange height measurements. These three concepts are essential to the detection of the major vehicle causes for derailments.

Phase II – Construction and evaluation of a multi-sensor field service Wayside Detection Facility that will provide for Composite Analysis of Railcar Safety and Components with Automatic Notification (CAR-SCAN).

Phase III – Evaluation of the effectiveness and cost-benefits of CAR-SCAN facilities deployed in a network configuration. Phases II and III will overlap the Phase I testbed stage.

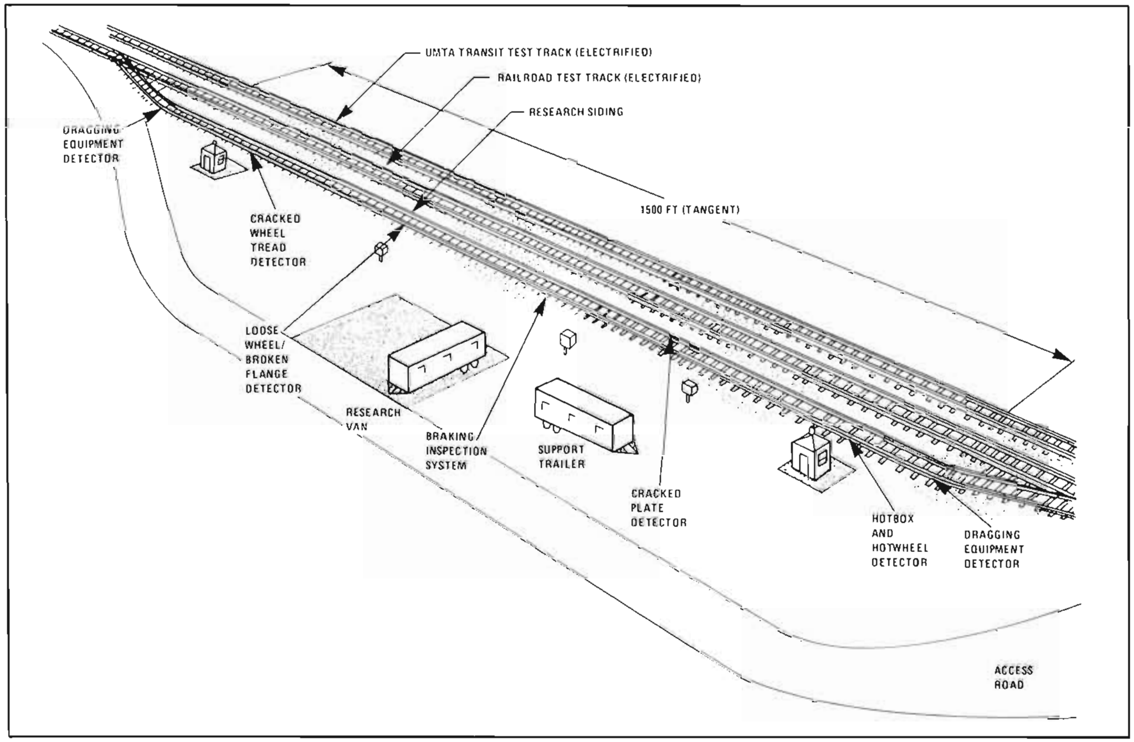
The FRA Office of Research and Development has constructed and is operating a Wayside Detection Research Facility (WDRF) at the Transportation Test Center in Pueblo, Colorado, to detect rail car defective equipment and unsafe conditions while the car is in motion. Related objectives are to:

1) identify the location of defect(s);
2) report the defects and locations in near real-time and in a digitized format;
3) detect and report defects faster and more accurately than current practices; and
4) detect defects not amenable to current inspection practices.

This facility incorporates a Research Data Van with a central electronic complex which integrates responses from various types of sensor systems installed on a test track siding. The WDRF is being developed to have capabilities for detecting overheated wheels and bearings, loose wheels, broken flanges, cracked wheel treads, dragging equipment, braking conditions for each wheel, high wheel flanges, and excessive and/or uneven wheel wear, as well as capability for in-motion measurement of rail car weight and load distribution.

The WDRF central electronics complex is configured to permit test and evaluation research to determine operating characteristics of various sensor systems. Initially, the eight types of sensor systems previously discussed will be evaluated over representative ranges of sensor calibration settings, consist speeds and other controlled or monitored conditions, such as weather.

Experiments are conducted utilizing railcar components with fabricated defect conditions to permit controlled testing and data analysis. To date, the first series of tests has been conducted to determine the operating characteristics of the Ultrasonic Cracked Tread Detector (UCTD) and the Acoustic Cracked Plate Detector (ACPD). Series I, characterization testing, is currently underway for a Braking Inspection System (BIS).



WAYSIDE DETECTION RESEARCH FACILITY SITE CONFIGURATION

Each series of tests for a sensor system(s) will investigate the system(s) response to a significant set or class of conditions, such as defect type, defect size, defect location, speed variation, system modification, etc. Test reports for each series, sensor or group of sensors will be published. In addition, an executive summary report will be published which identifies key elements of progress toward the evolution from the WDRF to a CAR-SCAN field facility.

It is anticipated that an eventual production version of CAR-SCAN will offer a significant cost/benefit advantage over current inspection techniques and will incorporate modularity to permit railroads to configure their facilities to satisfy individual site requirements.

Wayside Detection Research Facility (WDRF), Phase I

Contract No.: Interagency Agreement AR-74355
Funding: $3,202,000
Schedule: October 1977 – September 1983 (Phase I)
FRA Technical Contact: J.D. Ferguson (202) 426-1682
Agency/Contractor: Aerospace Corporation

The Aerospace Corporation is providing systems engineering and technical coordination for establishing and operating the automated Wayside Detection Research Facility (WDRF) at the Transportation Test Center (TTC) in Pueblo, Colorado, to detect in-motion rail car defective equipment and unsafe conditions. The WDRF has capabilities to detect in-motion rail car defective components, identifying defect locations, generating real-time digital reports of the defects and locations and detecting defects not amenable to current-day inspection practices, i.e., braking performance, wheel plate cracks and skewed axles.

The development schedule for this facility is as follows: FY77 was used to study the need for the automated multi-sensor wayside inspection approach. A Wayside Detection Facility concept was developed and preliminary planning was completed. FY78 was devoted to design, construction and equipment installation at the TTC research facility. FY79 testing involved evaluation of the Cracked Tread Detector System and preliminary testing of the Loose Wheel/Broken Flange Detector, Wheel Presence Detectors, Wheelsize and Flange Height Measurement, and Braking Inspection Systems. FY80 primary activities focused on test and evaluation of the basic braking inspection and cracked wheel plate, and initiation of the alarm logic development. In addition, the measurements and design for grounding and power separation were scheduled for completion. FY81 activities will be devoted to completion of testing on wheel defects in support of developing alarm algorithms for braking inspection. Testing will include 1) cracks in wheel tread, flange and plate; and 2) sticking brakes, excessive or inadequate braking, no brakes, dragging brake shoes and dropped brake rigging. Power and grounding separation will be completed together with the development of an automated data management system and improved integrated system controls. FY82 activities will include integration of cracked plate and braking inspection systems with all other facility sensors, evaluation of weight-in-motion measurement, and testing of individual and combined sensor capabilities for 1) overheated bearings, 2) dynamic overload and excessive load imbalance, and 3) improved reliability of detection of wheel cracks. FY83 activities will include the completion of Phase I testing (including CPD, BIS and HB/HW systems).

DRAGGING EQUIPMENT DETECTOR

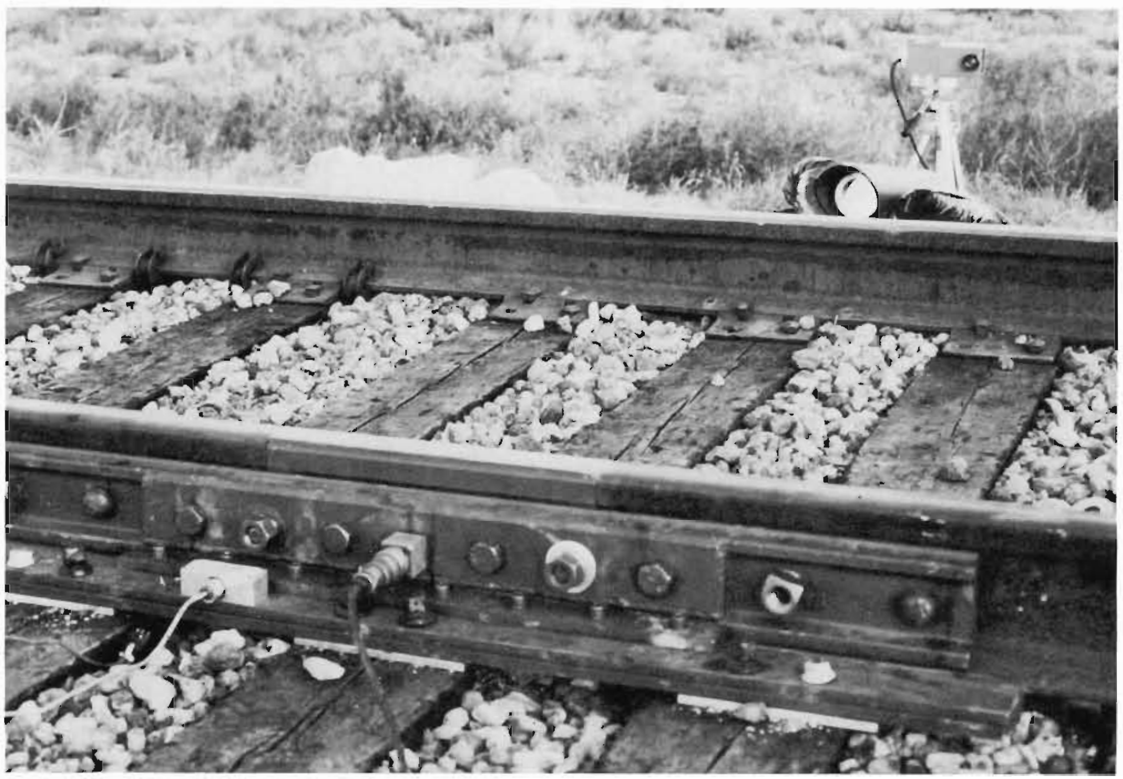
Brake Inspection System
Contract No.: DOT-FR-8079
Funding: $114,000
Schedule: June 1978 – September 1980
FRA Technical Contact: J.D. Ferguson
(202) 426-1682
Agency/Contractor: Novatek, Inc.

Air braking systems on railway cars have traditionally been inspected by trainmen walking the length of a consist while visually and/or manually checking the performance, adjustment and condition of the braking components.

The objective of this contract was to develop concepts into a wayside brake inspection system capable of evaluating railcar braking performance in a dynamic mode.

An effective brake inspection system, if widely deployed, should result in a significant decrease in railway accidents due to brake failures.

A two-phase effort was undertaken to study the feasibility of one particular brake inspection concept. The concepts utilized and evaluated consisted of the following: reaction rail force detectors, infrared detectors, car counters, and support electronics and hardware.



A PROTOTYPE WAYSIDE BRAKE INSPECTION SYSTEM

Feasibility Study on the Utilization of a Modified Pitless In-Motion Railway Scale to Detect Faulty Components and Component Systems
Contract No.: DOT-FR-8003
Funding: $24,160
Schedule: August 1978 – April 1980
Technical Contact: J.D. Ferguson
(202) 426-1682
Agency/Contractor: S.H. Raskin Corp.

The objective of this contract was to develop a detailed feasibility plan that could utilize a Modified Pitless-In-Motion Railway Scale system to detect faulty components and component systems.

This plan includes detecting critical components and performance conditions such as: lateral and vertical rail forces, defective wheels, brakes and bearings, centerplate friction, consist speed, hunting, creep, rock and roll.

The feasibility plan considers:

1) Data acquisition and management;
2) Recommended site (existing railroad facility) for data acquisition;
3) Manpower requirements;
4) Specification of modification to existing (on-site) equipment and software programs;
5) Analysis of methodology vs. reliability for optimum data sample;
6) Recommended milestones; and
7) A description of all testing, test facilities and data analysis.

A final report recommended the implementation of the Feasibility Study Plan with any railroad company that meets the required site, scale, and operating criteria described in the plan requirements.

Operation and Maintenance of the Wayside Detection Research Facility (Task 468)

Contract No.: DOT-FR-64113

Funding: $347,515 (Estimated Completion Value)

Schedule: March 1979 -- September 1980

FRA Technical Contact: J.D. Ferguson (202) 426-1682

Agency/Contractor: ENSCO, Inc.

The objectives of this contract were to provide detailed engineering and installation support for the Automated Wayside Detection Facility and to provide operations and maintenance of the Wayside Research Facility.

ENSCO provided qualified personnel and material to operate and maintain the Wayside Detection Research Data Van (WRV) and the in-rail instrumentation (IRI) installed on the Wayside Detection/Safety Research Siding at the Transportation Test Center (TTC). This work included all normal engineering activities associated with the operation of the WRV and the IRI.

ENSCO maintained the data records collected during the tests, including information in the form of recorder charts, video magnetic tape, digital magnetic tape, magnetic disc cartridges and computer printouts.

INSPECTION AND TEST SUPPORT BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

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Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Design, Fabrication, and Evaluation of Prototype Wayside Brake Inspection Sensors
Novatek, Inc.
David B. Spaulding, et al
Report No. FRA/ORD-80/20 June 1980

Development of an Inertia Profilometer
ENSCO, Inc.
Report No. FRA/ORD-75/15

Development of the Locomotive Track Hazard Detector
MITRE Corp.

Development of a Prototype EMAT System for Inspection of Rails
Rockwell International
G. Alers, et al
Report No. FRA/ORD-80/45 Sept. 1980

Feasibility of Flaw Detection in Railroad Wheels Using Acoustic Signatures
University of Houston
Report No. FRA/ORD-76/290

Feasibility of LORAN-C In Determining the Position of Rail Vehicles in Transit
ENSCO, Inc.
J. Donahue and J. Conner
Report No. DOT-FR-80/32 Aug. 1980

Interim Data Report for the Ultrasonic Cracked Tread Detector Tests at the Transportation Test Center
Aerospace, Inc.
George J. McPherson, Jr. July 1980

On-Board Failure-Protection Requirement for Railroad-Vehicle Equipment
Shaker Research Corp.
R.L. Smith and J.L. Frarey
Report No. FRA/ORD-78/72 March 1979

Operational Parameters in Acoustic Signature Inspection of Railroad Wheels
University of Houston
D. Dousis and R.D. Finch
Report No. FRA/ORD-80/21 April 1980

Prevention of Roller Bearing – Initiated Burnoffs in Railroad Freight Car Journals
SKF Industries, Inc.
G.E. Allen, et al
Report No. FRA/ORD-78/16

Rail Car Component Defect Detection Using Pitless Railway Scales (A Feasibility Study Plan)
S.H. Raskin Corp.
S.H. Raskin
Report No. FRA/ORD-79/50 Sept. 1980

Rail Inspection System Analysis and Technology Survey
Report No. FRA/ORD-77/39 Sept. 1977

Review of Measurement Techniques, Requirements, and Available Data on the Dynamic Compliance of Railroad Track
ENSCO, Inc.
Report No. FRA/ORD-76/70

Track Geometry Measurement System for Hi-Railer Application
ENSCO, Inc.
Report No. FRA/ORD-80/80 Nov. 1980

Track Geometry Measurement Vehicle
MITRE Corp.

Use of Automatically Acquired Track Geometry Data for Maintenance-Of-Way Planning
ENSCO, Inc.
G. Hayes, et al
Report No. FRA/ORD-80/44 June 1980

Wayside Derailment Inspection Requirements Study for Railroad Vehicle Equipment
Shaker Research Corp.
J.L. Frarey, et al
Report No. FRA/ORD-77/18 May 1977

CHAPTER 5
HUMAN FACTORS

From 1976 to 1978, the total number of casualties sustained by on-duty personnel during train operations rose 12.4 percent, with casualties in 1978 totaling 65,193. During this period, rail activity actually declined when measured in terms of annual train miles run and employment.

To improve railroad safety through crew operations, the Federal Railroad Administration (FRA) is developing a sophisticated research tool, the Locomotive and Train Handling Evaluator. The evaluator has the capability to simulate actual locomotive operations under a variety of operating conditions. Research in this area includes train handling, training, and safety programs.

The objective of the Human Factors subprogram is to reduce the safety hazards experienced by the engine crew, improve train handling and limit occupant casualties through improved design of locomotive interiors.

The two projects included in the Human Factors subprogram are:

1) Crew Operations, and

2) Employee Personnel Safety.

Each project is carried out by the FRA through contracts with private and Federal research organizations. Descriptions of each project, associated contracts and bibliography of published reports follow.

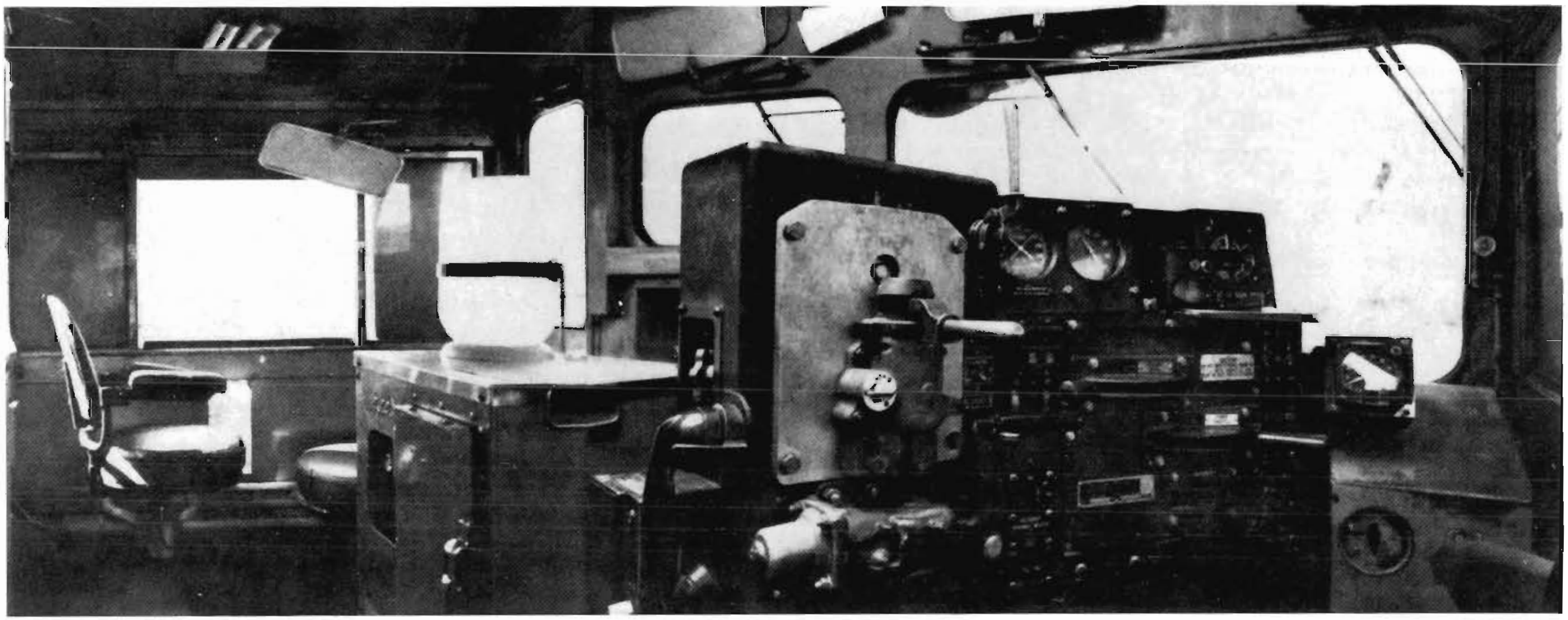
CREW OPERATIONS PROJECT

A majority of the causes of train derailments and collisions can be attributed to human causative factors. Costly damage and serious personal injury often result. The objective of this project is to reduce the occurrence of such accidents through improved crew operations.

Personnel behavior, human/machine interaction, and environmental conditions have been identified as particular areas in which countermeasures can and should be developed.

A locomotive and train handling simulator is currently being developed which is intended to provide a rapid evaluation of crew performance in response to changes in these areas. Specific considerations include variations in cab environment, different training methods, improved train handling techniques and devices, and proposed equipment and procedural revisions.

The data obtained from the operation of the locomotive simulation will be utilized in safety improvements, systems development, and reduction in costs.



INTERIOR OF SD-45 EMD LOCOMOTIVE

CONTRACTS

Research Locomotive and Train Handling Evaluator
Contract No.: FR-9142
Funding: $8,260,000
Schedule: September 1979 – September 1982
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: Teledyne Ryan Aeronautical

The focus of this contract is the development of a Locomotive and Train Handling Evaluator. The evaluator will simulate operating conditions as realistically as possible and provide data concerning the response and performance of the train crew in controlling the train. The effects of different operator procedures, operator aids, locomotive cab environments and work cycles on engine crew performance will be determined.

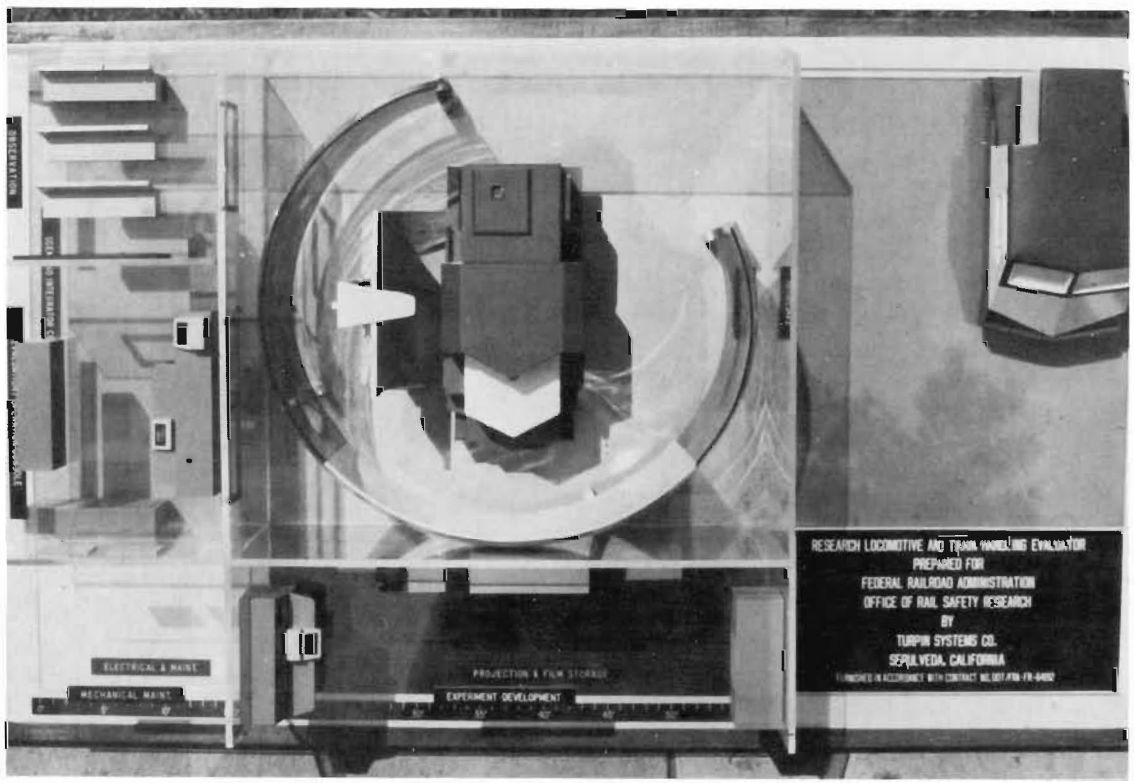
State-of-the-art computer models will be utilized. More realistic visual and sound producing systems will be developed. Tests of operating procedures, equipment, etc., not currently in use will be provided.

Research Locomotive and Train Handling Evaluator Support
Contract No.: FR-5380
Funding: $225,000
Schedule: January 22, 1980 – April 22, 1983
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: Joint Cruise Missile Project Office

The objective of this contract is to help maintain the schedule and cost estimates of the basic contract with Teledyne Ryan involving the development of the locomotive evaluator by the review and analysis of subsystem specifications, block diagrams and schematics, software development data and reliability and maintenance designs.

Monthly reviews of cost data to analyze expenditure rates will be performed.

Master work schedule, cost plan, monthly progress reports and a final report containing conclusions and recommendations will be provided.



RESEARCH LOCOMOTIVE EVALUATOR

EMPLOYEE PERSONNEL SAFETY PROJECT

Accident/Incident Bulletins issued annually by the FRA contain data analyses which indicate the rail safety for the rail employee deteriorated during the period between 1976 and 1978.

Rail safety is a major concern of the FRA, and studies which look into safety programs and procedures to uncover the underlying causes of rail casualties have been set up.

The Employee Personnel Safety Project is involved in research studies to improve the work environment for crew members working on board trains, and for those working on and around railroad cars. Past research investigated the in-cab environment for fumes and noise, methods of reducing hazards to employees working on and around trains, and the problem of railroad vandalism. Performance specifications were developed for glazing material to be used in locomotives, cabooses, and passenger cars. These specifications have since been incorporated into an FRA regulation.

The FRA has conducted research to study these three areas of importance in rail safety:

1) A Human Factors Engineering Systems Analysis of the design of equipment such as ladders, handholds, grab irons, breakwheels, brake platforms, etc., found on typical U.S. rail rolling stock and suspected of being, in part, responsible for incidents resulting in personal injuries;
2) Identification of the degree of personal injury hazard associated with certain rail operations and railroad job classifications; and
3) Recommended safety appliance design modifications intended to enhance their effectiveness.

This study acknowledged the subjective element in assessing injury severity data during Getting On/Off incidents. Hence, there was a search for an injury classification and severity rating scheme. Finally, it was decided to combine this approach with that of using the average number of work days lost per injury as a measurement of the injury's severity.

Combining these two approaches resulted in injury profiles based on major occurrence in each functional area which will be of considerable use to those formulating and implementing rail safety programs, practices, and procedures.

Both the FRA and the Atchison, Topeka and Santa Fe Railway Company provided data on major occurrences in each functional area: getting on and off, uncoupling cars, disconnecting hoses, and operating handbrakes. These areas were then cross-referenced with appliances in order to identify each safety appliance which then could be studied and evaluated as to physical design characteristics.

Another area of major concern is identifying man/machine interfaces in order to be able to design safety equipment which will reconcile the simultaneous requirements of an operational/technical nature with those of a functional/human nature.

Analysis of Engineer Performance
Contract No.: DOT-FR53-80C 00096
Funding: $49,589
Schedule: May 1980 – May 1981
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: B&M Technological Services

B&M Technological Services is conducting a task analysis for the FRA of the locomotive engineer in order to determine areas where potential exists for improved safety.

National Transportation Safety Board (NTSB) recommendations and other data will be analyzed to develop trends in engineer performance which affect his train handling capability.

Analysis of Personal Injury Hazards
Contract No.: FR-8012
Funding: $344,451
Schedule: March 1978 – March 1981
FRA Technical Contact: D.A. Vaughn
(202) 426-1227
Agency/Contractor: Dynamic Sciences, Inc.

Dynamic Sciences, Inc. is conducting a human factors engineering systems analysis for the Federal Railroad Administration (FRA) of the designs of existing U.S. rail cars in order to assess whether or not those designs contribute to employee personal injury accidents.

It has been noted that train and engineer transportation workers are subjected to a large number of injuries in and around or on locomotives or rolling stock.

Four tasks are to be accomplished in this study, as described below.

Task 1: Comparative Analysis – Review of the design of U.S. and foreign rail cars and locomotives (European and Japanese).

Task 2: Development of Human Engineering Safety Assessment Methodology –. Develop a methodology for analytically performing an employee personal injury hazard assessment.

Task 3: Development of a Hazard Index for Covered Hopper Cars – Determine overall employee personal hazard index for covered hopper cars using Task 2 methodology.

Task 4: Validation of Countermeasure Safety Effectiveness – Study the effectiveness of Task 3 countermeasures.

EVALUATION OF PROTOTYPE SAFETY APPLIANCES ON A MODIFIED CAR

Railroad Vandalism
Contract No.: AR-8038
Funding: $225,000
Schedule: March 17, 1978 – September 30, 1981
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: Ballistics Research Laboratory

The Ballistics Research Laboratory is conducting a research study for the FRA to assess the extent of vandalism to urban area railroads. This study will determine the degree to which an improved communications network improves the effectiveness of the various railroad police forces in reducing vandalism, as well as the desirability of expanding this approach to other large urban areas in the U.S.

This effort has been divided into five tasks: Task 1 – Assessment of current vandalism status;

Task 2 – Improved communications network;

Task 3 – Implementation and utilization of an improved communications system unifying all surveillance efforts;

Task 4 – Collections of data; and

Task 5 – A final report on the results of this study.

A Study of the Relationship Between Railroad Employee Safety Program Context and Methods of Implementation

Contract No.: AR-8082
Funding: $195,400
Schedule: July 1978 – June 1980
FRA Technical Contact: D. Levine
(202) 426-1227
Agency/Contractor: Ballistics Research Laboratory

A review of railroad safety program goals, context, emphasis areas and approach indicates that there is a general lack of uniformity/categorization among programs. The degree to which scientific categorization, uniformity, or upgrading of program context and approach to implementation will increase safety within the railroad industry must be assessed. BRL has successfully completed Phase I of this study for the FRA.

The BRL has reviewed responsible railroad personnel and determined the factors perceived to have the greatest influence on employee program success. An in-depth survey was conducted for the Safety Directors of 18 railroads. The BRL and the Association of American Railroads (AAR) selected a subset of two railroads for an in-depth management and labor study. The performance of the railroad's safety program was assessed.

TESTING OF VANDAL – RESISTANT WINDSHIELDS

HUMAN FACTORS BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

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Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Locomotive Cab Design Development: V.1, Analysis of Locomotive Cab Environment and Development of Cab Design Alternatives
Boeing Vertol Co.
J. Robinson, et al
Report No. FRA/ORD-76/275.1 Oct. 1976
PB 262-976/AS

Locomotive Cab Design Development: V.2, Operator's Manual
Boeing Vertol Co.
J. Robinson
Report No. FRA/ORD-76/275.2 Oct. 1976
PB 264-114

Locomotive Cab Design Development: V.3, Design Application Analysis
Boeing Vertol Co.
J. Robinson
Report No. FRA/ORD-76/275.3
PB 264-115/AS

Locomotive Cab Design Development: V.4, Recommended Design
Boeing Vertol Co.
J. Robinson
Report No. FRA/ORD-76/275.4 Nov. 1978
PB 290-214

Maintaining Alertness in Railroad Locomotive Crews
Transportation Systems Center
C.B. DeVoc and C.N. Abernathy
Report No. FRA/ORD-77/22 March 1977
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Personnel Safety on Electrified Railroads
Transportation Systems Center
J.D. Abbas, et al
Report No. FRA/ORD-80/36 June 1980
PB 80-220858

Proposed Qualification Requirements for Selected Railroad Jobs
Dunlap and Assoc., Inc.
A. Hale and H.H. Jacobs
Report No. FRA/ORD-75/44 May 1975
PB 251-115

Research Locomotive and Train Handling Evaluator Definition: Concept 1
M.B. Associates
S. Hubert, et al
Report No. FRA/ORD-77/46 Aug. 1977
PB 276-362 (set)

Research Locomotive and Train Handling Evaluator Definition: Concept 1
M.B. Associates
S. Hubert, et al
Report No. FRA/ORD-77/46 Aug. 1977
PB 276-363

Research Locomotive and Train Handling Evaluator Definition: Concept 1, V.1, Evaluator Performance Specification
M.B. Associates
S. Hubert, et al
Report No. FRA/ORD-77/47.1 Sept. 1977
PB 276-364

Research Locomotive and Train Handling Evaluator Definition: Concept 1, V.2, Detailed System Studies
M.B. Associates
S. Hubert, et al
Report No. FRA/ORD-77/47.2 Aug. 1977
PB 276-365

Research Locomotive and Train Handling Evaluator Definition: Concept 1, V.3, Estimated Costs
M.B. Associates
S. Hubert, et al
Report No. FRA/ORD-77/47.3 Aug. 1977
PB 276-366

Research Locomotive and Train Handling Evaluator Definition, Concept 2 Interim Report
Turpin Systems Co.
Report No. FRA/ORD-77/55 Aug. 1977
PB 276-491

Studies of Freight Train Engineer Performance
Transportation Systems Center
E.D. Sussman & D. Ofsevit
Report No. FRA/ORD-76/306 Dec. 1976
PB 267-622

Train Generated Air Contaminants in the Train Crew's Working Environment
Transportation Systems Center
J.R. Hobbs, et al
Report No. FRA/ORD-77/08 Feb. 1977
PB 265-355

CHAPTER 6
GRADE CROSSINGS

Grade crossing accidents persist in being the major cause of fatalities in railroad operations. The goal of the grade crossing subprogram is to reduce the number and the severity of such accidents by:

1) improving the credibility of motorist warning devices at crossings;
2) demonstrating improved systems for alerting the motorist to the presence of trains; and
3) developing practical means for protecting motorists and crew members from serious injury and death when involved in grade crossing accidents.

Grade crossing research is jointly conducted by the FRA and the Federal Highway Administration (FHWA). Areas of research include on-board devices, motorist warnings, and train detection. New concepts are developed and provided to the supply industry so that appropriate hardware can be developed. Performance specifications and guidelines for improved motorist warnings can be used by states, local governments, and railroads to achieve maximum effectiveness of motorist warning devices.

Descriptions of contracts for this area follow.

IMPROVEMENTS BEING MADE AT A RAIL-HIGHWAY GRADE CROSSING

CONTRACTS

Grade Crossing Accident/Injury Minimization Study
Contract No.: FR-8197
Funding- $97,096
Schedule: September 1978 – January 1981
FRA Technical Contact: J.V. Mirabella (202) 426-1227
Agency/Contractor: H.H. Aerospace Design Company

The purpose of this contract was to evaluate alternatives for minimizing injuries to motorists, train passengers, and crew members resulting from grade crossing accidents.

The contractor reviewed, identified, and investigated grade crossing injury minimization concepts and equipment. Included in this analysis were a compilation of data concerning the degree of injury for given accident conditions and speed conduct, and a cost/benefit analysis of the various injury minimization concepts and equipment. The goal of this study was to minimize the degree of injury in those accidents which cannot be avoided.

Constant Warning Time Concept Development for Motorist Warning at Grade Crossings
Contract No.: FR-8042
Funding: $321,391
Schedule: April 1978 – July 1980
FRA Technical Contact: J.V. Mirabella (202) 426-1227
Agency/Contractor: Systems Technology Laboratory

The objective of this contract was to identify, evaluate and demonstrate the feasibility of concepts upon which a system can be based to provide motorist warnings at grade crossings, independent of the speed of the approaching train, without having the warning device activated by railroad switching movements near a grade crossing.

The contract was divided into two phases. Phase I focused on contacting other groups involved in the manufacture and research of safety warning devices and reporting on concepts providing constant warning time to motorists, emphasizing innovative and new techniques rather than improvements on existing systems.

Phase II included an analysis of the concepts selected for study and a concept demonstration test plan for each, identifying the effects of using new types of locomotive controls on train detection.

Investigation of Grade Crossing Accident Countermeasures and Research Requirements
Contract No.: AR-8088
Funding: $95,000
Schedule: August 1978 – July 1981
FRA Technical Contact: J.V. Mirabella (202) 426-1227
Agency/Contractor: National Aeronautics and Space Administration

The probable causes of railroad grade crossing accidents will be studied through the identification of potential research and its assessment. The goal of this study is to reduce the number and severity of railroad grade crossing accidents by providing measures which will prevent such accidents.

GRADE CROSSINGS BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

A Communication-Link Approach to Actuation of Grade Crossing Motorist Warning Systems
Transportation Systems Center
John B. Hopkins, et al
Report No. FRA/ORD-75/80 July 1975
PB 244-584

Field Evaluation of Locomotive Conspicuity Lights
Transportation Systems Center
D.B. Devoe and C.N. Abernathy
Report No. FRA/ORD-75/54 May 1975
PB 244-532

Guidelines for Enhancement of Trains at Grade Crossings
Transportation Systems Center
John B. Hopkins and A.T. Newfell
Report No. FRA/ORD-75/71 May 1975
PB 244-551

Identification and Evaluation of Off-Track Train Detection Systems for Grade Crossing Applications
GARD, Inc.
E.E. Nylund, et al
Report No. FRA/ORD-80/32 April 1980
PB 80-186430

Improvement of the Effectiveness of Motorist Warnings at Railroad-highway Grade Crossings
Transportation Systems Center
John B. Hopkins and E. White
Report No. FRA/ORD-77/07 Feb. 77
PB 266-784

Innovative Concepts and Technology for Railroad-highway Grade Crossing Motorist Warning Systems
V.1 Overview and Concept Generation and Analysis
Cincinnati Electronics Corp.
I.H. Raab, et al
Report No. FRA/ORD-77/37.1 Sept. 1977
PB 273-354

Innovative Concepts and Technology for Railroad-highway Grade Crossing Motorist Warning Systems
V.2 The Generation and Analysis of Alternative Concepts
Tracor Jitco, Inc.
D.D. Peterson and D.S. Boyer
Report No. FRA/ORD-77/37.2 Sept. 1977
PB 273-355

A Methodology for Determination of Grade-Crossing Resource-Allocation Guidelines
Transportation Systems Center
John B. Hopkins and Morris E. Hazel
Report No. FRA/ORD-76/04 Aug. 1975
PB 259-005

Operational Testing of Locomotive-Mounted Strobe Lights
Transportation Systems Center
John B. Hopkins
Report No. FRA/ORD-80/48 June 1980
PB 80-224348

Potential Means of Cost Reduction in Grade Crossing Automated Gate Systems
V.1 Overview and Low Cost Railroad-highway Grade Crossing Gate Systems
MB Associates
Andrew St. Amant
Report No. FRA/ORD-77/06.1 Feb. 1977
PB 265-724

Potential Means of Cost Reduction in Grade Crossing Automatic Gate Systems
V.2 Improved Gate Arm Concepts for Railroad-highway Grade Crossings
Report No. FRA/ORD-77/06.2 Feb. 1977
PB 265-725

Potential Means of Cost Reduction in Grade Crossing Motorist-Warning Control Equipment V.1 Overview Technology Survey, and Relay Alternatives
Storch Engineers
C.L. DuVivier, et al
Report No. FRA/ORD-77/45.1 Dec. 1977
PB 277-946/AS

Potential Means of Cost Reduction in Grade Crossing Motorist-Warning Control Equipment V.2 Comparison of Solid State and Relay Devices and Techniques
Lowell University Research Foundation
F.Ross Holmstrom
Report No. FRA/ORD-77/45.2 Dec. 1977
PB 277-947

Standby Power for Railroad-highway Grade Crossing Warning Systems
Lowell University Research Foundation
F. Ross Holmstrom
Report No. FRA/ORD-76/286 Sept. 1976
PB 263-592

CHAPTER 7
SAFETY TESTING (FAST)

The Facility for Accelerated Service Testing (FAST) track is a research tool which, for the first time, provides the U.S. railroad community with a means of testing track and equipment components in a simulated service environment. FAST is a means of evaluating components which show promise in laboratory testing prior to their evaluation in revenue service. This evaluation can be accomplished readily under tightly-controlled test conditions.

FAST has now been in successful operation since 1976. A great deal has been learned; much remains to be accomplished. FAST continues to operate in the spirit of cooperation which enabled a highly complex research facility to be approved, assembled, and made fully operational in well under a year. Support for this project has come from an industry-wide base: the railroads, the railroad supply industry, the Railroad Progress Institute, the Association of American Railroads (AAR), the Federal Railroad Administration (FRA), and the Transportation Development Agency of Canada.

FAST commenced operations in 1976 to answer the need for a full systems approach to track structure and rail vehicle research.

The first of its kind in the United States, FAST evaluates the performance of track structures and components 7 to 10 times more rapidly than conventional test applications. This reduction in test time is achieved by operating a train consisting of 4 locomotives and 75 freight cars over a closed track loop for 15 hours a day, 5 days a week, thereby permitting the rapid accumulation of tonnage.

The FAST subprogram is a cost-sharing, cooperative effort with the railroad industry, which has donated all of the rolling stock, track test specimens, training, power, and shop labor. This participation is equivalent to more than 20 percent of the total FAST cost.

Through FY80, FAST has exceeded 540 million gross tons of track service and 302,000 miles of train operation. The FRA anticipates that FAST will prove to be a vital element in providing timely data for improvement of railroad operations in the areas of track, rolling stock, control and surveillance equipment maintenance and operating practices.

Several track-related experiments at FAST are supported through the Improved Track Structures Research Subprogram. These include studies on rail, wood and concrete ties and fasteners, ballast and subgrade. Support is accomplished by either direct involvement in the project through the Experiment Manager (EM) process or through contracts with outside organizations. The EM is an important part of the FAST organization, being responsible for experiment preparation, management, data analysis, and report writing.

Significant among the many accomplishments of this project are the following FAST research findings.

Wheels: Results from the first wheel experiment indicate that the flange life of heat-treated wheels (Grade C) is 2 1/3 times longer than untreated wheels (Grade U). Unit train operators are increasing the use of Grade C wheels. Other variables (cast wheels as opposed to wrought wheels, CN profile as opposed to AAR profile, 14-inch center plate as opposed to 16-inch center plate, and constant friction snubbing truck as opposed to variable friction snubbing truck) indicate a slight improvement in flange life.

Car Structure: Fatigue cracks developed in certain car designs. FAST Test results discovered the cause of the cracks, and determined the best method of preventing the cracks in the future. C&O and CNW will incorporate the FAST method of fixing the cracks if they develop on their lines. The car manufacturer is also aware of the results.

Fatigue Guidelines: The results of the Fatigue Test have indicated the conservative nature of the Fatigue Design Guidelines utilized by the industry, and have suggested certain changes that should be made to the guidelines to make them more realistic.

Track Lubrication: A recent evaluation of track lubrication practices at FAST revealed differences in distribution patterns of silicone and petroleum-based greases. Also, the two locations and the output of track lubricators which provide uniform lubrication of the FAST Loop were identified.

Radial Trucks: Initial results from the Radial Truck Experiment indicate that radial trucks may improve wheel flange life by 2½ to 4 times over conventional trucks. Also, the radial trucks appear to be sensitive to initial axle alignment and wheel profile.

Variable Axle Load: Initial results from the Variable Axle Load Experiment indicate that for a 100-ton car, flange wear rate as a function of car lading does not increase significantly above 80 tons (from 80 to 110 tons). This result requires further investigation.

Concrete Tie Track: Results from the first experiment indicate that concrete tie track has higher lateral stiffness than wood tie track.

Rail Wear: From the wear results of the first two rail metallurgy experiments, premium rail metallurgies exhibit better wear resistance than standard rail in unlubricated track conditions; but the relative improvement decreases when the track is lubricated.

CONTRACTS

FAST Operations and Maintenance
Contract No.: PR 4491
Funding: $8,064,000
Schedule: October 1979 – September 1980
FRA Technical Contact: D.E. Gray
(202) 755-1877
Agency/Contractor: Transportation Test Center (TTC)

This funding provides for the day-to-day test operations and maintenance support of the facility at TTC. This includes the technical and management labor, fuel and materials required to support 16 hours of test operations and 8 hours of track maintenance and measurements daily. In addition, test planning, data collection, test measurement equipment, major track maintenance equipment and data analysis and preparation of test report services are provided to support current and planned experiments.

Improved Track Structure Research
Contract No.: DOT-FR-54090
Funding: $95,000
Schedule: July 1979 – September 1980
FRA Technical Contact: H. Moody
(202) 426-4377
Agency/Contractor: MITRE Corp.

The objective of this contract was to assist the FAST Experiment manager in planning, designing and analyzing FAST experiments.

Under this contract MITRE Corporation had a wide range of objectives. They included preparing experiment test plans; reviewing test specifications; recommending to the experiment manager measurement techniques, data analysis methodologies, data formats, data quality control and reporting requirements; analyzing reduced test data and reporting results; periodically providing status reports on each assigned experiment; preparing summary reports which state when and by what means experiment objectives were met; and evaluating and coordinating the analysis and reporting of any unique requirement.

Research and Technology Sharing Support Services, Task 3 FAST Test Support
Contract No.: FR-9044
Funding: $110,197
Schedule: August 1979 – April 1981
FRA Technical Contact: D.E. Gray
(202) 755-1877
Agency/Contractor: Unified Industries, Inc.

The Research and Technology Sharing contract will enable the FRA to monitor and evaluate the railroad wheel wear experiments conducted under the FAST program. Recently, the wheel data collection procedures were reviewed and the quality of the data analyzed. Experiment managers monitored and evaluated on-going experiments in FAST to ensure that overall experimental objectives were being met and to provide analysis of data and preparation of reports.

This contract will continue to provide data analysis and associated technical reports and experiment plans for the second FAST wheel experiment currently in progress and on other wheel-related tests and mechanical experiments which will occur in the near future. The second wheel experiment includes harder steel wheels and returned wheels. Other projects in the future include investigation of axle weight versus wear and metal content versus wear.

Metallurgical Evaluation of FAST Rail
Contract No.: TSC-1551 (Managed by the Transportation Systems Center)
Funding: $45,168
Schedule: February 1979 – May 1981
TSC Technical Contact: J. Morris
(617) 494-2011
Agency/Contractor: University of Connecticut

The objective of this contract is to generate information characterizing the rail materials currently in test at FAST, as well as those materials which may offer potential for future inclusion in FAST testing. This effort will encompass the generation of mechanical behavior, chemical analysis, and microstructural information characterizing existing as well as candidate rail steels for FAST testing. Where candidate materials are involved, there will be inclusion of such unique untried modification of metallurgical structures as may be expected to improve rail safety and performance.

Field Thermite Welding Study
Contract No.: DOT-TSC-1567 (Managed by the Transportation Systems Center)
Funding: $35,000
Schedule: April 1979 – March 1981
TSC Technical Contact: J. Morris
(617) 494-2011
Agency/Contractor: University of Arizona

The objective of this contract is to evaluate thermite welds from FAST. The reliability of thermite welds at FAST has always been poor. By thoroughly analyzing failed weldments from FAST, a means to improve the weld process might be determined.

FAST Data Management and Support
Contract No.: FR-9159
Funding: $2,115,430
Schedule: September 1979 – September 1981
FRA Technical Contact: T.P. Larkin
(303) 545-5660 X291
Agency/Contractor: Association of American Railroads

This contract will provide a data management base for the FAST test data, and fulfill all approved requests for such data by users. This effort will be accomplished by the use of the DEC-20/50 computer system located at the Association of American Railroad's (AAR) computer center in Chicago with AAR personnel in Chicago and at the Transportation Test Center (TTC) in Colorado.

A data storage support system will be maintained to respond to data requests and raw test data processing in preparation for storage in the FAST management system.

FAST Track Test Design and Analysis
Contract No.: TSC-1554 (Managed by the Transportation Systems Center)
Funding: $364,450
Schedule: September 1978 – September 1981
TSC Technical Contact: H.D. Reed
(617) 494-2220
Agency/Contractor: H.H. Aerospace, Inc.

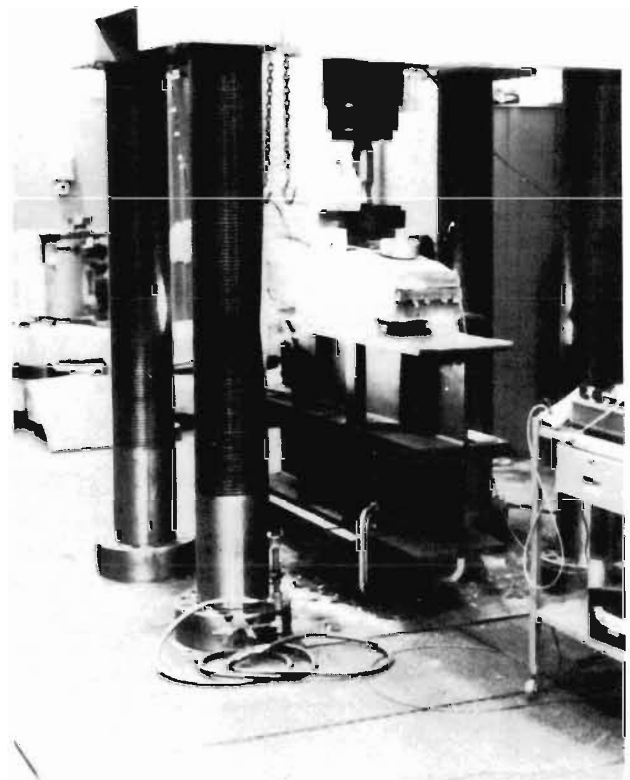
Technical capability is being provided in the fields of testing, analysis, surveying, component evaluation, metallurgy, soil mechanics, plan procedure and report preparation, and in the field of railroad engineering and maintenance-of-way practices.

Tie/Fastener Performance Verification Studies
Contract No.: DOT-TSC-1652
Funding: $323,884
Schedule: February 1979 – May 1981
FRA Technical Contact: H. Moody
(202) 426-4377
Agency/Contractor: Battelle Columbus Laboratories

The objectives of this contract are to evaluate and quantify the performance of specific track components at FAST and to determine performance requirements for rail/tie fastening systems.

Specific experimentation will be done in four areas. There will be reports on FAST tests such as concrete ties and lateral track strength, evaluation of a means of measuring longitudinal rail stress, conduct of fastener field performance measurements, and evaluation of different wood and concrete tie systems in the laboratory.

Reports on each of these items will be issued periodically as each task is completed.



TIE/FASTENER PERFORMANCE VERIFICATION STUDY

Concrete Tie and Fastener Performance Analysis and Correlation Analysis

Contract No.: DOT-FR-8164

Funding: $1,102,000

Schedule: September 1979 – January 1982

FRA Technical Contact: H. Moody
(202) 426-4377

Agency/Contractor: Battelle Columbus Laboratories

The concrete tie and fastener research contract is expected to provide data which will be of use in correlating revenue service tests with those done at FAST.

The scope of this contract includes development of an instrumentation, inspection, and analysis test plan; pretest calibration and laboratory testing to determine instrumentation techniques, configuration, and life expectancy of the instrumentation; instrumentation of four concrete tie test sites and at least four field inspections; tests of a similar nature on a wood tie control section at one location; post-test laboratory testing as required to verify calibration; evaluation and analysis of government furnished data from FAST; and correlation analysis with FAST test results. This will establish a level of confidence in the use of FAST data to predict results of performance in revenue service.

TRACK ALIGNMENT PERTURBATIONS

DEVICE WHICH MEASURES SERVICE LOADS FOR CONCRETE TIE AND TRACK WHICH IS UTILIZED FOR LONG TERM PERFORMANCE MEASUREMENT

Wheel Rail Load Test
Contract No.: PR 4471
Funding: $83,000
Schedule: June 1979 – July 1980
FRA Technical Contact: D.E. Gray
(202) 755-1877
Agency/Contractor: Transportation Test Center Transfer

FAST has been in operation for over 4 years and has accumulated over 500 million gross tons of traffic. With the exception of one small test in 1977, comprehensive tests have not been run to determine the FAST wheel/rail load environment.

This contract has examined all the variables affecting loading. Four instrumented test cars were operated over the FAST track and the Railroad Test Track (RTT) in various car and consist configurations while dynamic on-board data was recorded for wheel/rail vertical and lateral loads, car body and truck accelerations, consist speed, position, and time.

This test will provide a large amount of data that will assist FAST experiment managers in interpreting the results of FAST experiments in evaluating the current 100-ton car test at FAST when considering future tests.

Analysis of FAST Wheel/Rail Loads
Contract No.: DTFR53-80-C00078
Funding: $21,632
Schedule: April 1979 – August 1980
FRA Technical Contact: H. Moody
(202) 426-4377
Agency/Contractor: Battelle Columbus Laboratories

The objective of this contract was to expand the FAST test results data base and provide assistance to experiment planners in designing future tests. This was accomplished by identifying differences in wheel/rail loads due to changes in operating conditions, axle load, and car types. Analysis was also done to demonstrate the effects on parameters such as speed, car weight, center plate diameter and truck type.

Once completed, this information was to be incorporated into a technical report. This report will afford the FRA an opportunity to better plan for future tests at FAST.

FAST/CONSIST WITH DOT-003, ALASKA RAILROAD AND UNION PACIFIC LOCOMOTIVES

SAFETY TESTING (FAST) BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

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Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Analysis of Data from the First Wheel Experiment at the Facility for Accelerated Service Testing (FAST)
Unified Industries, Inc.
K.W. Larsen
Report No. FRA/TTC-79/01 July 1979
PB 299-433

Concrete and Wood Tie Track Performance Through 150 Million Gross Tons
Report No. FRA/TTC-80/02 March 1980

Dynamic Hopper Car Test
Report No. FRA/TTC-80/01 March 1980

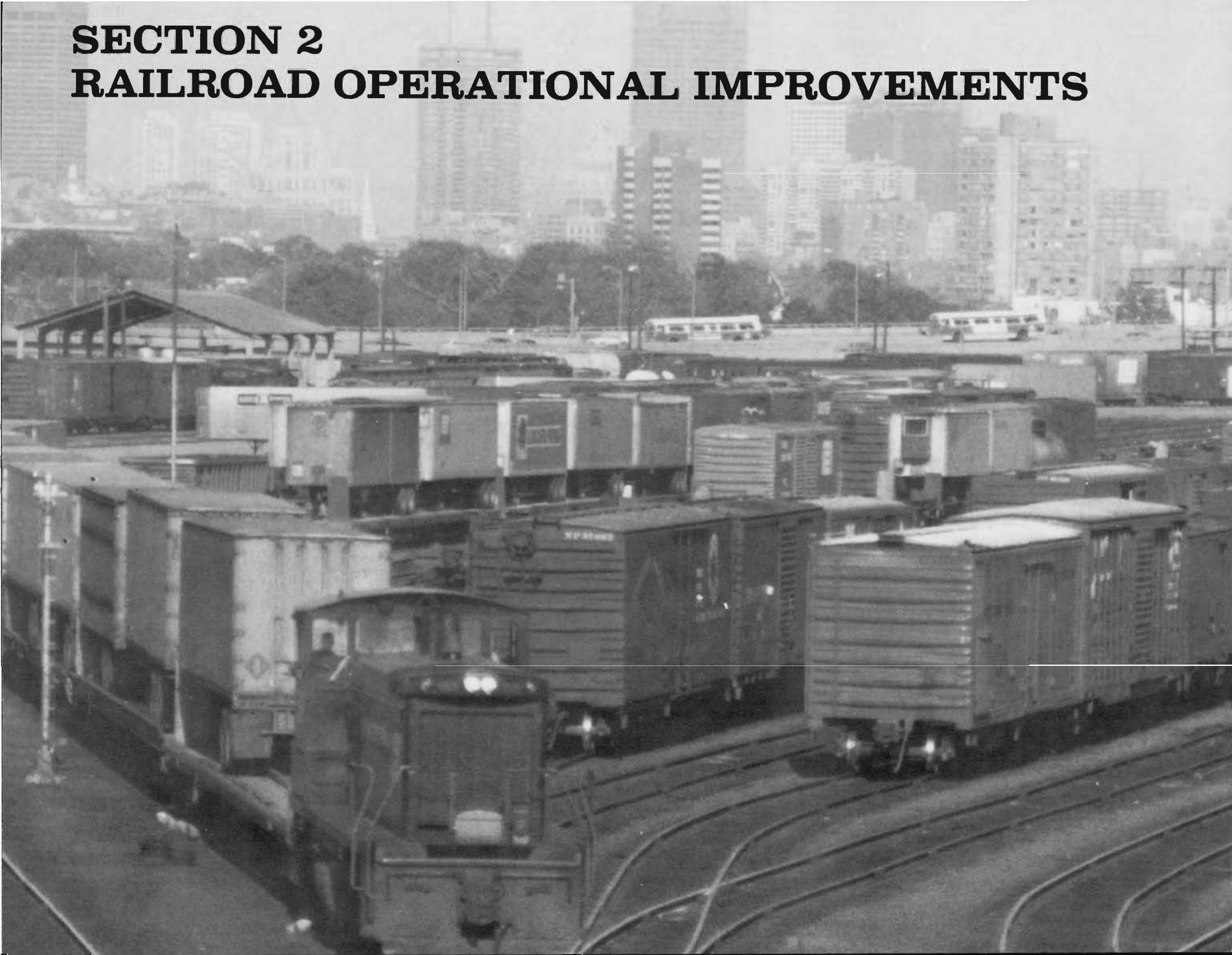
Freight Car Fatigue Analysis Test on FAST
Report No. FRA/TTC-80/04 July 1980

Functional Requirements for a Facility for Accelerated Service Testing (FAST)
Association of American Railroads, Research and Test Department
G.C. Martin, S.K. Punwani, and J.R. Lundgren
Report No. FRA/ORD-76/139 Sept. 1976
PB 263-605

Note: A large number of technical notes and memoranda on experiments performed at FAST are available directly from the Transportation Test Center. For a list of these publications, contact:

Technical Documentation Section
Transportation Test Center
Code 0-16
P.O. Box 11008
Pueblo, CO 81001

SECTION 2
RAILROAD OPERATIONAL IMPROVEMENTS



RAILROAD OPERATIONAL IMPROVEMENTS PROGRAM

SUBPROGRAM	PROJECTS
8. **Freight Systems Technology**	Intermodal Systems Technology Intermodal Freight Service Operations Classification Yard Technology Systems Analysis/Technology Assessment
9. **Energy/Environment**	
10. **Electric Traction/Electrification**	Catenary Chopper Locomotive AC Traction Traction Studies PCB Transformer Coolant Substitution Electrification Studies

SECTION 2
INTRODUCTION

The Railroad Operational Improvements program is committed to the continued viability of the nation's railroads. The objectives of the program are:

1) Improvements in rail freight service reliability and operational efficiency;
2) Identification and resolution of performance problems associated with classification yards;
3) Acceleration of intermodal freight service growth through improvements in equipment terminals, operating practices, management information systems and marketing techniques;
4) Effective exchange of technical information between the railroad community here and abroad;
5) Identification and ranking of R&D requirements; and
6) Assessment of railroad electrification.

Descriptions of each subprogram, project, supporting contracts and bibliography follow.

CHAPTER 8
FREIGHT SYSTEMS TECHNOLOGY

The Freight Systems Technology subprogram is designed to identify, develop and evaluate technology and operating techniques which will improve service and reduce costs of railroad freight operations. This subprogram addresses improvements in cost of railroad operations, reliability and service aspects, petroleum dependence and environmental protection in the following areas: train operations, classification yards, intermodal systems, and intermodal service operations.

In addition, a continuing evaluation of R&D projects is conducted through Systems Analysis/Technology Assessment techniques. This subprogram also provides for railroad technical information exchange, both domestically and with foreign railroad interests.

There are four projects organized under the Freight System Technology subprogram. These include:

1) Intermodal Systems Technology;
2) Intermodal Freight Service Operations;
3) Classification Yard Technology; and
4) Systems Analysis/Technology Assessment.

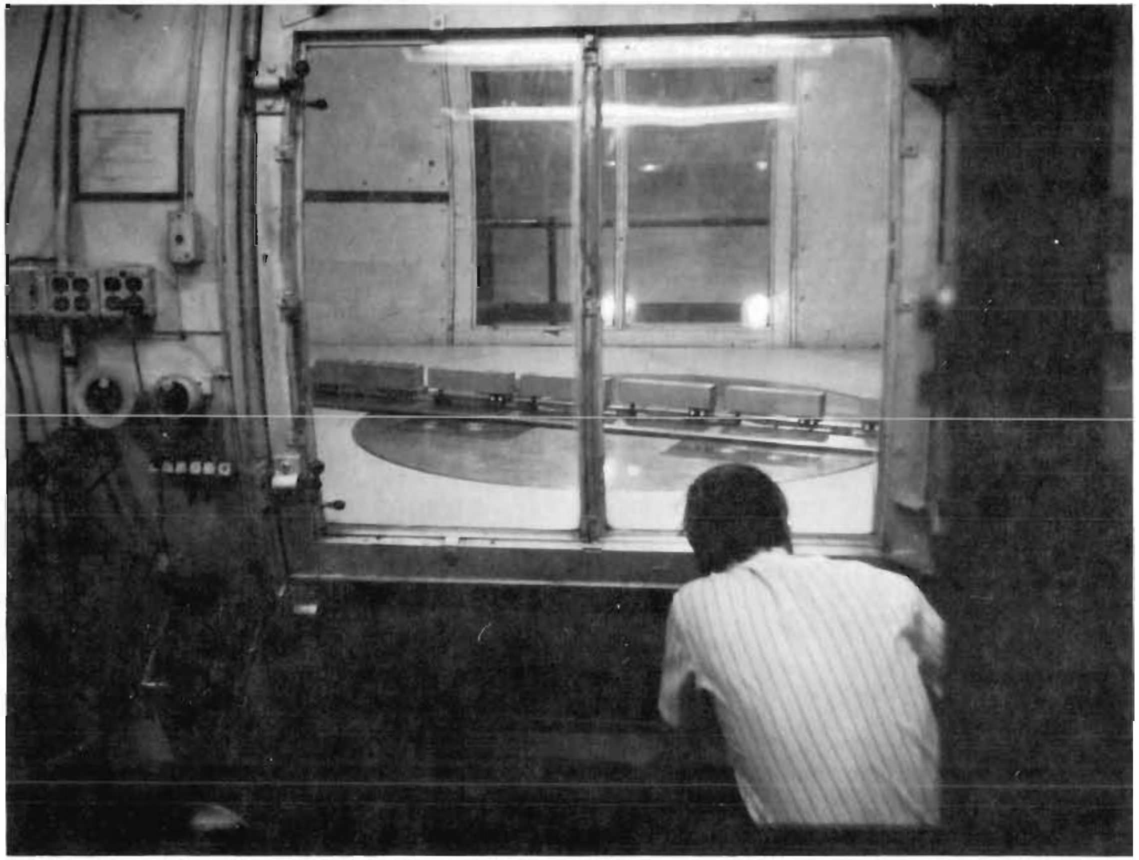
Each project is carried out by the Federal Railroad Administration (FRA) through contracts with private and Federal organizations. Descriptions of each project, associated contracts, and a bibliography of published reports follow.

INTERMODAL SYSTEMS TECHNOLOGY PROJECT

For a number of years, a great deal of attention has been focused on the concept of intermodal freight transportation (i.e., using rail/highway/water). This attention comes from a belief that a rather significant cost savings can be realized by using the flexibility of highway transportation at the origin and destination of a trip on combination with the cost and energy advantage of rail transportation for line-haul movements. In this way, the "best" features of various modes could be combined to form a more efficient freight transportation system.

For the past several years, annual intermodal revenues have exceeded a billion dollars and annual carloading increases in the area of 12-15 percent have been experienced. Despite these gains, experience has shown that even more widespread use of intermodal transportation is likely. Two recent studies have forecast a 2 to 4 times increase in the demand for intermodal service by the 1990's. Several impediments to this growth have been cited, however.

For example, some believe that intermodal growth has been retarded by reluctance on the part of motor carriers and railroads to join forces as part of a single system. Others believe that the marketing efforts necessary to obtain the line-haul portion of the motor carrier's haul have



A RESEARCHER SUBJECTS SCALE MODELS OF NEW INTERMODAL RAILCAR DESIGNS TO TESTS IN A WIND TUNNEL TO MEASURE AERODYNAMIC DRAG. THE RESULTS ARE BEING USED TO PREDICT THE FUEL SAVINGS THAT COULD BE ACHIEVED OVER A VARIETY OF RAILROAD OPERATING SCENARIOS AND WIND CONDITIONS. SAVINGS ON THE ORDER OF 35 PERCENT APPEAR LIKELY.

not been adequately addressed. Still others maintain that inefficiencies exist in the present intermodal system which render it less cost and/or service competitive than motor carriage in short- and medium-haul markets.

Recognizing the need for greater research in intermodal systems, the FRA (in 1977) initiated an effort to analyze this area from a systems engineering approach in order to assess strengths and weaknesses and to suggest actions which would result in improved efficiency and increased market share and profitability for railroad intermodal systems. A great deal was learned from the initial investigation which included an analysis of the present intermodal system and identification of areas where improvements could be made.

Based upon this initial work, the FRA has concentrated on selected "high payoff" areas. These are characterized by three common attributes: 1) they can be implemented quickly, 2) they require only modest capital expenditures, and 3) they will exert a high degree of leverage so that sizeable payoffs will be realized compared with their implementation considerations.

These R&D efforts are targeted at two specific areas, service competitiveness and cost reduction.

Rail intermodal service performance must equal or beat that of the motor carriers on a shipper-to-consignee basis. Total dock-to-dock performance is what counts, and the measures are in terms of cost, time and reliability. That means no delays in the freight flow, whether built-in, planned, or accidental. Smooth, consistent service is most critical in the short-haul markets and these markets have the potential of doubling the annual intermodal volume within a few years.

With respect to the cost target, railroads have a high consciousness of cost issues; and efforts are to be directed at boosting the efficiency and capacity of the existing plant. The goal is to widen the gap between the incoming revenues and the cost of providing the transportation service.

The two principal areas identified and which have been targeted by FRA for primary R&D considerations are 1) terminals and 2) line-haul.

Terminal areas are especially interesting because they must be able to provide smooth overall performance out of a series of discontinuous and frequently independent activities. A number of opportunities exist in terminals, and a special project has been formulated to provide improvement guidelines. The emphasis of the FRA terminal project will be on those opportunities that require only modest capital expenditures.

Several opportunities also exist for improving intermodal line-haul operations. Fuel consumption is the key area of research here, and the payoffs are potentially quite significant. Specifically, the focus for FRA R&D will be in analyzing the potential impacts of specific new equipment designs as well as alternative operational procedures such as trailer orientation and placement, priority unit trains, single locomotives and more frequent departures.

Contract work in these two areas was underway in FY80 and future work in FY81 will include R&D in developing intermodal terminals and wind histogram experiments.

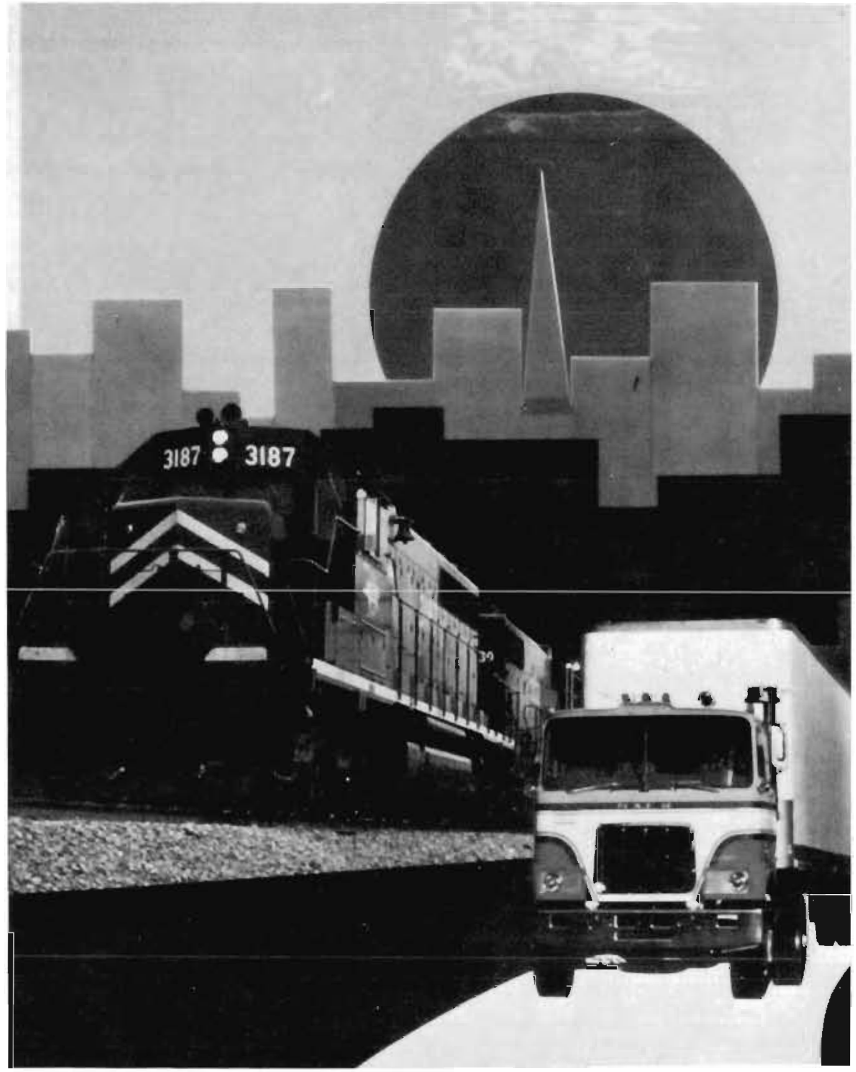
Intermodal Freight Systems Engineering
Contract No.: TSC PPA #RR 157 (formerly RR016)
Funding: $118,000
Schedule: June 1980 – December 1981
FRA Technical Contact: J.R. Blanchfield
(202) 426-0855
Agency/Contractor: Transportation Systems Center (TSC)

The results of an extensive study of the intermodal freight system are being evaluated and supplemented with additional work in key subject areas. These are based on the needs of intermodal carriers and shippers as well as departmental planning and policy activities. The purpose of this contract is to develop a group of concise reports, each addressing a specific subject area.

Definitive information will be developed on line-haul operations with assessment of the impact of new rolling stock configurations and train handling techniques on energy consumption and travel time. Operations between major city pairs will be studied utilizing newly refined simulation models for both the rail and highway modes.

Operational recommendations concerning terminal areas will be formulated with attention to shipper-oriented aspects important to market share growth. Differences between motor carrier and railroad intermodal pick-up and delivery activities are to be evaluated in the process of formulating the recommendations.

The outputs of this work will be a number of brief reports, each addressing a specific topic.



A NEW ERA FOR SHIPPING TRAILERS BY RAIL IS AT HAND AS INTERMODAL TRAFFIC GROWTH SETS NEW RECORDS AND RANKS SECOND ONLY TO COAL AS A SOURCE OF RAILROAD TRAFFIC. MORE THAN 3 MILLION TRAILERS A YEAR MOVE BY RAIL.

Intermodal Freight Terminal Model System — Requirement Definition

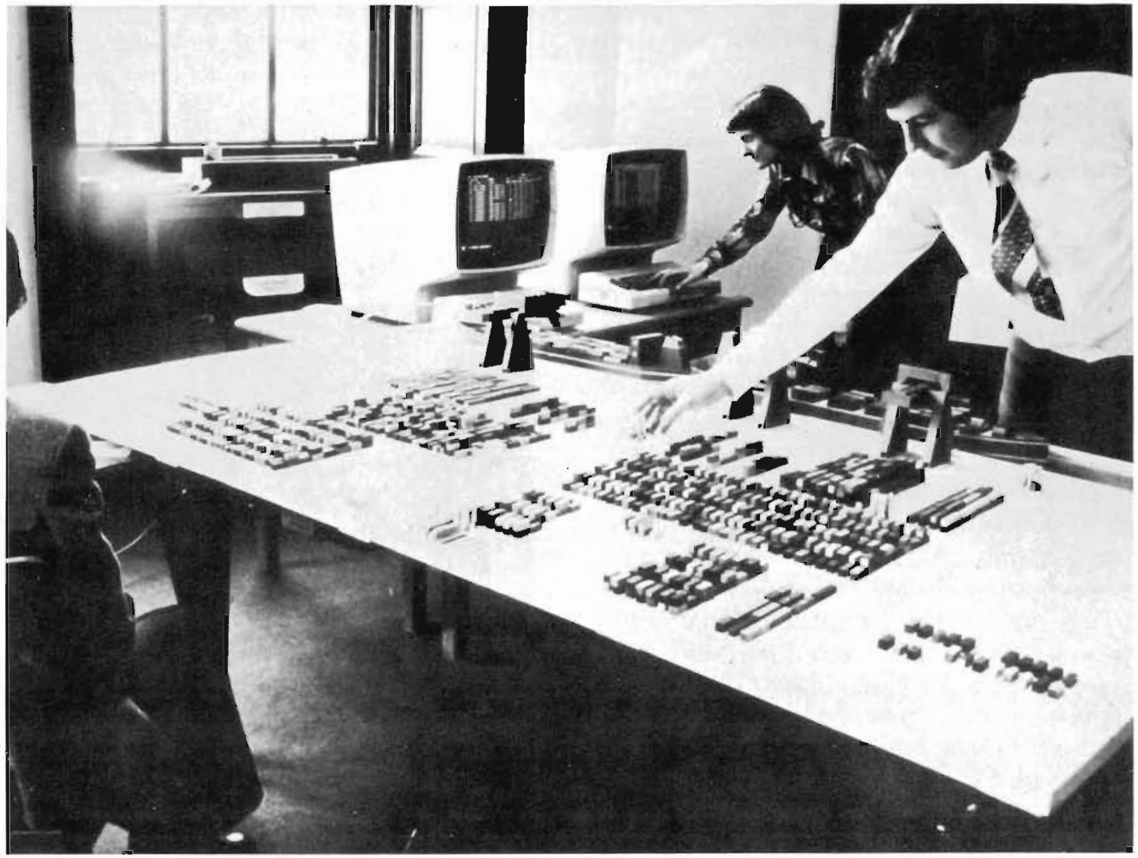
Contract No.: DOT-FR-9050
Funding: $45,000
Schedule: May 1980 – February 1981
FRA Technical Contact: J.R. Blanchfield (202) 426-0855
Agency/Contractor: Systems Control, Inc.

The need for increasing the capacity and productivity of the nation's intermodal terminals has been well documented. This need will assume more importance in the future as energy considerations force significant modal shifts from highway to piggyback. The objective of this contract is to accomplish the first step toward establishing comprehensive terminal improvement and development guidelines for the public and private sectors. Specifically, it involves the definition of functional and technical requirements for a computer-assisted intermodal terminal modeling system capable of identifying and diagnosing design and operating problems in existing terminals; evaluating proposed changes in terminal layout, equipment or operating procedures; developing methods of responding to abnormal situations; training terminal personnel; and highlighting interdependencies between intermodal and other railroad departments.

The system will utilize a physical representation of the terminal of interest, in combination with a computer. Various layouts, equipment combinations, and operational alternatives can be imposed upon the system and evaluated in terms of key measures of performance using the computer as a recordkeeping and scoring device. The user of the system will be responsible for all decision-making logic, to simplify the computer application and improve the likelihood of innovation.

The present activity is to formulate the functional and technical requirements for the model system, documented in a form suitable for its subsequent development.

The intermodal terminal model system would be disseminated to railroads, local governments, shippers, labor groups and the investment community through purchase, time sharing and rental arrangements.



SIMULATION MODELS CAN BE USED TO EVALUATE INTERMODAL TERMINAL DESIGNS. THE FRA IS STUDYING HOW SUCH MODELS COULD BE USED IN BOTH PLANNING NEW FACILITIES AND INCREASING THE CAPACITY OF EXISTING TERMINALS.

INTERMODAL FREIGHT SERVICE OPERATIONS PROJECT

In addition to the R&D work on intermodal line-haul equipment and terminals, the FRA has also been exploring a variety of measures intended to improve operations using existing cars, motive power, and terminal facilities. Efforts have been directed toward nonhardware-related aspects of intermodal service such as marketing, sales, pricing, train operating practices, crew scheduling, equipment utilization, management information systems, and operating control systems. Always, the objective has been to improve profitability by raising the productivity of labor and capital already in place.

The major component of this project was a demonstration to provide an opportunity for railroads to experiment with these commercial aspects, but shoulder only a part of the financial risk during the start-up period of new operations. Representatives of major railroads, suppliers, carbuilders, labor organizations, and trucking subsidiaries all participated in the planning and implementation phases of the demonstration. The Association of American Railroads (AAR) became FRA's contractor, and in conjunction with the Task Force on Rail Transportation, the AAR Research and Test Department was responsible for the planning, coordination, reporting, and evaluation of the demonstration service.

There were several requirements for candidate demonstration operations. First, the trailers (and containers) must move in solid, dedicated trains handling intermodal traffic only. Second, the trains should originate and terminate directly at TOFC terminals, and not require the transfer of cars to other yards, nor involve any switching enroute. Third, the trains must be used primarily for loads only, with no more than 10 percent empty return movement. Further, more than one departure a day should be offered. These requirements lead to radically different operating policies on many railroads not accustomed to operating numerous short, fast trains.

SEVERAL RAILROADS NOW OPERATE PROFITABLE LONG DISTANCE PIGGYBACK TRAINS. THE FRA INTERMODAL FREIGHT SERVICE OPERATIONS PROJECT FOCUSED ON EXPANDING THE SERVICE TO SHORTER-HAUL MARKETS.

The choice of locations for a demonstration involved consideration of both route length and potential traffic volume. There are many important routes with line-haul in the 300- to 400-mile range and with significant traffic volumes; most of this traffic now moves by highway. In these shorter distances, railroads seldom compete successfully, but the potential for profit is there if sufficient volume can be developed to spread out the terminal fixed costs.

The demonstration finally selected was an operation between Chicago and St. Paul over the Milwaukee Road. It began operating in June 1978, as the "Sprint" service, with three round trips per day. FRA participated for 2 years, and the railroad is continuing the service of a self-sustaining basis.

As railroad intermodal service continues to expand, the need for effective management tools becomes stronger. An Intermodal Management Information System (IMIS) has been developed in a modular fashion by an FRA contractor working with two railroads. The system includes three independent components dealing with equipment control, repetitive waybilling and rating, and profitability analysis. IMIS was developed for use by railroad intermodal departments on a minicomputer, with all programs written in COBOL to enhance the system's transferability to other types of hardware configurations. Following a 5-month test period on a major railroad, all documentation was made available to the industry.

Still another FRA contract assessed the feasibility and economics of an exclusive intermodal terminal roadway in Chicago connecting many of the railroad terminals scattered throughout the city. To avoid delay, trailers interchanged between connecting carriers must be unloaded from incoming piggyback cars and taken to other yards over the city streets. This is a costly process which becomes more and more unacceptable to the community as traffic increases. The ultimate solution would be a single consolidated terminal serving all Chicago railroads — an extremely expensive undertaking. One alternative would be a roadway on available railroad property once used for trackage and facilities no longer needed for passenger train service. The same approach might be applicable in other "gateway" cities where many trailers must be interchanged.

LOADING TRAILERS ON BOARD A SPRINT TRAIN ON THE FIRST DAY OF SERVICE

CONTRACTS

Intermodal Freight Program — Phase II: Demonstration Management
Contract No.: DOT-FR-708-5169
Funding: $4,223,427 (originally $8,597,731)
Schedule: January 1977 — September 1980
FRA Technical Contact: W.D. Edson
(202) 472-1014
Agency/Contractor: Association of American Railroads

The demonstration experimented with fast, frequent, all-piggyback train service, focusing on relatively short-distance markets (400 miles) where railroads seldom compete successfully with motor carriers. FRA shared up to 60 percent of operating losses during the time required to develop sufficient traffic for the service to become self-sustaining.

Starting in June 1978, the Milwaukee Road operated three round trips daily (later four) between Chicago and St. Paul. The railroad performed as subcontractor to AAR. Traffic handled by the new Sprint trains grew to over 1700 trailers per week, mostly ex-highway. Low operating costs reflected productivity improvements in crew assignments and equipment utilization. Revenue exceeded direct costs almost from the start, with profitability on a full-cost basis achieved during periods of heavy traffic volume.

Part of the demonstration was a comparative test of fuel consumption for both the Sprint service and competing trucks. Results favored the Sprint over 2.5 to 1 on the basis of trailer-miles per gallon, and exactly 2 to 1 considering revenue ton-miles per gallon.

THE MILWAUKEE ROAD'S FIRST SPRINT TRAIN FROM ST. PAUL, ON JUNE 5, 1978

Intermodal Management Information System
Contract No.: DOT-FR-741-5157
Funding: $1,451,936
Schedule: September 1977 – December 1979
FRA Technical Contact: W.R. Brooks
(202) 426-7574
Agency/Contractor: Planning Research Corp.

A specialized management information system was long ago identified as an essential feature of a successful intermodal operation. The system developed under this contract is designed to facilitate improvements in the following functions:

- Trailer handling in terminals and trains;
- Processing loss and damage claims;
- Collecting revenue due;
- Utilizing salesmen and terminal personnel; and
- Utilizing trailers, cars, and terminal equipment.

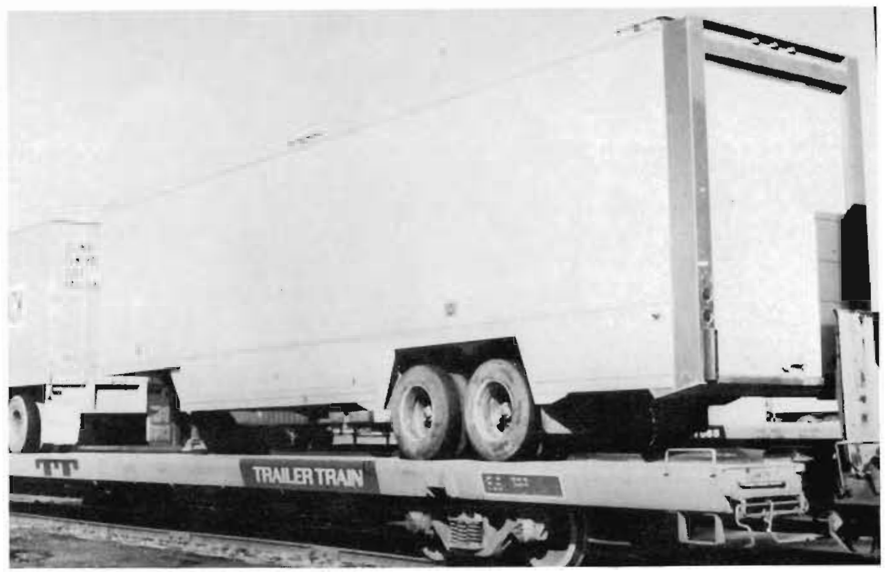
The Intermodal Management Information System (IMIS) consists of three modules that can be readily transferred to the railroad industry. They are as follows.

1) **Intermodal Equipment Control System (IMECS)** – This system has been designed to provide control of intermodal trailers in the terminals and in the customer's hands, generating adequate records for responsible detention billings.

2) **Repetitive Waybilling and Rating System (RWRS)** – This system applies repetitive rates to calculate both line-haul and accessorial charges, printing car movement and/or revenue waybills. It stores all waybill data, maintaining a comprehensive audit trail of waybill activity and work status that interfaces electronically with host car movement systems and/or accounting.

3) **Profitability Analysis System (PAS)** – This is an automated collection of intermodal records (from IMECS and RWRS and other sources), revenues, and costs to ascertain profitability for use of intermodal department managers and top level management.

The three modules were tested on the Norfolk and Western, and a post audit was conducted. Baseline and detailed specifications were then printed, along with training manuals and computer procedures, comprising a total system that FRA can provide to the railroad industry without charge.



THE INTERMODAL MANAGEMENT INFORMATION SYSTEM WAS DESIGNED TO GIVE TERMINAL AND OPERATING PERSONNEL BETTER CONTROL OVER THE USE OF EXPENSIVE EQUIPMENT AND TRAILERS.

Chicago Intermodal Terminal Roadway Feasibility Study
Contract No.: FOT-FR-8156
Funding: $253,559
Schedule: August 1978 – November 1980
FRA Technical Contact: W.R. Brooks
(202) 426-7574
Agency/Contractor: Barton-Aschman Associates, Inc.

This study reviewed the trailer interchange and street operations of the 13 railroads which operate 16 intermodal terminals in Chicago. An analysis was then made to explore the feasibility of a railroad-owned private roadway connecting most of these terminals. The objectives were to reduce the cost of trailer interchange which now must be performed using the city streets, or using much slower switching service by rail. The roadway would obviously relieve street congestion, reduce fuel consumption and air pollution, and assure better connections for through trailers.

THE CHICAGO ROADWAY STUDY INVESTIGATED THE FEASIBILITY OF AN EXCLUSIVE INTERMODAL ROADWAY ON RAILROAD RIGHT-OF-WAY TO CONNECT INTERMODAL TERMINALS. NOW, TRUCKS MUST DRIVE OVER CITY STREETS TO REACH THE TERMINALS OF CONNECTING CARRIERS.

CLASSIFICATION YARD TECHNOLOGY PROJECT

It is generally accepted that the best railroad operating policy is to schedule trains so that they bypass as many intermediate switching terminals as possible. However, the wide dispersal of traffic origination and destination points and the low car count of the average customer indicate that most railroad traffic must still undergo considerable switching and consolidation before trains can be formed that bypass terminals. Since the bulk of this switching and consolidation takes place in terminals, the railroad terminal will remain an important factor in railroad operations as long as freight is shipped in carload units by widely distributed shippers to widely distributed receivers.

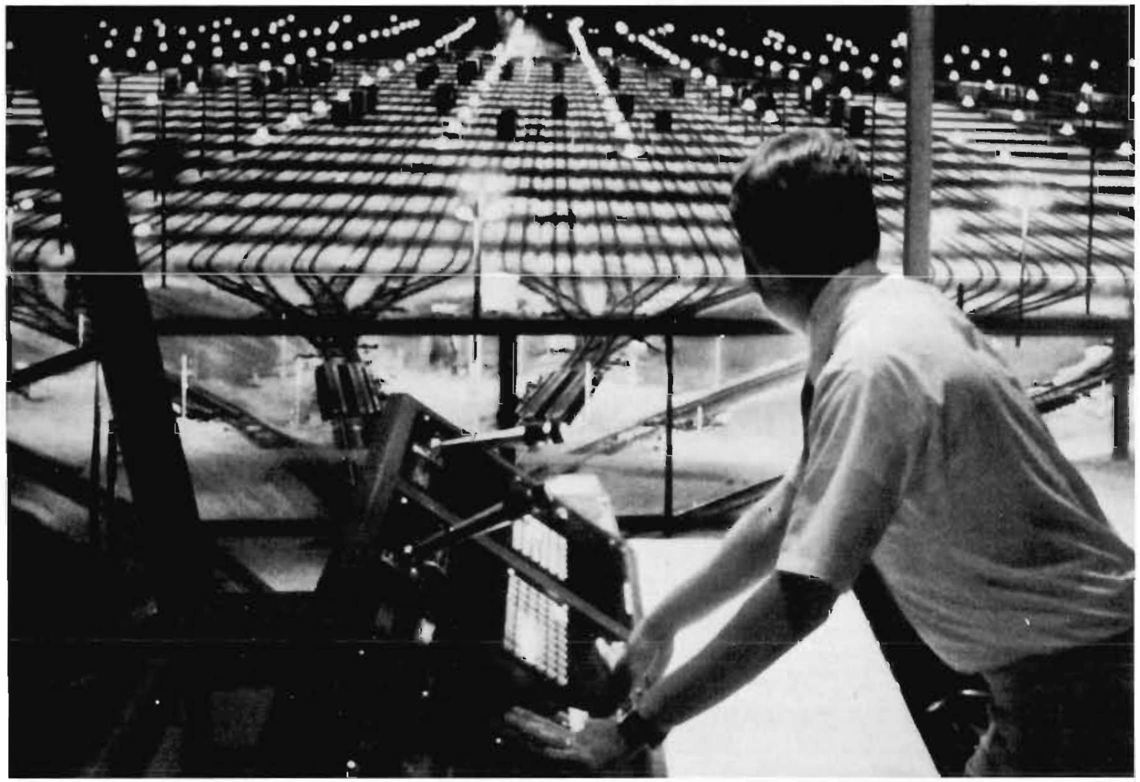
Recent studies on car utilization and freight service reliability have concluded that the rail terminal has the largest negative impact on service reliability, car utilization, and damage liability. Furthermore, it has been estimated that 25 percent to 50 percent of the time freight cars spend in classification yards is closely associated with deficiencies related to yard layout and design. This is roughly equivalent to a loss of 55 million to 85 million car-days per year, underutilization of approximately 210,000 freight cars. Consequently, it is apparent that yard designs can have a substantial impact on the ability of terminals to process cars when better designs are implemented.

With cars spending 63 percent of the car cycle time in the yard, it is obvious that even minor improvements in the yard can have significant benefits within and beyond the yard. This time in the yard certainly affects car utilization. Also, yard operating expenses each year have been costing the industry approximately $4 billion, more than 1/3 of the total railroad expenses. Even with this high expense, yard transit times are notorious for being the prime reason for shipping delays.

Yard projects can represent a huge investment for the railroad. With a new yard costing up to $50 million, railroads cannot afford to use less than the best technology. With the huge investment needed and a needed expected return-on-investment at 25 to 40 percent, railroads find it most difficult justifying a yard project, let alone introducing innovation. A recent study indicates 200 classification yards will receive major reworking or will be newly constructed in the next 25 years. Hopefully, the FRA involvement in yard technology can act as a catalyst to increase the level of innovation for improvements in these yards. Also, the FRA involvement in participative projects (cost sharing with railroads and suppliers) allows perhaps enough financial and technical leverage to introduce innovation. A recent report prioritizing research needs indicates that approximately $10 billion savings over a 20-year period can be potentially realized by improvement — in the technologies represented in this research program. The degree of actual return in savings is, of course, dependent on the success of the research and the degree of implementation over the years ahead.

This project has been examining technologies to improve classification yard operations. The major objectives are to:

- Develop technologies that will substantially reduce car delays in yards;
- Quantify areas where yard improvements are feasible and desirable;
- Evaluate components and systems that will improve efficiency in yards, in cooperation with railroads and suppliers; and
- Improve the effectiveness of railroad communication and control systems.



A MODERN CLASSIFICATION YARD – SHEFFIELD YARD ON THE SOUTHERN RAILWAY

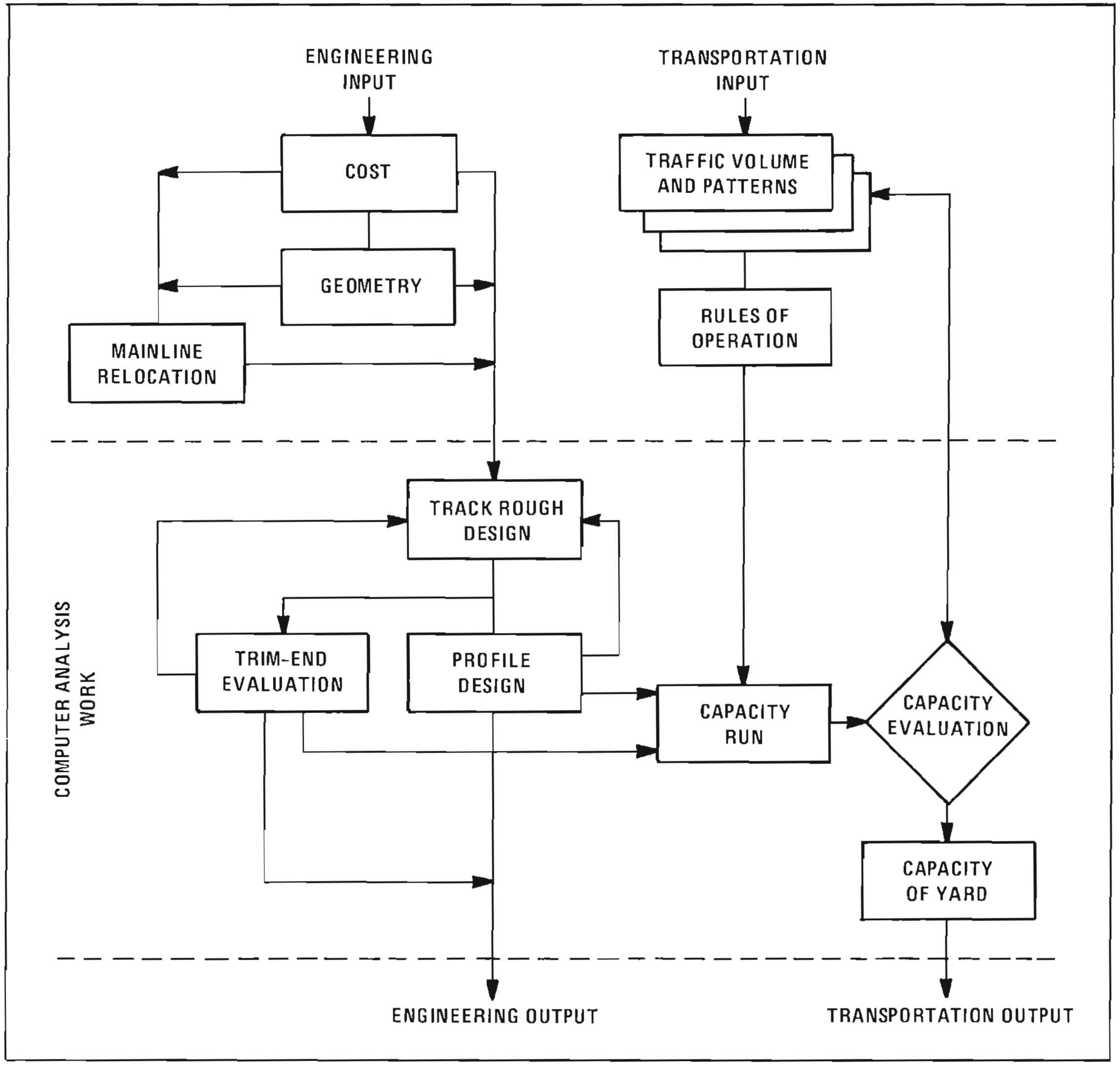
Classification Yard Design Methods: State-of-the-Art
Contract No.: DOT-TSC-1337 (Managed by Transportation Systems Center)
Funding: $588,064
Schedule: May 1977 — February 1981
FRA Technical Contact: W.F. Cracker (202) 426-0855
TSC Technical Contact: J.B. Hopkins (617) 494-2081
Agency/Contractor: SRI International

This contract will establish a set of practical guidelines and procedures, accompanied by a sufficient amount of data, computer programs and other resources, to significantly improve the design and engineering of classification yards. The results of the contract will also enhance the efficiency of the design process.

The methodology is applicable to the design of new or existing yards, both flat and hump yards, whether manual or automated. In particular, the design process has emphasized site selection, economic analysis, yard geometry and layout, hump grade profile design, yard capacity determination, trim-end conflict evaluation and computer systems.

Case studies of yards have been used to verify the practical relevance of the methodology. The following railroads have been assisted by the methodology in the design process: Conrail, Union Pacific, and the Boston and Maine. In one case study yard where sufficient economic data was available, it has been estimated that the methodology will save the railroad $900,000 annually through reduced car detention time.

Currently, the methodology is being applied for a design study to assist Richmond, Fredericksburg, and Potomac Railroad in upgrading the Potomac yard for computer control. The industry has been introduced to the methodology through interaction with the AREA Yards and Terminals Committee and FRA Yard Workshop recently conducted in Chicago for 125 attendees.



FLOW CHART OF A CLASSIFICATION YARD PROJECT

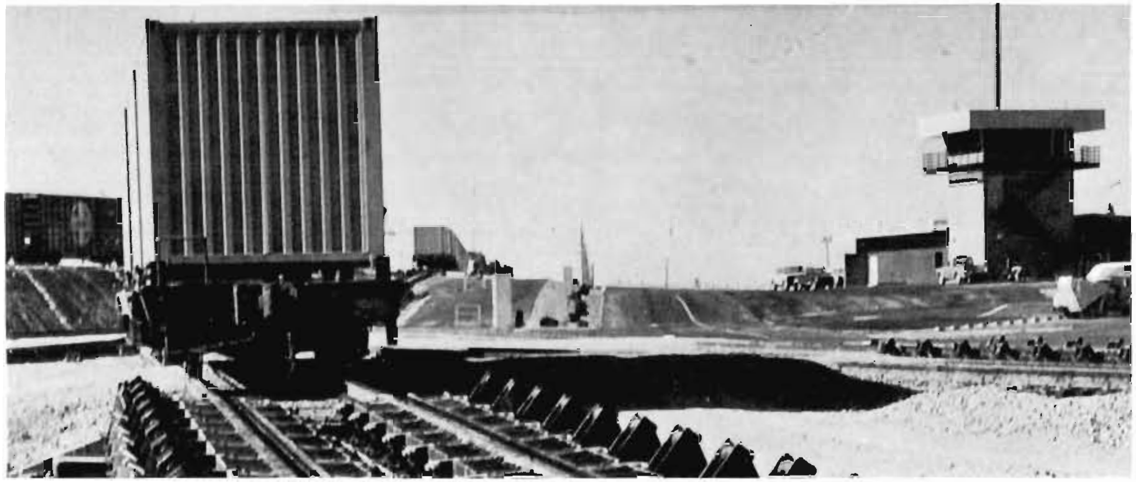
New Concepts in Speed Control Systems for Classification Yards

Contract No.: DOT-FR-8084
Funding: $189,939
Schedule: July 1978 – December 1980
Technical Contact: W.F. Cracker
(202) 426-0855
Agency/Contractor: SRI International

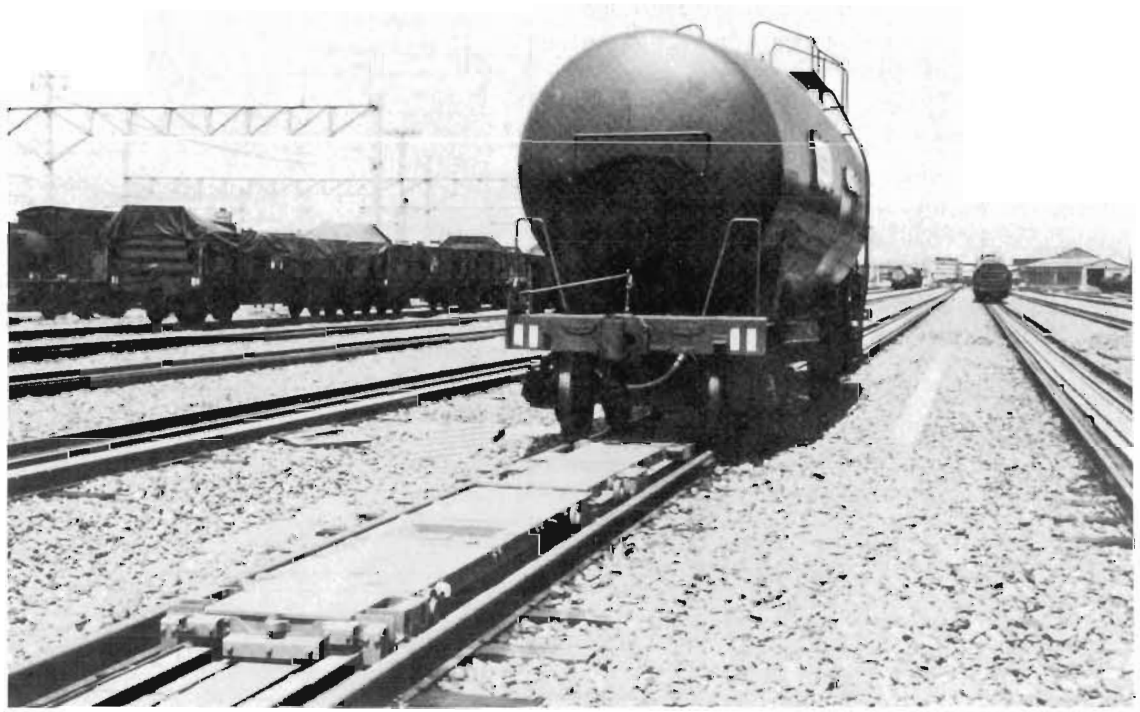
A railroad car is powerless once detached from its locomotive. Hence, in classification yards, external power and speed control systems are needed to perform the classification operation. In flat yards, the locomotive supplies the power and "kicks" each car into its destination track. In hump yards, power is provided free by gravitational energy and speed control has been traditionally provided by clasp-type retarders.

Although the fundamental hardware of the clasp retarders has remained the same for decades, the control of these retarders has grown from a manual operation into a very sophisticated computer operation. The computer operation has no doubt improved the efficiency and safety of this conventional speed control scheme but it has also increased the cost and complexity of the system considerably.

In the meantime, radically new speed control devices and systems have been developed in many other countries. There is some question whether these systems are better and more cost effective than the method currently used in the United States. This contract examines these other options and selects only the most promising car speed control concepts and technology and recommends them as candidates for yard integration and test/demonstration. The most promising concepts and technology will be selected on the basis of cost effectiveness, technical stability, and the likelihood for near-term (10 years or less) application in upgraded or new U.S. yards.



CONVENTIONAL CLASP-TYPE CAR RETARDER SYSTEM



TANK CAR DRIVEN BY NEW SPEED CONTROL DEVICE – LINEAR INDUCTION MOTOR CAR-PUSHER – IN USE IN JAPAN

Study of Freight Car Rollability
Contract No.: DOT-TSC-1762 (Managed by Transportation Systems Center)
Funding: $150,000
Schedule: August 1979 – July 1981
FRA Technical Contact: W.F. Cracker (202) 426-0855
TSC Technical Contact: J.B. Hopkins (617) 494-2081
Agency/Contractor: SRI International

An estimated 300 million freight cars are classified (i.e., sorted onto different tracks) in railroad classification yards every year. About 80 percent of these cars are classified in flat yards and the remainder in hump yards. In hump yards, freight car classification is performed by pushing a large group of cars up a slight hill, releasing them at appropriate intervals and switching them onto the required track as they roll freely down the hill.

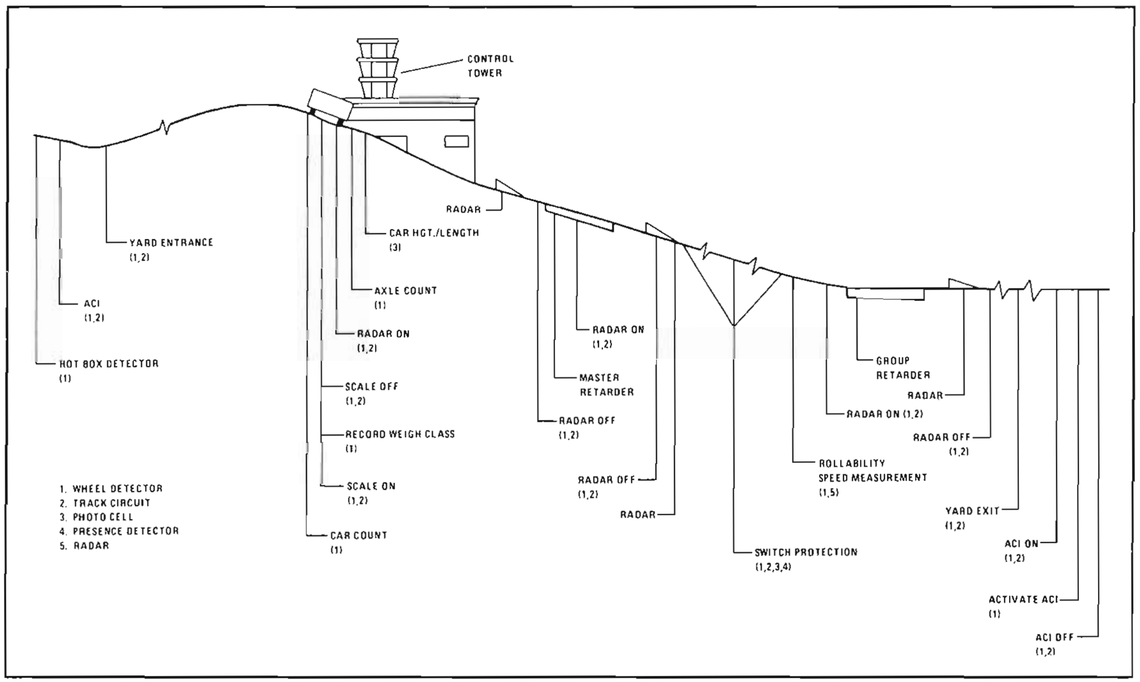
All cars do not have the same characteristics and rolling resistances (i.e., rollability) and this poses not only problems in operation but also in yard design. Information on rolling resistances is scarce and much guesswork is involved. Because of the need for and the importance of information on rolling resistance, the American Railway Engineering Association (AREA) Committee on Yards and Terminals and other groups and individuals within the railroad industry have recommended that a study of rolling resistance be conducted.

The objective of this contract is to provide an understanding of rolling resistances at the low speeds that typically occur in classification yards (1 to 6 mph). This study, exploratory in nature, specifically limited itself to the collection and analysis of existing data and to data that could easily be obtained using existing yard sensing devices and computers. Data has been collected at three yards on the Union Pacific, Burlington Northern, and Conrail systems. It is planned to collect additional data on the Southern and Santa Fe systems.

Assessment of Approaches to Railroad Yard Car Presence Detection
Contract No.: DOT-FR-8199
Funding: $206,390
Schedule: September 1978 – February 1981
FRA Technical Contact: W.F. Cracker (202) 426-0855
Agency/Contractor: Shaker Research Corporation

The current trend of American railroad classification yard technology is toward automation of car traffic and inventory control. Yard automation necessitates accurate knowledge of railroad car presence throughout the classification yard. This requirement places increasing demands on the reliability and accuracy of devices used to detect the presence of railroad cars. As automation increases, these presence detectors not only monitor car location but increasingly are used to activate devices such as weigh scales, turning on/off closed circuit television, counting devices, inventory control, track movement monitoring devices and various measuring devices.

This contract will determine the requirements for car presence detection devices and systems. A survey will be conducted of the various current and future car presence detection systems. The study will examine their probable impact on the overall track system and likely problems. The devices will be evaluated as to how they satisfy the requirements. The best technologies, both technically and economically, will be evaluated and tested with performance specifications being derived. Currently, recommended detector improvements are being field tested at yards on the Grand Trunk Western Railroad.



APPLICATION OF SENSORS IN HUMP YARD

SYSTEMS ANALYSIS/TECHNOLOGY ASSESSMENT PROJECT

This project has two objectives. First, it seeks to promote the exchange of information regarding railroad technology research and development (R&D). This will facilitate the implementation of R&D results and minimize the duplication of prior research. The second objective is to identify and rank R&D requirements and projects. The output of this effort will be utilized by FRA management in structuring R&D programs, by other government and industry researchers in planning and conducting their R&D programs, and by railroads in making operational and product acquisition decisions.

The activities carried out in order to achieve these objectives include:

- Cost/benefit and trade-off analyses of potential and ongoing FRA R&D projects;
- Railroad Research Information Service operations;
- International Railroad Technology Exchange support; and
- Conduct of domestic and international technology exchange conferences.

MEETINGS AND CONFERENCES ON RAILROAD RESEARCH AND DEVELOPMENT ENHANCE THE INTERCHANGE OF INFORMATION WITHIN THE RAILROAD COMMUNITY.

CONTRACTS

International Railroad Technology Exchange Program Support
Contract No.: DOT-FR-9044 (Task 1)
Funding: $94,720
Schedule: August 1979 – April 1981
FRA Technical Contact: N. Ahmed
(202) 426-0955
Agency/Contractor: Unified Industries, Inc.

The objectives of this contract are to support the implementation of FRA's bilateral agreements with foreign agencies and to assist FRA in the dissemination of technical information received through these agreements.

The tasks performed include the following.

- Conducting literature searches to identify U.S. documents of interest to FRA's counterparts in foreign countries.
- Reviewing abstracts and cataloging foreign documents received by FRA. These documents and abstracts are subsequently transmitted to the Railroad Research Information Service (see previous contract) for publication in Railroad Research Bulletin.
- Translating brief technical documents, abstracts and correspondence.
- Providing logistics support to visiting foreign delegations.

Support of Railroad Reasearch and Dissemination of Information
Contract No.: DOT-FR-74266
Funding: $440,000
Schedule: January 1977 – January 1981
FRA Technical Contact: N. Ahmed
(202) 426-0955
Agency/Contractor: Transportation Research Board (TRB)

The goals of this contract are to support a continuing FRA effort to identify problem areas in railroad transportation, recommend areas requiring research and development, and to disseminate research findings to the railroad community.

The major task consists of making arrangements for the railroad portion of the January annual TRB meeting in Washington. This involves arranging for presentation of technical papers and for publishing and disseminating them to the railroad community.

In addition, TRB establishes railroad committees and coordinates and supports the work of these committees on critical areas of railroad transportation. These committees play a central role in identifying research needs by keeping an active dialogue with state DOT's, academic institutions, research organizations, and the railroad community.

Systems Analysis Support to FRA
Contract No.: TSC PPA No. RR-040
Funding: $150,000
Schedule: June 1979 – September 1981
FRA Technical Contact: P. Olekszyk
(202) 426-0955
Agency/Contractor: Transportation Systems Center

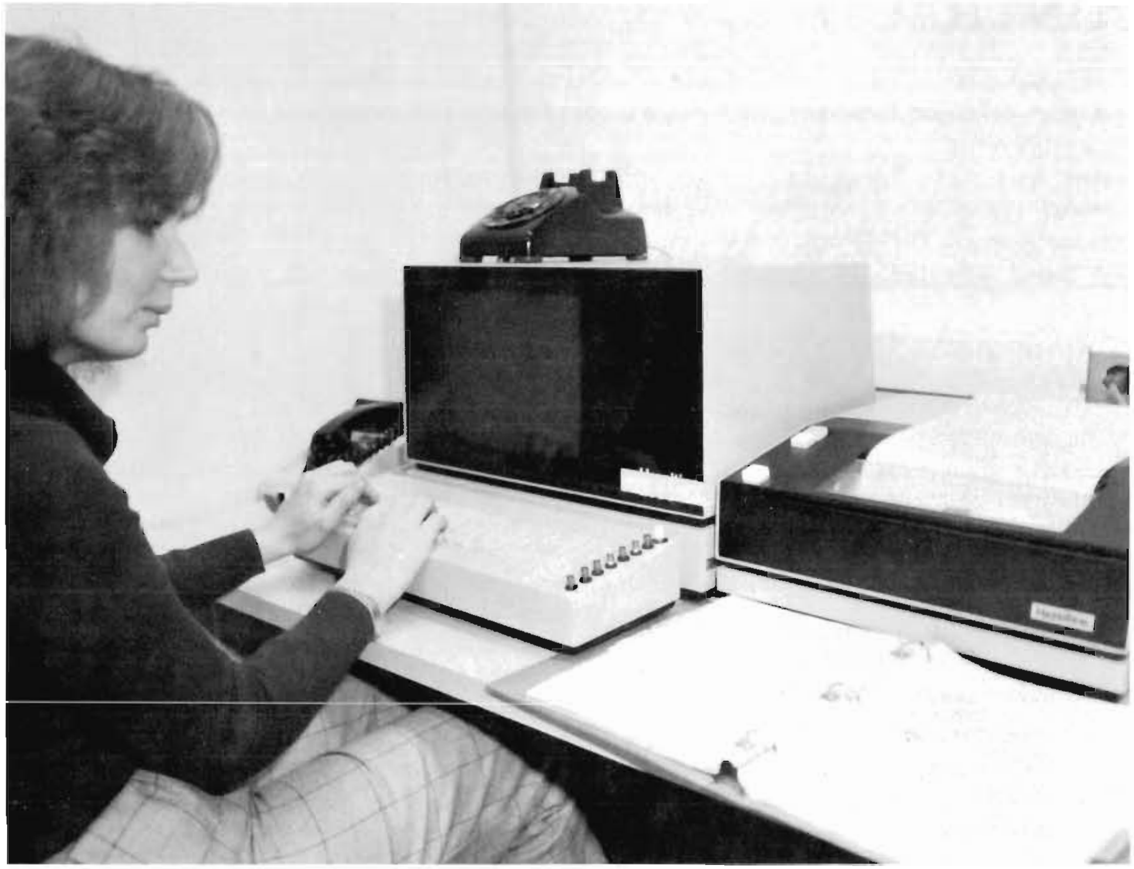
This effort requires the establishment and application of a methodology to characterize and evaluate FRA/RRD research and development programs. This provides support to the FRA in prioritizing R&D projects to meet FRA goals in safety, energy consumption, efficiency and quality of rail freight and passenger service and environment.

The studies of R&D projects will include definition of the potential benefits of R&D project results applicable to users (e.g., Office of Safety, railroads, shippers, public, etc.) and the degree to which the projects meet FRA overall objectives and responsibilities. Additional factors that will be evaluated for R&D projects, as appropriate, include basic R&D costs, institutional issues, necessity of industry cooperation or participation, technical risks, secondary and qualitative benefits, interaction with other research projects, and alternative R&D approaches. In an additional task, support was provided to the 15th Annual Railroad Engineering Conference.

Railroad Research Information Service (RRIS) Support
Contract No.: DOT-FR-74193
Funding: $1,020,000
Schedule: April 1977 – September 1982
FRA Technical Contact: N. Ahmed
(202) 426-0955
Agency/Contractor: Transportation Research Board

The objective of this contract is to develop, maintain, and operate a comprehensive source of railroad information service relating to railroad R&D. Users of this source are railroad researchers, policy makers, railroad operators, and the railroad community in general.

The contract provides for the acquisition of documents, their abstracts, preparation of abstracts from documents, and their indexing, coding, and computer storage. Descriptions of ongoing research are also acquired and stored. These abstracts are subsequently published in the Railroad Research Bulletin (a semi-annual publication), as well as special bibliographies and indexes. In addition, when a request for specific information is received, RRIS records are retrieved as part of this contract. The current RRIS holdings comprise over 21,000 records desired from world-wide sources.



AUTOMATED SEARCHES HELP IDENTIFY REPORTS USEFUL IN CARRYING ON RAILROAD RESEARCH

FREIGHT SYSTEMS TECHNOLOGY BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

INTERMODAL SYSTEMS TECHNOLOGY

Lightweight Intermodal Flatcar Evaluation Program
Vol. I, Modal Analysis of Railcars, an Explanation and Applications Guide
ENSCO, Inc.
Report No. FRA/ORD-80/07.I Dec. 1979

Lightweight Intermodal Flatcar Evaluation Program
Vol. II, Test Results Report (Including Appendix A – Transducer Locations)
ENSCO, Inc.
Report No. FRA/ORD-80/70.II Dec. 1979

Lightweight Intermodal Flatcar Evaluation Program
Vol. III, Data Appendices B through F
ENSCO, Inc.
Report No. FRA/ORD-80/70.III Dec. 1979

Low-Profile, Light-Weight Intermodal Railcar
Vol. I, Performance Specification
Systems Control, Inc.
Report No. FRA/ORD-81/04.I

Low-Profile, Light-Weight Intermodal Railcar
Vol. II, Acceptance Test Plan
Systems Control, Inc.
Report No. FRA/ORD-81/04.II

Low-Profile, Light-Weight Intermodal Railcar
Vol. III, Requirements Definition
A.T. Kearney, Inc.
Report No. FRA/ORD-81/04.III Feb. 1981

Systems Engineering for Intermodal Freight Systems
Vol. I, Executive Summaries
A.T. Kearney, Inc. and Peat, Marwick, Mitchell & Co.
Report No. FRA/ORD-78/24.I April 1978
PB 282-370

System Engineering for Intermodal Freight Systems
Vol. II, Task Results
A.T. Kearney, Inc.
Report No. FRA/ORD-78/24.II April 1978
PB 293-757

Systems Engineering for Intermodal Freight Systems
Vol. III, Appendices
A.T. Kearney, Inc.
Report No. FRA/ORD-78/24.III April 1978
PB 297-395

System Engineering for Intermodal Freight Systems
Vol. IV, Task Results
Peat, Marwick, Mitchell & Co.
Report No. FRA/ORD-78/24.IV April 1978
PB 286-935

System Engineering for Intermodal Freight Systems
Vol. V, Appendices
Peat, Marwick, Mitchell & Co.
Report No. FRA/ORD-78/24.V April 1978
PB 286-036

Transportation of Vibration Sensitive Equipment by Highway Trailer on an Intermodal Railcar
Vol. I, Test Results Summary
ENSCO, Inc.
M. Kenworthy
Report No. FRA/ORD-79/05.I July 1979
PB 301-219

Transportation of Vibration Sensitive Equipment by Highway Trailer on an Intermodal Railcar Vol. II, Detailed Test Data
ENSCO, Inc.
Report No. FRA/ORD-79/05.II
PB 80-114655

See also Chapter 9 Bibliography, especially "Aerodynamic" research.

INTERMODAL FREIGHT SERVICE OPERATIONS

Chicago Intermodal Terminal Roadway Feasibility Study
Barton-Aschman Associates, Inc.
Report No. FRA/ORD-80/64

Intermodal Freight Program Phase II, Demonstration Management
Association of American Railroads
Report No. FRA/ORD-80/69 Oct. 1980
PB 81-106510

Intermodal Management Information System Phase II Task I, State-of-the-Art Survey
Planning Research Corp.
Report No. FRA/OPPD-78/8 March 1978
PB 281-016/AS

Intermodal Management Information System Phase II Task 2, Interim Report
Planning Research Corp.
Report No. FRA/OPPD-78/12 April 1978
PB 282-287/AS

Intermodal Management Information System Phase III Task 1, Baseline Specification
Planning Research Corp.
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PB 80-107022

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SRI International
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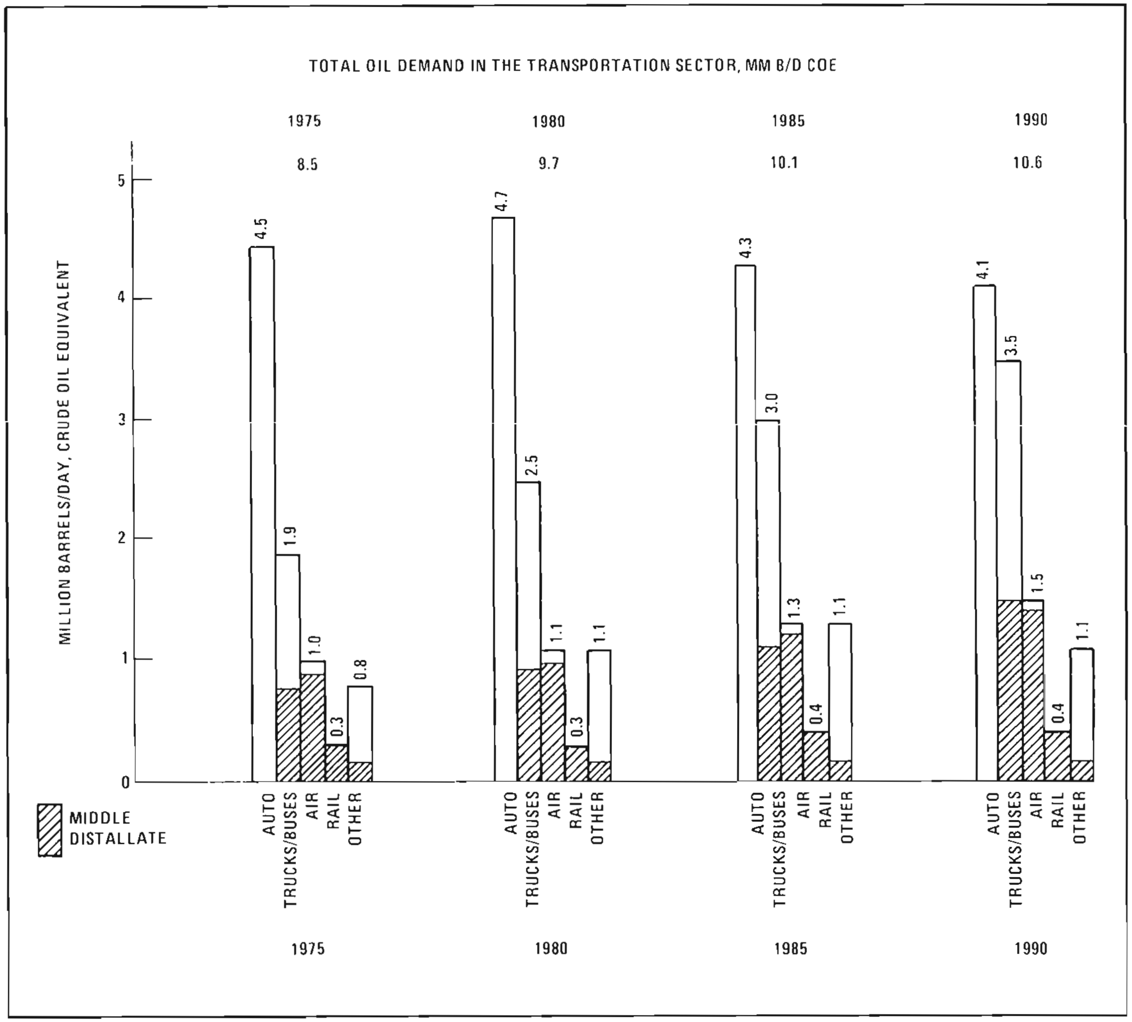
Transportation Systems Center
Report No. FRA/ORD-80/35 June 1980
PB 80-205206

CHAPTER 9
ENERGY/ENVIRONMENT

The major focus of the Energy/Environment project is directed at the future fuel needs and noise considerations of the railroad industry.

Railroads in the Class I category consume approximately 4 billion gallons (roughly 100 million barrels) of fuel per year. One of the major oil companies has published in a report a projection of fuel demand in the transportation industry through 1990*. The accompanying graph shows total projected demand by mode. It should be noted that total petroleum demand increases 9.3 percent, from 9.7 million B/CD (barrels/crude per day, crude oil equivalent) to 10.6 million B/CD during the 1980s. Gasoline consumption, although not precisely shown in the figure, is projected to decline due to greater automotive fuel efficiencies mandated by existing law. Middle distillate demand, on the other hand, in transportation is expected to increase by 1.1 million B/CD during the decade, an overall increase of 45 percent. Aviation turbine fuel represents 35 percent of the increase, diesel fuel used in trucks and buses about 55 percent, and railroad consumption 10 percent (0.1 million B/CD).



OIL DEMAND IN TRANSPORTATION BY MODE AND FOR MIDDLE DISTILLATE

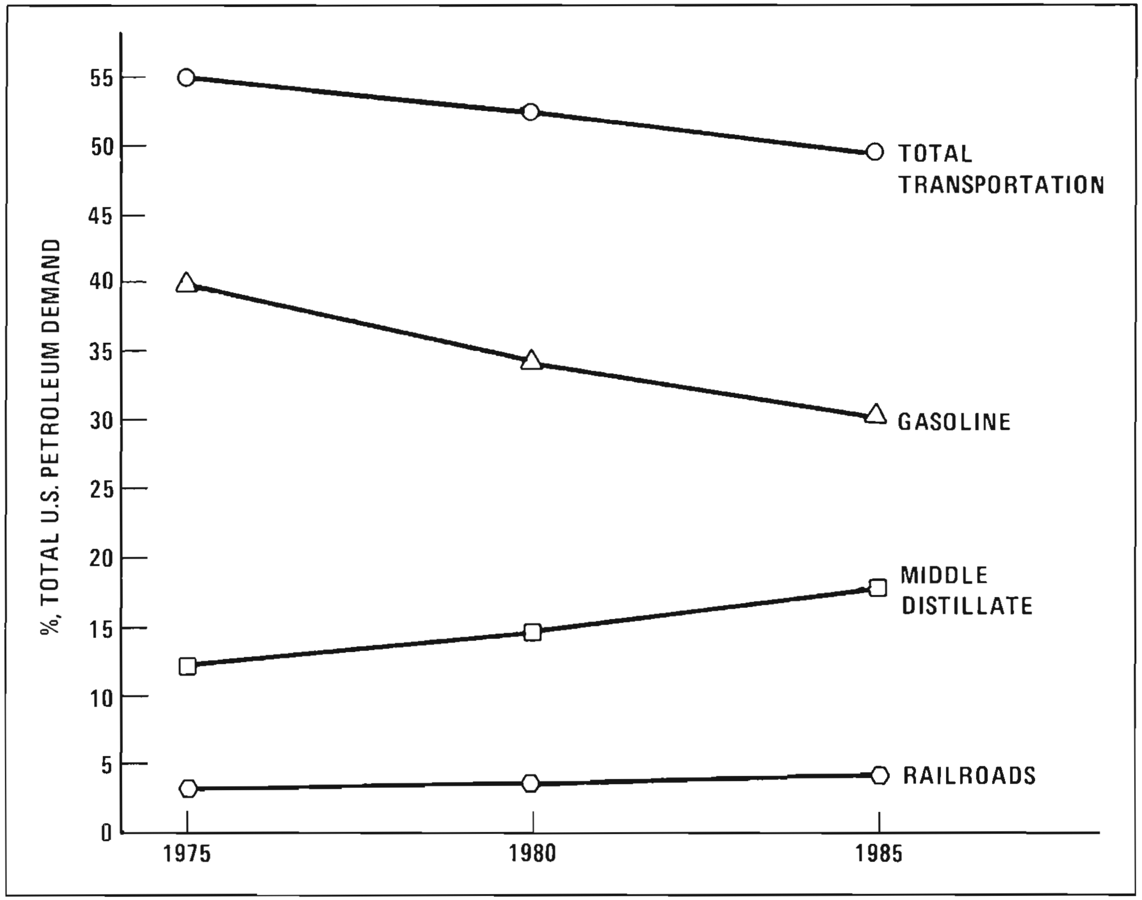
*Source: Locomotive Maintenance Officers Assoc., Committee on Fuels and Lubricants.

A number of factors indicate that between now and 1985, the competition for available high quality middle distillate fuel oil will intensify and the price will increase more rapidly than the price of gasoline. According to petroleum industry estimates, the crude petroleum available from domestic sources by 1985 will decrease approximately 25 percent compared to 1975 production. During the same period, total transportation demand will increase approximately 30 percent. While the percentage of transportation needs will remain approximately 50 percent of total petroleum demand, the portion required for gasoline will decrease and middle distillate demand will increase significantly. During the same time period, railroads are expected to require 25 percent more fuel to operate.

In summary, these projections for the railroads are as follows:

Year	Million Barrels Crude per day	% Increase
1980 (current)	0.27	–
1985	0.35	30
1990	0.40	50

The cost of diesel fuel to the railroads is generally predicted to double over the 1980-1990 decade, rising from $0.85/gallon in 1980, to about $1.70/gallon in 1990 (1980 dollar). These estimates, however, tend to be somewhat conservative and are subject to perturbation beyond the ability of the forecast to predict direct cause/effect relationships.



TRANSPORTATION FUEL REQUIREMENTS

For example, a large U.S. chemical company forecast indicates $60/barrel price for domestic crude oil by 1985. Our prediction is that this would result in $2.00/gallon (1980 dollars) for diesel fuel. The impact of these price increases on railroad operating revenue based on industry projections indicate a shift from current 15 percent fuel/operating revenue ratio to about 32 percent in the future.

FRA energy-related research is currently at a funding level slightly over $500,000 per year. The overall objective of the energy program is to develop improvements in railroad equipment, facilities and operations which can increase energy efficiency. Short-term objectives include: development of fuel efficient train operation techniques; assessment of the potential for a dual-mode locomotive (diesel-electric/electric); evaluation of potential for use of alternative fuels in diesel locomotives; and conduct of energy audits to identify opportunities for conservation of energy on railroads.

Previous energy research activities provide supportive knowledge to the activities outlined above. Earlier works have included studies of:

a. Fuel-Efficiency Improvement in Rail Freight Transportation;

b. Locomotive Multiple-Unit Throttle Control to Conserve Fuel;

c. Estimation of Fuel Consumption in Rail Transportation;

d. Resistance of a Train to Forward Motion;

e. Aerodynamic Forces on Freight Trains;

f. Flywheel Energy Storage Switcher;

g. Wayside Energy Storage; and

h. Locomotive Data Acquisition Package.

Once a need is established and a government role is deemed appropriate, budget requests will be submitted to obtain the required resources. When resources become available, every effort will be expended to execute the research through cooperative arrangements except when this course is clearly inapplicable. In any event, industry participation in the process of conducting research will be encouraged and actively solicited. Where standing industry committees exist their review of project progress shall be solicited. In research of broad interest, "open" in-progress reviews will be conducted.

When research results are obtained that are deemed to be of significant value to the industry, conferences and/or workshops will be called to disseminate the information and afford the participants the opportunity to directly interact with the researchers involved. Technical reports of all work will be submitted to the National Technical Information Service for public availability. In addition to the above, other techniques will be employed to further technology transfer and diffusion. Examples are presentation of papers at technical society meetings and informal presentations before various industry organizations. The use of video tape cassettes will be employed where a mailable presentation to many small groups is expected and the expenditure of travel funds is otherwise not warranted.

ENERGY/ENVIRONMENT THRUST

- **ENERGY AUDIT**
- **ALTERNATIVE FUELS**
- **FUEL EFFICIENT TRAIN OPERATIONS**
- **DUAL-MODE LOCOMOTIVE**

This program can influence change in the industry status quo by contributing to the overall knowledge base. It can act as a stimulus to industry action that might not otherwise occur. Examples of this are evident in the private sector development of the multiple-unit throttle control and other instrumentation for locomotives, several lightweight, low-profile intermodal railcars and various versions of Train Performance Calculators/Train Operations Simulators. All of these developments, in part, owe their occurrence to previous work done under this program.

In the environment area of this project it has been recognized that under certain conditions rail vehicles can generate high noise levels. However, their generally infrequent movement along any given right-of-way, their long history of service in the United States and their low growth in recent years, when compared to other transportation modes, has contributed to a widely held opinion that, in any ranking of transportation noise source impacts, rail noise is considered to be of relatively low priority. Rail noise was addressed by the Department of Transportation (DOT) to a limited extent in a survey report dated November 1970. This report was a compilation of railroad noise-related data, mostly from American and European sources. Its significant finding was that little definitive information existed on heavy rail noise sources.

With the decision by Congress to include specific railroad noise provisions in legislation leading to the Noise Control Act of 1972, the paucity of technical information became more acute.

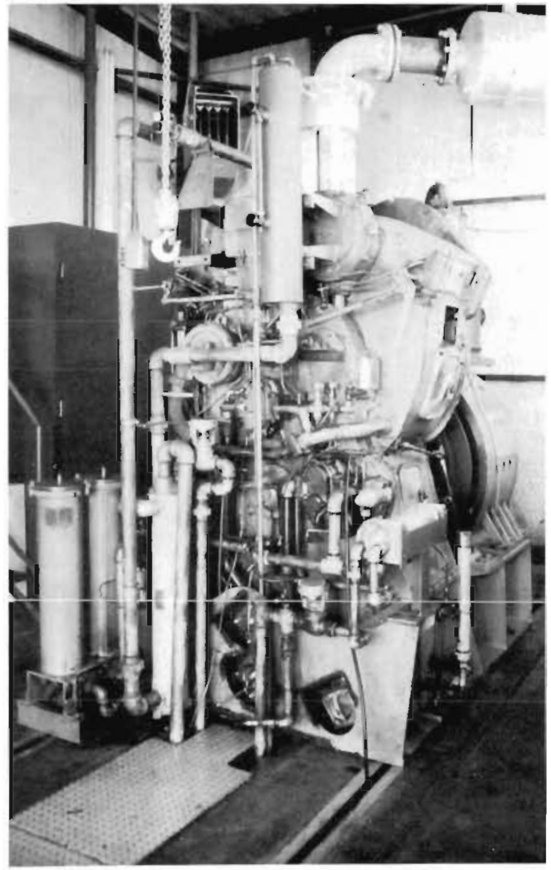
To address this issue, a series of opportunity measurement programs were conducted along rail waysides and in freight yards to identify major noise sources, their levels, speed effects and information on their frequency of occurrence. Based on this series of noise measurements and information submitted by the railroad industry in response to an Advanced Notice of Proposed Rulemaking (Docket No. ONAC 7201001) for Railroad Noise Emission Standards, later promulgated by the Environmental Protection Agency (EPA), important noise sources were identified. Without regard to any priority ranking, locomotives, rail/wheel interaction, whistles and horns, mechanical refrigeration cars and trailer-mounted refrigeration units on flat cars were determined to be important noise sources. Noise emitted from fixed facilities including public address systems, classification yard retarders, maintenance facilities and loading equipment was also identified. Coupling noise during train make-up has also been observed to be intrusive.

Because opportunity-gathered data does not provide a full description of these railroad noise sources, DOT proposed a Cooperative Railroad Noise Research Program to members of the railroad industry through the Association of American Railroads (AAR). The thrust of the program has been to accurately define through controlled parametric tests: major railroad noise sources; simple, accurate noise test procedures; operational noise levels; noise propagation effects and noise level identification problems caused by measurement site anomalies. Costs of the programs have been shared between DOT and the railroad industry through the AAR. The AAR has provided, through its member roads, dedicated railroad equipment, test sites and maintenance and operating personnel. DOT has provided, either inhouse or by contract, measurement and analysis personnel to perform all acoustic and performance data gathering, analysis, and report preparation tasks. The information obtained to date forms the first definitive body of data on United States rail operations available for public scrutiny.

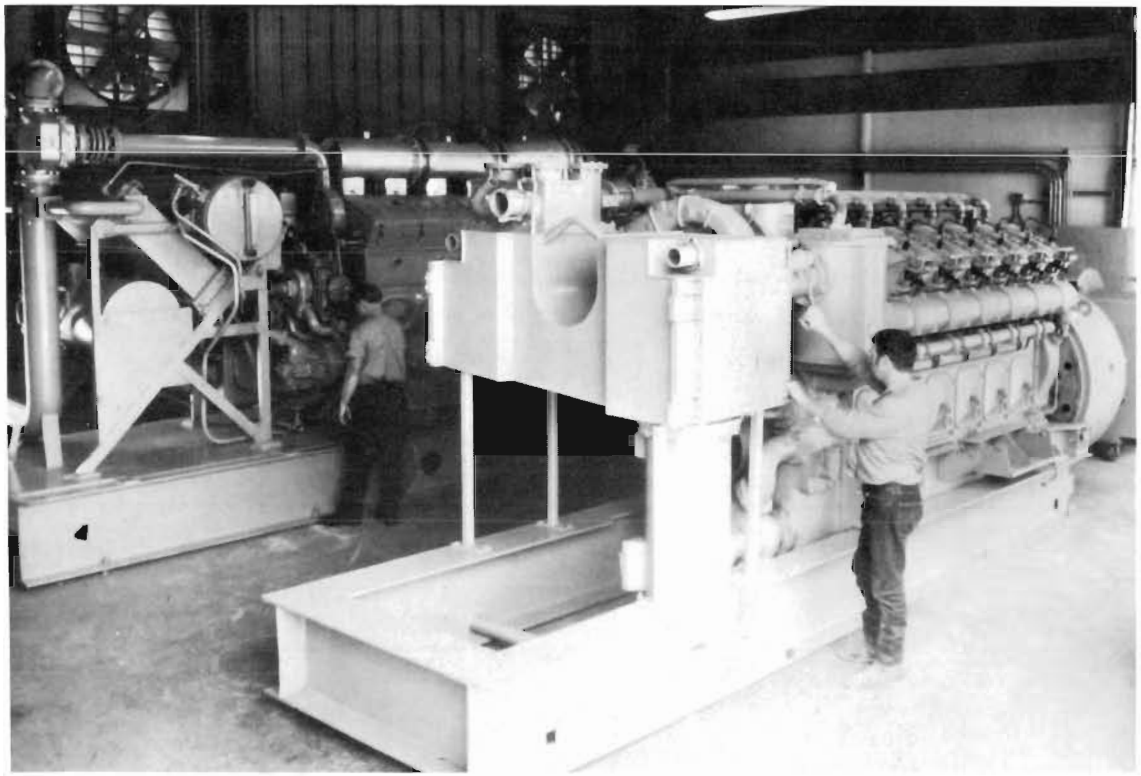
Alternative Fuels for Railroad Locomotives
Contract No.: AR-8163 (Interagency Agreement with DOE)
Funding: $776,000
Schedule: September 1978 – September 1981
FRA Technical Contact: J. Koper (202) 426-0808
Agency/Contractor: Southwest Research Institute (SWRI)

The objective of this contract is to assess the performance of a medium-speed locomotive diesel engine on various alternative fuels, diesel and non-diesel, for the effects on combustion characteristics, emission levels, and piston ring wear.

Presently the work involves exploring the use of alternative fuels for locomotive diesel engines with a two-cylinder experimental engine at SWRI. As currently planned, the small engine tests will be scaled up to test potential fuels in both a two-cycle and a four-cycle full-size diesel engine. Current fuels under evaluation include off-specification diesel fuels and non-diesel fuels such as alcohols and synthetic liquid fuels derived from coal, shale, or tar sands.



TWO-CYLINDER EXPERIMENTAL ENGINE AT SOUTHWEST RESEARCH INSTITUTE



TWELVE-CYLINDER FULL SIZE DIESEL ENGINES (GE & EMD) AT SOUTHWEST RESEARCH INSTITUTE

Handbook for Measurement, Analysis and Abatement of RR Noise
Contract No.: DOT-TSC-1786 (Managed by Transportation Systems Center)
Funding: $145,980
Schedule: September 1979 – July 1981
FRA Technical Contact: J. Koper
(202) 426-0808
TSC Technical Monitor: R.L. Mason
(617) 494-2443
Agency/Contractor: Wyle Laboratories

The Environmental Protection Agency (EPA) has promulgated Railroad Noise Emission Standards for locomotives and rail cars, and the FRA has issued complementary compliance regulations covering these standards. The EPA is presently under court order to expand these standards to include railroad facility noise emissions. These new standards will then be incorporated into the present FRA compliance regulations. In order to facilitate the work of FRA safety inspection personnel charged with enforcing these regulations, railroad personnel who must demonstrate compliance, and railroad facilities design engineers, a handbook combining existing information and experience in the field of railroad noise abatement was determined to be needed.

The contractor has been charged with the responsibility of producing a handbook which will be understandable for technicians and designers untrained in acoustics, to include noise measurement procedures under ideal and non-ideal conditions applicable to railroad operations; existing data on railroad noise sources; and proven abatement procedures applicable to railroad noise sources. The handbook will be arranged in a format to facilitate modifications, improvements and the introduction of new information as it is developed.

Energy Management Workshops
Contract No.: DOT-FR-905113
Funding: $14,900
Schedule: August 1979 – February 1980
FRA Technical Contact: J. Koper
(202) 426-0808
Agency/Contractor: A.T. Kearney, Inc.

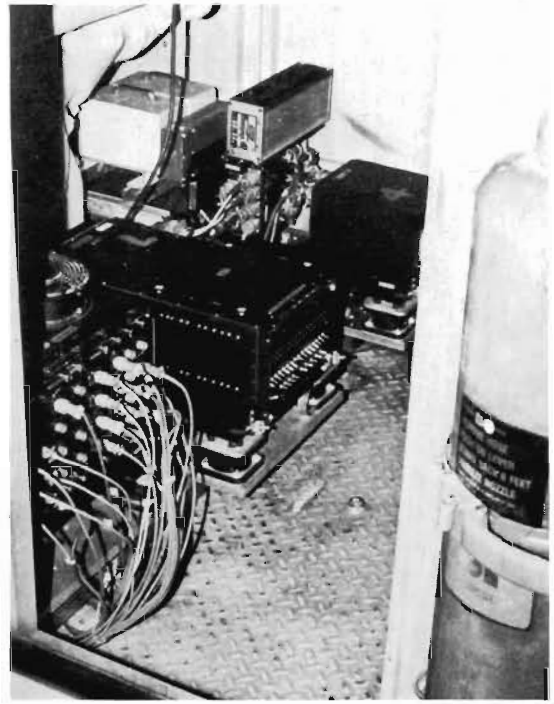
The objectives of this contract were the diffusion of technology and utilization from government to industry contributing to energy conservation activity.

The initial FRA Energy Management Workshop was conducted to demonstrate the utilization of computer models and analytical techniques to improve train performance prediction methodology. The Workshop was attended by invited railroad industry representatives, consultants and equipment designers. Participants included FRA, DOE, MITRE Corp., and TSC.

Locomotive Data Acquisition Package (LDAP)
Contract No.: AR-74348; AR-DOT-FR-53-80-X-00073 (Interagency Agreements with DOE)
Funding: $596,000; $533,000
Schedule: September 1977 – March 1980; March 1980 – March 1981
FRA Technical Contact: R. Patel
(202) 426-0855
Agency/Contractor: Lawrence Berkeley Laboratory/DOE

The objective of this contract is to develop a preprototype semi-portable Locomotive Data Acquisition Package (LDAP) for line-haul data recording and analysis directly on board the locomotive. The system will primarily serve as a research tool to monitor, define, and analyze those parameters directly affecting locomotive operational efficiency and reliability. Potential applications of the LDAP system can encompass the areas of energy conservation, alternate fuel studies, train operations and safety, and locomotive equipment characterization.

During the first phase of the research the functional requirements were studied. In the second phase, the LDAP preprototype was designed, built and tested. As a result of the service testing and an evolving interest in energy conservation on the part of the railroads, additional experiments and field tests are being planned and conducted. At the end of the field tests, FRA will be in a position to procure a small number of improved LDAP's from a commercial source should the necessary resources become available.



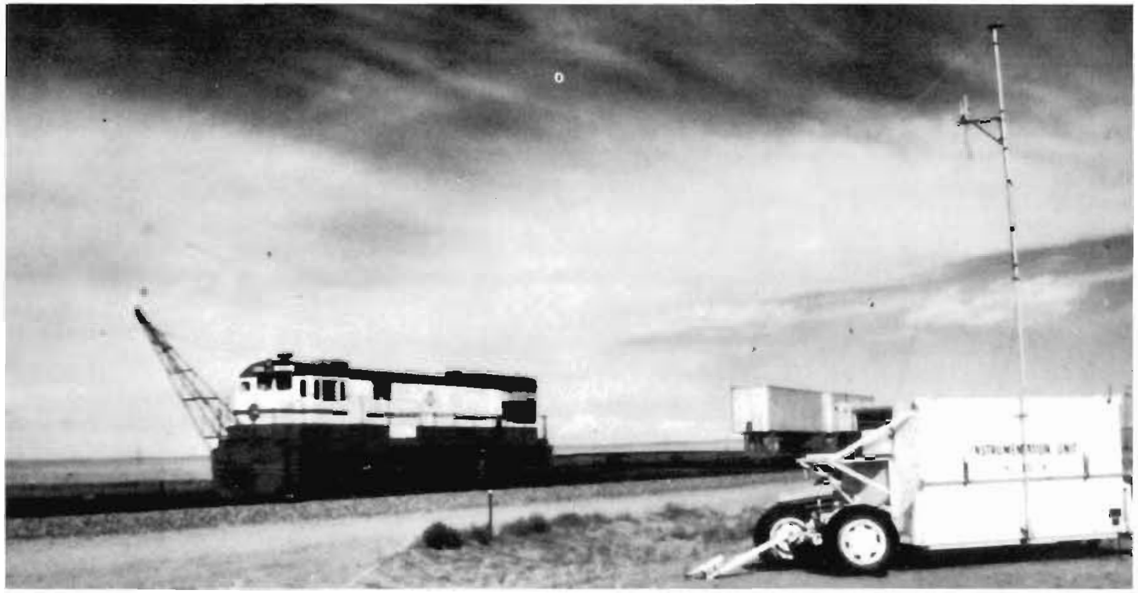
LDAP INSTALLATION ON THE UNION PACIFIC RAILROAD, LOCOMOTIVE 3670/SD40-2

Investigation of the Aerodynamic Characteristics of Rail Freight Rolling Stock

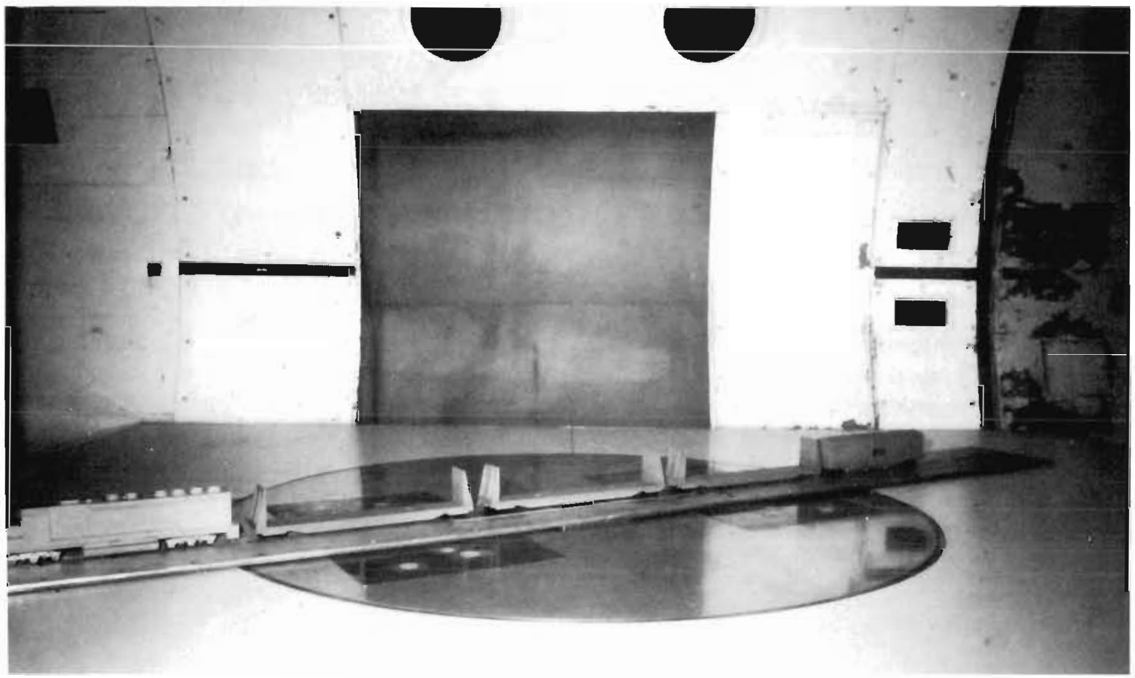
Contract No.: DOT-FR-8058
Funding: $152,264
Schedule: May 1978 – May 1980
FRA Technical Contact: J. Koper
(202) 426-0808
Agency/Contractor: Andrew G. Hammitt, Assoc.

The objective of this contract was to obtain information on the aerodynamic characteristics of a variety of rail freight rolling stock and of selected configurations modified to improve their aerodynamics. This was accomplished by means of a series of wind tunnel investigations.

The contractor was to investigate the aerodynamic resistance component of rail freight cars and locomotives in a series of wind tunnel tests using scale models. A series of block tests were performed as a continuation of earlier tests to determine the effects of gaps and spacing between cars. A variety of standard freight cars were tested both in trains of their own type and with other cars. Tests were also conducted on several new cars designed to carry trailers and containers. The experimental results from this contract have been used to refine the methodology and augment the related research of total train resistance and the impact on fuel consumption.



FULL-SCALE AERODYNAMIC DRAG VALIDATION TEST AT TRANSPORTATION TEST CENTER (TTC)



WIND TUNNEL TEST OF FREIGHT TRAIN CONFIGURATION

Train Resistance in Freight Operation
Contract No.: DOT-FR-54090
Funding: $215,000
Schedule: January 1977 – May 1980
FRA Technical Contact: J. Koper
(202) 426-0808
Agency/Contractor: MITRE Corp./METREK Div.

The objective of this contract was to develop techniques to improve railroad fuel consumption and reduce operational energy costs through potential design improvements and/or operational modifications. In addition, the contractor assisted the FRA Office of Research and Development in developing an overview of both near-term and long-range considerations of energy requirements for improved rail freight service.

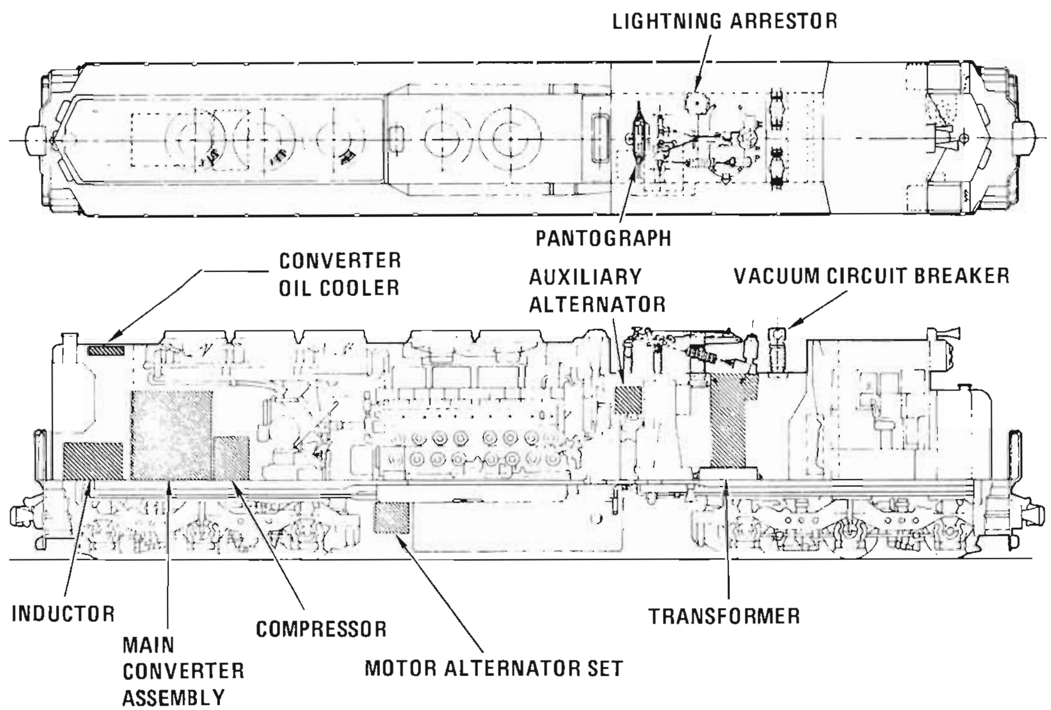
This contract was carried out by the investigation of the resistance components, mechanical and aerodynamic, of freight car rolling stock. A methodology relating train resistance to fuel consumption has been developed. This activity has made active use of ongoing FRA-sponsored aerodynamic research results. The resultant computer program has been documented in a User's Manual.

Dual-Mode Locomotive (DML)
Contract No.: DOT-FR-53-80-C-00010
Funding: $115,000
Schedule: December 1979 – November 1980
FRA Technical Contact: J. Koper
(202) 426-0808
Agency/Contractor: AiResearch Manufacturing Co. of California

A dual-mode locomotive (DML) is one that is powered either from an on-board diesel engine or from a high-voltage catenary via a roof-mounted pantograph, a concept developed during the Wayside Energy Storage Study (DOT-TSC-1349). The proposed DML's advantage is that it is able to operate from a high-voltage (25 or 50 KV) catenary, while past DML's have been able to operate only from a low-voltage (600 Vdc) power source.

A DML that is compatible with mainline railroad electrification will enhance the economies and the extension of electrification. One of the major benefits of railroad electrification is the improved availability of the electric locomotive fleet and the increased power available in each locomotive. Furthermore, railroads can save money by using catenary-supplied energy from coal rather than by burning diesel fuel on board locomotives.

After initial systems engineering, if it appears appropriate, subsequent phases of the program could include the selection of an existing locomotive to retrofit, and detailed design, fabrication and testing. Several major U.S. and Canadian railroads have expressed interest in the results of these studies.



DUAL MODE LOCOMOTIVE – 50 kV DML ARRANGEMENT ON SD-40-2

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The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Aerodynamic Forces on Freight Trains
Vol. I, Wind Tunnel Tests of Containers and Trailers on Flatcars
Andrew G. Hammitt Assoc.
A.G. Hammitt
Report No. FRA/ORD-76/295.I Dec. 1976
PB 264-304

Aerodynamic Forces on Freight Trains
Vol. II, Test Results Report, Full-Scale Aerodynamic Validation Tests of Trailers On-A-Flatcar (Series II)
ENSCO Inc.
P.B. Joshi
Report No. FRA/ORD-76/295.II March 1978
PB 281-823

Aerodynamic Forces on Freight Trains
Vol. III, Correlation Report, Full-Scale Tests of Trailers on Flatcars and Comparison to Wind Tunnel Results
Andrew G. Hammitt Assoc.
A.G. Hammitt
Report No. FRA/ORD-76/295.III Sept. 1978
PB 288-137

Aerodynamic Forces on Freight Trains
Vol. IV, Wind Tunnel Tests of Freight Cars and New Trailer and Container Car Designs
Andrew G. Hammitt Assoc.
A.G. Hammitt
Report No. FRA/ORD-76/295.IV June 1979
PB 80-174899

Aerodynamic Forces on Various Configurations of Railroad Cars for Carrying Trailers and Containers, Wind Tunnel Tests of Six Scale Model Configurations
Andrew G. Hammitt Assoc.
A.G. Hammitt
Report No. FRA/ORD-79/39 Jan. 1979
PB 80-174881

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Vol. I, Two Cylinder Off-Specification Fuel Testing
Southwest Research Institute
Report No. FRA/ORD-80/40.I May 1980
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P.J. Remington and M.J. Rudd
Report No. FRA/ORD-76/142 Aug. 1976
PB 260-410

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Lawrence Berkeley Laboratory, University of California, Berkeley
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Bolt, Beranek and Newman, Inc.
P.J. Remington, M.N. Alakel, and N.R. Dixon
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PB 80-153042

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The MITRE Corporation/METREK Div.
J.D. Muhlenberg
Report No. FRA/ORD-78/04.I April 1978
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Andrew G. Hammitt Assoc.
A.G. Hammitt
Report No. FRA/ORD-80/51 March 1980

CHAPTER 10
ELECTRIC TRACTION/ELECTRIFICATION

The goal of the Electric Traction/Electrification subprogram is to foster the development and use of cost- and energy-efficient American traction technology for use on American railroads. The principal current activities are described in more detail in the following pages, and include:

1) Catenary Project;
2) Chopper Locomotive Project;
3) AC Traction Project;
4) Traction Studies;
5) PCB Transformer Coolant Substitution; and
6) Electrification Studies.

To date, major accomplishments in this subprogram area include:

- Conclusion of testing of a large ac propulsion system, originally built for levitated vehicles and now being considered for locomotives;
- Traction studies for the Northeast Corridor and the LA-San Diego line;
- Identification of a potential replacement for poisonous polychlorinated biphenyl which is presently used as a transformer coolant on board electric locomotives;
- The electrification of the 14-mile test loop at TTC, which will be used to test and evaluate electric locomotives and the catenary design for the Northeast Corridor Project; and
- A report, submitted to Congress, providing data on cost, energy implications, and railroad and government costs and benefits of railroad electrification.

Each project has been or is being carried out by the FRA, in cooperation with other DOT offices and Federal research organizations.

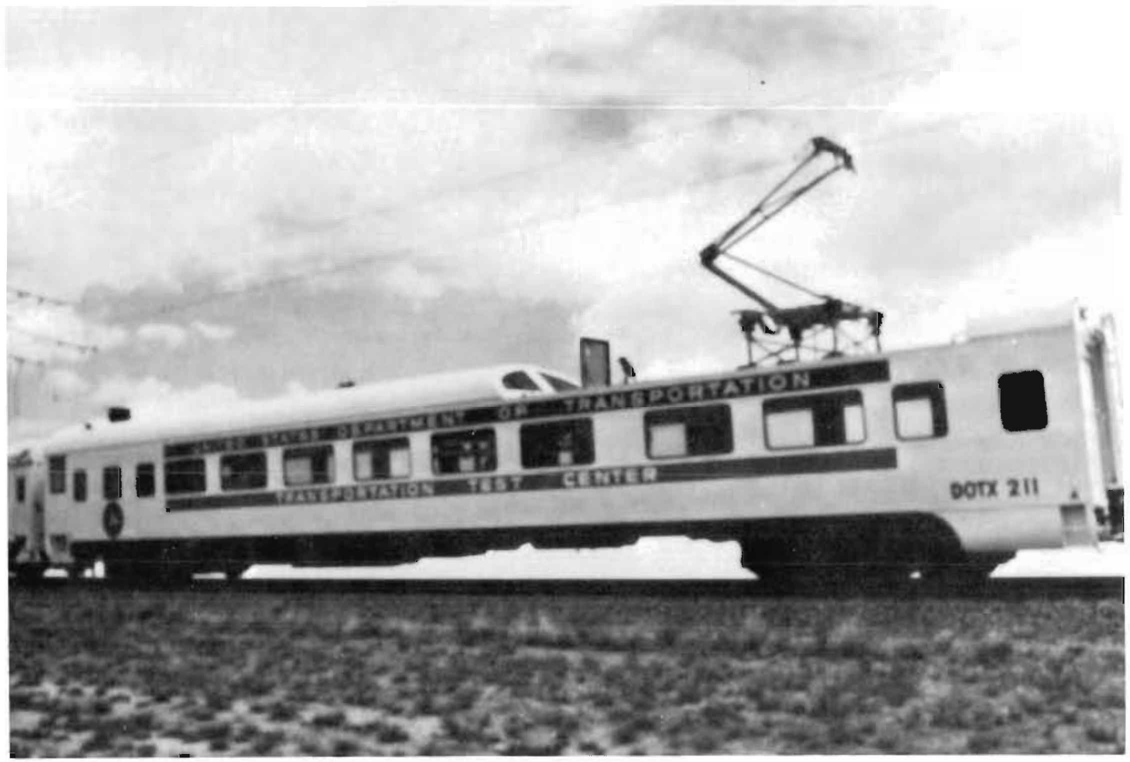
CATENARY PROJECT

The objective of this project is to investigate and define viable alternative catenary systems to those in use today. A consideration of this research will be to evaluate the potential benefits versus the implementation costs. In the final analysis of course, if the implementation costs prove to be prohibitive, taking into consideration the wide range of potential benefits, the research will be terminated.

The potential benefits appear at this time to include eliminating dependence on one conducting material, copper; lighter supporting structures; and fewer electric poles. All of these factors can result in more economical railroad electrification.

The FRA has been investigating various aspects of railroad electrification. FRA plans to utilize the electrified Railroad Test Track (RTT) at the Transportation Test Center (TTC) in Pueblo, Colorado, for advanced research and development of pertinent electrical systems and associated component hardware. This has included the aluminum catenary. This catenary system consists of the overhead high-voltage conductors (contact wire), insulators, and fittings. The range of voltage is from 11 kV to 50 kV, nominal. However, prior to the TTC carrying out their testing, it will be necessary to specifically define the aluminum catenary system hardware, including preliminary testing, optimize it, and determine whether the optimized design shows a potential for significant benefits.

The work done under this project is a detailed engineering study, based largely on hardware activities. These activities include the design and fabrication of test specimens, the performance of laboratory tests and preliminary testing of a full-scale section of the candidate catenary system, for future adaptation and testing at the TTC. As part of the study, a direct comparison will be made of a new design with the more conventional catenaries now used, to determine possible implementation at the TTC and on operational railroads.



CONTRACTS

Aluminum Catenary System
Contract No.: DOT-FR-9154
Funding: $175,000
Schedule: September 1979 – April 1981
FRA Technical Contact: M. Guarino, Jr.
(202) 426-9665
Agency/Contractor: Alcoa Aluminum

Alcoa's contract for the aluminum catenary development is aimed at the investigation and definition of an aluminum catenary system as a fundamental and viable alternative to the present system. It includes the laboratory work required, prior to full testing at the TTC.

During FY80 Alcoa selected, designed, and tested required fittings; make comparative wear tests on a drum of aluminum and compared it with a drum of copper; and erected a test facility at the Alcoa plant in Massena, N.Y. to begin preliminary testing.

On a volume basis, aluminum is 70 percent lighter than copper, which gives direct advantage in shipping, handling, and erection cost support requirements, and catenary/pantograph dynamics.

Since railroad electrification involves relatively high capital expenditures, lowering these costs becomes a prime consideration for a new catenary system. Considerable savings can be realized by using aluminum instead of bronze and copper, due to the relative costs.

Low-Cost Catenary Concept Analysis
Contract No.: DTFR53-80-C-00045
Funding: $110,000
Schedule: July 1980 – June 1982
FRA Technical Contact: N. Kamalian
(202) 426-9564
Agency/Contractor: American Electric Power

American Electric Power (AEP) has prepared a candidate catenary system which could potentially lead to a greatly reduced cost of catenary installation and maintenance for electrified railroads. This system will provide an elevated contact conductor that is built and maintained very much as power companies build and maintain transmission or distribution lines. Preliminary cost estimates provided by the AEP indicate that the new system has a potential of reducing the cost of catenary installation to less than 50 percent of present costs. If the cost of installation can indeed be reduced by 50 percent in future electrification installation, this would provide greater returns to the railroads on their investment.

In the final analysis, the objective of this contract is to determine if the electrification system described is technically feasible and more economical to build and construct than conventional railroad electrification systems in order to improve the railroads' operating efficiency and to encourage the application of a transportation system independent of petroleum.

CHOPPER LOCOMOTIVE PROJECT

The objective of this project is to obtain a moderate improvement in the overall adhesion of an all-electric locomotive as well as to reduce electromagnetic interference and to obtain a better electrical interface with the overhead catenary. This latter goal would result in a reduction in current requirements and a drop in voltage. This research will lead to quantifying the improvement in power factor and efficiency that can be made by a chopper locomotive as compared to a phase-controlled electric locomotive.

Modern electric locomotives such as the E-60 make use of solid-state, phase-controlled rectifiers to convert ac to dc and to control the flow of current to the traction motors. Unfortunately, these devices produce poor power factor and considerable electromagnetic interference.

The General Electric Company has developed a chopper propulsion system that promises to correct the poor features of the phase-control locomotive and provides individual motor control. The chopper propulsion system also promises to provide an improved power factor over the total speed range of the locomotive and, in particular, will be more efficient at lower speeds. In addition, each motor will be individually controlled by a chopper, thus improving the overall adhesion of the locomotive.

The project is a cooperative development effort between Conrail, General Electric, and the FRA. General Electric will design, manufacture and install a chopper propulsion system on a Conrail E-44 locomotive and will provide test personnel and test cars in support of the project.Conrail will provide an operable electric locomotive, locomotive maintenance, operating crews, power, and use of the electrified portion of the railroad for the locomotive test period.

Chopper Locomotive
Contract No.: DOT-FR-9027
Funding: $1,500,000 FRA, $2,250,000 G.E., $1,500,000 Conrail
Schedule: January 1979 – November 1981
FRA Technical Monitor: M. Guarino, Jr. (202) 426-9665
Agency/Contractor: General Electric Company

During FY80, the cooperative effort between the Federal Railroad Administration (FRA), Conrail, and General Electric continued in order to develop an improved all-electric locomotive. During the year there were three principle accomplishments: the completion of final locomotive-modifications drawings, the initiation of E-44 locomotive modifications, and the laboratory testing of a one-axle chopper.

The results of this research will have an impact on the procurement specifications for future locomotives.

AC TRACTION PROJECT

Railway traction in the United States is either all-electric or diesel/electric. Hence, an electric traction system is used on every single train, and its technological development should play a key role in the modernization of our railroads. All motors and motor controls used operationally today are variations of the dc motor. This system is basically an old system, and is expected to be eventually replaced by a modern ac (three-phase) system. The problem that must be overcome is the simplification and integration of system components to reduce their present nearly-prohibitive initial cost.

The objective of the ac traction project is to arrive at a practical and economic system. The principal problem lies with the PCU (power-conditioning unit, for torque and speed control) and its integration with the traction motors. Hence, the ac traction project focuses on an integrated single-axle drive (i.e., independent drive for each wheel axle) for locomotives, both all-electric and diesel/electric, to meet the following objectives:

a) Maximizing axle power density, i.e., the usable power per driven axle for a given axle load;

b) Minimizing the dynamic loading of the track;

c) Uniform wheel wear;

d) Operation with relatively large differences in wheel diameters (with respect to other wheel sets);

e) Reduced possibility of derailment;

f) Increased reliability (locomotive availability);

g) Reduced interference with signaling and communications (EMI control);

h) High power factor; and

i) Improved braking, particularly, regenerative braking.

The last three items are significant only when the drive is used in all-electric systems. For passenger traffic, higher axle power density tends to:

- Reduce advantages of MU trains in favor of the more economical locomotive-hauled operation, by reducing axle loads and, thus, allowing the use of locomotives at higher speeds;
- Reduce the complexity of MU cars by reducing the number of driven axles; and
- Foster the use of power cars.

For freight traffic, higher axle power densities tend to:

- Reduce the locomotive fleet;
- Increase the draw-bar pull at starting by maximizing the exploitable adhesion, within the limitations imposed by the prime mover; and
- Foster the use of mixed all-electric and diesel/electric locomotives for train consists, on electrified stretches and steep grades.

CONTRACTS

TLRV Power-Conditioning Hardware Utilization Study
Contract No.: DOT-FR-9132
Funding: $342,000
Schedule: September 1979 – September 1981
FRA Technical Contact: M. Guarino, Jr.
(202) 426-9665
Agency/Contractor: Garrett AiResearch

The most advanced and most powerful electrical traction system ever built is the one developed for the Tracked Levitated Research Vehicle (TLRV). This system was developed by the Federal Railroad Administration (FRA) under the levitated-systems program and was partially tested in 1976, before it was dismantled and stored at the Transportation Test Center (TTC). Low-speed tests were conducted successfully up to 44 mph. These low-speed tests, originally planned to be followed by tests up to 150 mph, were conducted after the levitated systems program was terminated because of the potential application of the system to conventional locomotives.

The contract primarily focuses on the possible application of the partially tested power conditioning system to conventional locomotives. It involves system definition for locomotive application, system definition for static power source application, novel control methods for ac traction, and advanced semiconductor cooling techniques. The principal accomplishment in 1980 is the preparation of a report on the first phase of the work.

This contract will establish the R&D groundwork for ac traction for locomotives and multiple unit (MU) cars. This type of electrical traction maximizes usable power per driven axle. It can, for example, lead to a reduction in the size of locomotive fleets.

Parity Simulation Model of Constant Current Source Motor Drive System
Contract No.: TSC 1646 (Managed by the Transportation Systems Center)
Funding: $24,956
Schedule: April 1979 – April 1980
TSC Technical Contact: R. Wlodyka
(617) 494-2143
Agency/Contractor: MIT

The purpose of the contract was to provide the FRA with a tool with which to evaluate power conditioning systems prior to initiating full-scale traction motor systems development for locomotives and multiple unit power cars.

Using the Parity Simulator, an evaluation of the entire Constant Current Source Induction Motor Drive System was performed. The value of any component value can be changed and nearly any fault condition can be investigated.

TRACTION STUDIES PROJECT

The objectives of the Traction Studies project are:

1) To identify worldwide innovative traction technology and monitor its progress;
2) To use specific railroad routes to quantify the potential benefits of specific traction innovations to U.S. railroads;
3) To identify specific R&D activities in electrical traction, tailored to meet the unique operational requirements of North American railroads; and
4) To establish realistic limits as to what modern traction can, and cannot do, to meet operational plans for specific routes. This establishes a foundation for cost-effective hardware R&D.

These studies are being performed for FRA by the Jet Propulsion Laboratory (JPL), and are now in their third phase. A description of Phases I and II (pre-1980) follows:

Phase I (FY75 to FY77)

JPL carried out a methodical investigation of foreign traction technology: new equipment, major R&D activities, trends, etc. This critical survey and subsequent selection of the most important articles was rendered possible by the availability at JPL of multilingual engineers, with considerable experience in U.S. electrical traction. The results of this survey were published in two reports (1976, 1977), "A Selected Bibliography of World Literature on Electric Traction for Railroads" (with abstracts), as well as two reports, "Survey of European Electrified Railroads" in 1976, 1977.

Phase 2 (FY77 to FY79)

To assess the potential and limitations of modern traction technology, OR&D decided to use an actual major route (Northeast Corridor) as a first "yardstick". JPL carried out this task in a series of system studies. This phase culminated in an Executive Summary Document, "Traction Studies of Northeast Corridor Rail Passenger Service", published in March 1980.

CONTRACTS

Railroad Traction Studies
Contract No.: NASA/DOT AR-84290
Funding: $179,000
Schedule: January 1979 – April 1981
FRA Technical Contact: M. Guarino, Jr.
(202) 426-9665
Agency/Contractor: Jet Propulsion Laboratory

The objectives of this contract are to provide for a broader basis for the assessment of the potential and limitations of modern traction technology. JPL was directed by FRA to initiate studies of Western railroads, to parallel those already done for the Northeast Corridor (NEC). The first study addressed the Southwest Passenger Service Corridor between Los Angeles and San Diego; the results of this study are contained in Letter Report 21, "San Diego Corridor Optimization Study". Next, with the cooperation of the Southern Pacific Transportation Company, JPL began an in-depth study of the potential and limitations of modern traction technology in the streamlining of present operations of major freight railroads, as well as providing new operational options (e.g., short- and medium-length trains). This study is far more complex than the one for the NEC because of the many parameters involved. The first year has been devoted largely to the identification and assessment of the principal problems and parameters. The concept of ac traction was studied. Two interim reports, documenting the findings to date, are being finalized.

PCB TRANSFORMER COOLANT SUBSTITUTION PROJECT

The objective of this research is to identify a substitute for polychlorinated biphenyl (PCB) fluids presently used as coolants in railroad transformers. The Environmental Protection Agency (EPA) has ruled that the PCB level in railroad transformers must be reduced to 6 percent by January 1, 1982, and to not more than 1000 ppm by January 1, 1984.

The FRA has been cooperating with the Southeastern Pennsylvania Transportation Authority (SEPTA) and Amtrack to test candidate substitute fluids. Laboratory tests of Silicone, Iralec, RTEmp, and Midel fluids have been completed. In-service tests of both RTEmp and Iralec fluids in a DOT transformer on a SEPTA vehicle have been completed. Testing of Midel and a second RTEmp fluid on a SEPTA vehicle will begin soon.

The transformers being used for testing consist of five DOT transformers which had been removed from track inspection cars. The identification of a suitable flushing technique and a satisfactory fluid will permit the computer railroads and Amtrack to replace PCB coolants and retain existing transformers. It is estimated that the cost of replacing transformers would be $70,000,000.

PCB Substitutes
Contract No.: DTFR 53-80-C00002
Funding: $41,000
Schedule: October 1979 – August 1981
FRA Technical Contact: M.C. Gannett
(202) 426-9665
Agency/Contractor: ENSCO, Inc.

The objective of this contract is to identify a suitable substitute for railroad transformer coolants containing PCB.

During FY80, the contractor installed instrumentation on and monitored the performance of transformers containing Iralec and RTEmp in service on SEPTA lines. Transformers are presently being prepared for in-service tests of Midel and RTEmp II.

Transformer Coolant Flammability Studies
Contract No.: DOT-TSC-1562 (Managed by the Transportation Systems Center)
Funding: $95,000
Schedule: August 1978 – February 1981
TSC Technical Contact: R. Wlodyka
(617) 494-2044
Agency/Contractor: Westinghouse Electric Company

The contractor developed a procedure for flushing PCB coolant fluid from railroad transformers and retrofilling the drained transformers with a substitute coolant. The retrofilled transformers were then load tested in the contractor's 25-Hz test cell. Fluids retrofilled under this contract were Silicone and Midel. The Midel-filled transformer is the only one of the two types which tests satisfactorily.

Transformer Coolant, Replacement for PCBs
Contract No.: DOT-TSC-1703 (Managed by the Transportation Systems Center)
Funding: $24,164
Schedule: April 1979 – January 1980
TSC Technical Contact: R. Wlodyka
(617) 494-2044
Agency/Contractor: Factory Mutual

The contractor tested samples of Silicone and RTEmp transformer fluid for flammability characteristics when contaminated with PCB's. Pool fires of uncontaminated Silicone and RTEmp were extinghished with a variety of extinguishing agents to identify suitable extinguishing agents.

ELECTRIFICATION STUDIES PROJECT

Prior to World War II, the United States led the world in railroad electrification with its 2500 electrified route-miles representing one-fifth of the world total. After the war, however, a cheap and abundant supply of diesel fuel led to the nearly universal adoption of the diesel locomotive as the power source for U.S. railroads. At present, less than 1 percent of U.S. railroad route-mileage is electrified.

The Arab Oil Embargo and the continuing increase in the price of diesel fuel have made railroad electrification once more an attractive option. Besides alleviating the uncertainties in the cost and supply of diesel fuel, electrification offers other advantages. Electric locomotives are easier to maintain than diesel locomotives and generate more horsepower per unit. Air pollution may be reduced since combustion occurs at a stationary source rather than on a moving source. The goal of energy independence is furthered by electrification since railroads can be powered by non-petroleum energy sources such as coal, nuclear, or hydroelectric power.

Other industrialized nations now have sizable segments of their track electrified. Due to the experience of these countries, the technology of electrification is mature, and its implementation in the United States should pose minimal technological risk. One important technological advance in electrification allows railroads to use commercial frequency power whereas formerly conversion was necessary.

The Railroad Revitalization and Regulatory Reform Act of 1976 (the "4-R Act") resulted in a major reassessment of railroad electrification and its potential role in future railroad operations in the United States. The Act required the Secretary of Transportation to conduct a study on the costs and benefits of U.S. railroad electrification. This study, conducted by the Federal Railroad Administration (FRA) investigated 1) the technology of railroad electrification; 2) the capital and operating cost differential

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for electrified and diesel/electric railroads; 3) the energy and environmental impacts of electrification; and 4) the options for government participation in rail electrification. Results of the study showed that electrification posed no significant technological barriers and that the rate of return on investment would be improved for those railroads with steady, high-volume traffic markets. The primary risk of electrification appeared to be financial. The heavy initial capital expenditures will be justified, based on the spread between diesel and alternative fuel source costs and if the market for railroad services holds up over the next 20 and 30 years. The most suitable candidates for electrification were identified as those routes with traffic volumes of 40 million gross tons/year or greater. Recently, an update of the study was conducted based on new information and experience.

The "4-R Act" offered loan guarantees of $200 million to Conrail for electrification of portions of its trackage if investigation proved this to be a financially viable option. A study was undertaken by Conrail of the possible electrification between Harrisburg and Pittsburgh, Pennsylvania and between Newark and Trenton, New Jersey. The FRA is providing technical assistance to Conrail and will generalize study findings for application to other proposed electrification projects. The FRA is working with the New Jersey Department of Transportation in the development of cost data for the conversion of existing electrification on the Erie-Lackawanna commuter railroad to new voltage and frequency levels.

An annual report prepared by the FRA summarizes current and planned electrification activity in the United States. This year the report will be expanded to include worldwide electrification activity.

A study, funded by the FRA, investigated the cost-effectiveness of various types of research and development related to railroad electrification. Through a series of government/industry workshops, a set of topics was identified worthy of future research and development activities. Topics included railroad/utility interface, improvements in catenary (overhead wire) design, improvements in electric locomotive design, and methods to reduce electromagnetic interference created in signal and communication systems.

Another current FRA study is investigating the types of electrical distribution systems appropriate for U.S. railroad electrification considering various railroad and utility supply factors.

Descriptions of the FRA's current research and development contracts related to railroad electrification follow.

AMTRAK E-60 LOCOMOTIVE

Railroad Electrification — Conrail Electrification Study Assessment
Contract No.: PPA-032
Funding: $150,000
Schedule: October 1977 -- October 1980
FRA Technical Contact: R.A. Novotny (202) 426-9564
Agency/Contractor: Transportation Systems Center

Section 606 of the Railroad Revitalization and Regulatory Reform Act offered $200 million in loan guarantees to Conrail for electrification of portions of its track where conversion to electricity could be shown to be financially viable. In response to this legislation, Conrail contracted to have a study done on the possible electrification of approximately 600 route-miles.

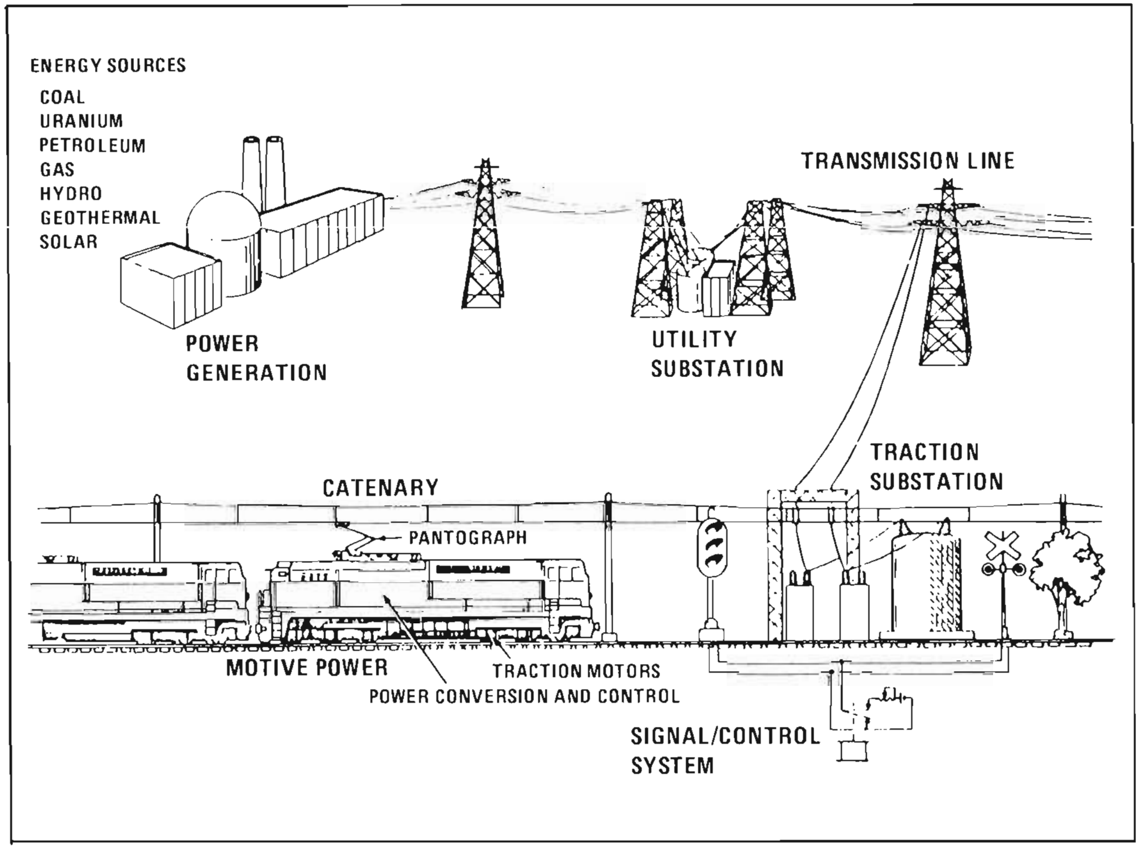
The FRA reviewed the study reports in the areas of civil reconstruction, catenary (overhead wires), power substations, locomotives, and energy requirements. Based on this work, the FRA will publish a report on the costs of electrifying the Conrail study route and an analysis showing how these costs can be applied to proposed electrification projects in other parts of the United States.

Analysis of Electrical Supply Configurations for Electrified Rail Systems
Contract No.: DTRS-57-80-0-0042
Funding: $160,444
Schedule: February 1980 — March 1981
FRA Technical Contact: N. Kamalian (202) 426-9564
TSC Technical Contact: C. Spenny (617) 494-2614
Agency/Contractor: Electrack Corporation

At the present time, electrification at commercial frequency in the U.S. is limited to a few private coal hauling operations with a combined length of a few hundred miles. Before large-scale electrification of freight operations can be considered, it is first necessary to examine thephysical and operational characteristics of different rail routes and electric supply facilities. One such factor which should be investigated is the voltage level chosen to be carried inthe catenary — the overhead wires that supply power to the train.

Accordingly, alternative design configurations on a site-specific basis will be evaluated in terms of both railroad and utility requirements.

The analysis will include data collection on high-density rail routes, i.e., is those routes suitable for electrification, and on electric supply facilities that would service them, Electric distribution systems that satisfy both railroad and utility requirements will be identified. Cost estimates will be developed for alternative distribution systems.



COMPONENTS OF AN ELECTRIFIED RAIL SYSTEM

Railroad Electrifiction Annual Status Report
Contract No.: PPA-032
Funding: $65,000
Schedule: October 1976 – Ongoing
FRA Technical Contact: R.A. Novotny
(202) 426-9564
Agency/Contractor: Transportation Systems Center

Although fewer than 1 percent of U.S. railroads are electrified, there has recently been a resurgence of interest in rail electrification. In anticipation of possible conversion to electrification, the FRA has undertaken to develop and maintain a data base for use by government and industry in their reassessment activities.

The report identified construction and maintenance activities in the United States, Canada, and Mexico on existing electrified railroads. Electrification planning activites being carried out by government, railroads, utilities, and government agencies are summarized, as are current private and public research and development activities related to electrification. The roles of financial institutions, the domestic supply industry, and architectural/engineering firms involved in railroad electrification are discussed.

ADVANTAGES	DISADVANTAGES
NATIONAL LEVEL	
• ENVIRONMENTALLY CLEAN	• CAPITAL COST
• CONSERVES SCARCE RESOURCES	• INFLEXIBILITY OF EQUIPMENT USAGE
• LESSEN IMPACT OF OIL SUPPLY DISRUPTIONS ON U.S. GOODS TRANSPORTATION	
CONRAIL NETWORK	
• ENVIRONMENTALLY & ECONOMICALLY SOUND	• FINANCIALLY BEYOND CONRAIL CAPABILITY
• CONSERVES PETROLEUM	• COMPETE WITH HIGHER PRIORITY WORK
• COAL WOULD BE PRIMARY POWER SOURCE	
RAILROAD INDUSTRY	
• SAVE ON LOCOMOTIVE MAINTENANCE	
• GREATER SYSTEM EFFICIENCY	
• IMPROVE FINANCIAL HEALTH OF RAILROADS	

PROS AND CONS OF ELECTRIFICATION

• DIESEL OIL SAVED ANNUALLY:

SYSTEM SIZE	MILLIONS BARRELS SAVED PER YEAR
CONRAIL 560 ROUTE MILE SYSTEM	1.7
NATIONAL 26,000 ROUTE MILE SYSTEM	56.0

- 56 MILLION BARRELS REPRESENT > 1/2 TOTAL CURRENT CONSUMPTION OF U.S. RAIL INDUSTRY
- 26,000 MILE SYSTEM REDUCES OIL DEMAND FOR U.S. RAIL SYSTEM TO .6% OF TOTAL U.S. OIL DEMAND
- END RESULT IS A BASIC RAIL NETWORK HIGHLY INSULATED AGAINST OIL SHORTAGES. DRAMATIC FUEL SAVINGS IN THE EVENT OF A SUPPLY SHORTAGE

POTENTIAL ENERGY SAVINGS OF ELECTRIFICATION

Railroad Electromagnetic Compatibility
Contract No.: AR 74311
Funding: $552,000 (thru FY81)
Schedule: February 1977 — ongoing
FRA Technical Contact: W.F. Cracker, Jr.
(202) 426-0855
Agency/Contractor: Department of Defense, Electromagnetic Compatibility Analysis Center (Interagency)

Electromagnetic compatibility (EMC) is the capability of electronic (or electrical) equipments or systems to be operated in their intended operational electromagnetic environment at designed levels of efficiency. All operating electrical equipment produce electric and magnetic fields which may influence other electrical equipment. This influence can produce a safety hazard, degrauation of equipment performance, or just be a nuisance. EMC is becoming increasingly important in view of the relatively hostile railroad environment and the introduction of more sophisticated electrical systems.

This contract will provide an EMC assessment of railroad systems and identify problems and concerns. Systems will include both mainline and classification yard environments. Locomotives, signaling, communication, and control equipment will be examined. Recommendations for EMC improvements and mitigation techniques will be developed.

Electromagnetic Compatibility Test Facility (EMCTF), Transportation Test Center (TTC), Pueblo, Colorado
Contract No.: DOT-FR-9048
Funding: $296,000 (not including industry-provided materials and equipment in excess of $250,000)
Schedule: February 1980—November 1980
FRA Technical Contact: W.F. Cracker, Jr.
(202) 426-0855
Agency/Contractor:
Construction: Transportation Test Center Program Code MAA
Design: Kaiser Engineers for Dynamic Science, Inc.

The electromagnetic environment surrounding a railroad is very complex and includes many dif-

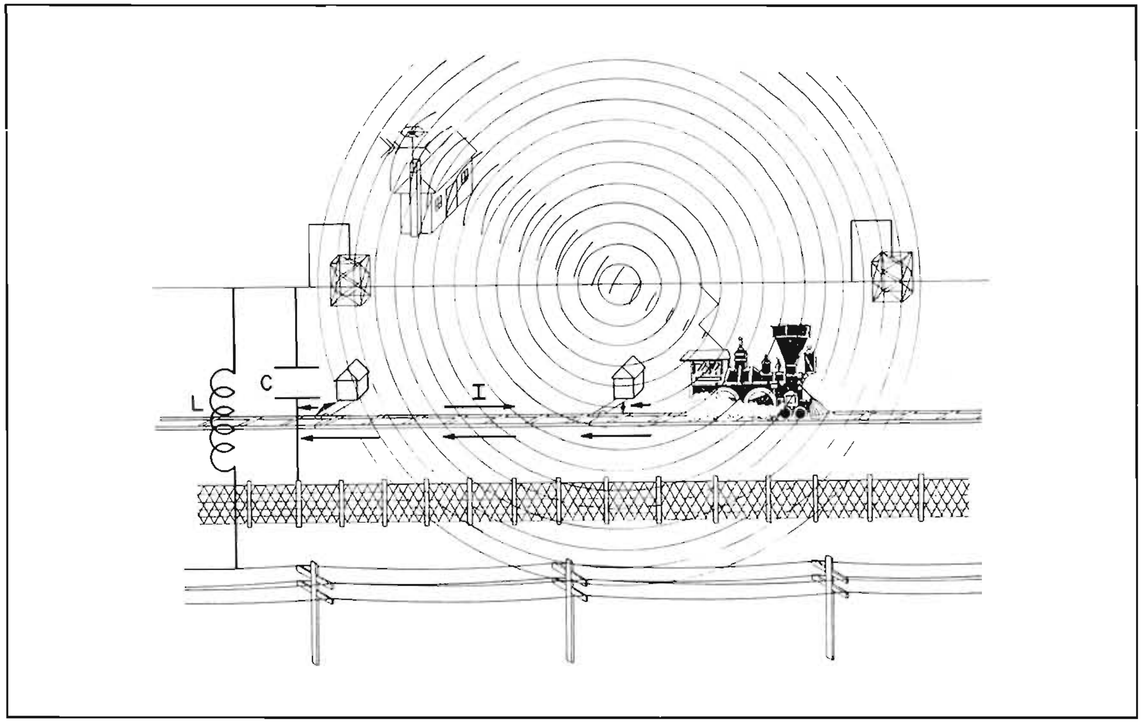
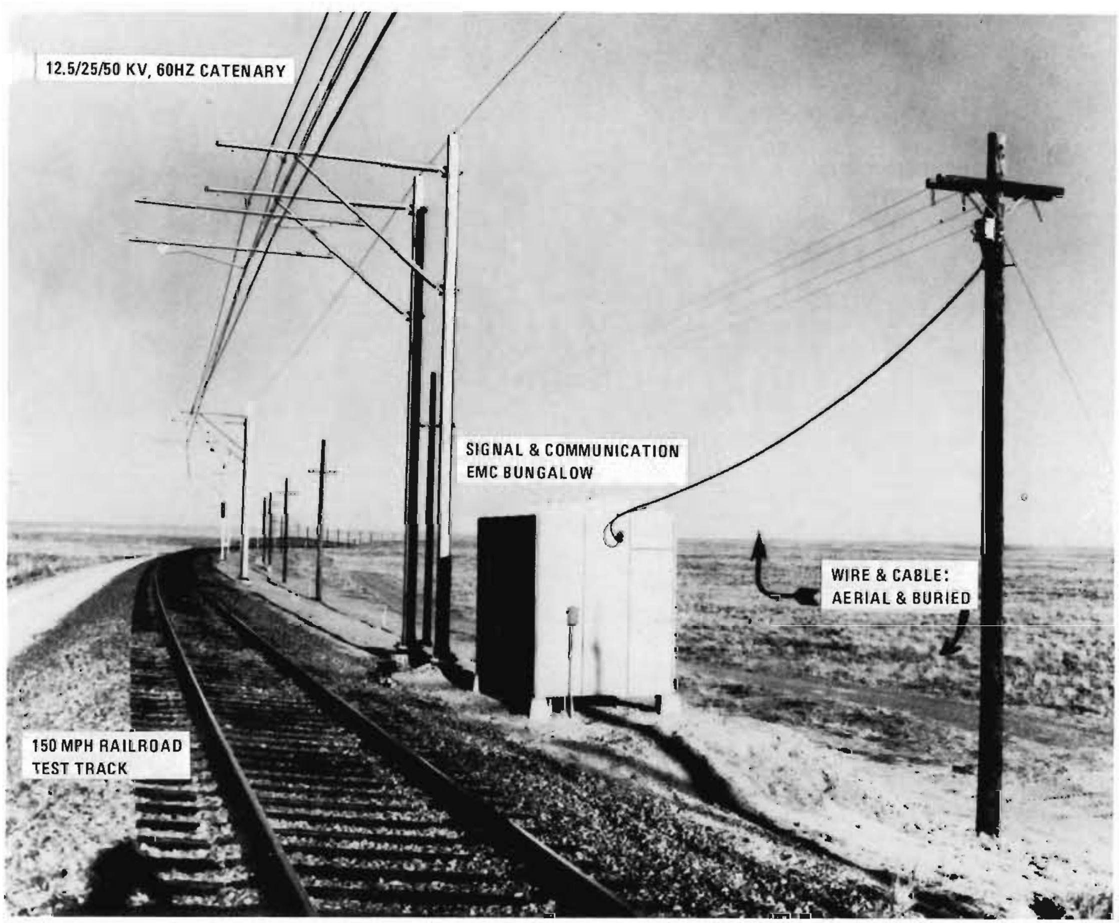


ILLUSTRATION OF VARIOUS FORMS OF ELECTROMAGNETIC INTERFERENCE INCLUDING: INDUCTIVE (L) AND CAPACITIVE (C) COUPLING; CONDUCTIVE CURRENTS (I); AND RADIOACTIVE INTERFERENCE

MEASUREMENT OF ELECTROMAGNETIC NOISE

ferent types of signals. While many of these signals are intentionally generated for command, control or communications purposes, other signals are extraneously emitted and constitute noise. If some electronic equipment or system emits energy that degrades the design levels of efficiency of other equipment or systems, it is considered to be a source of electromagnetic interference (EMI).

This contract was designed to provide for a permanent, multi-purpose, electromagnetic compatibility test facility (EMCTF) to provide for experiments addressing the concerns of the industry over EMI. It will be located in a 3-mile section of the Railroad Test Track and will provide a laboratory environment where a wide variety of signal and communications equipment and systems can be tested in an electrified mainline railroad situation. The Federal government has provided for the design and construction of the facility while industry has provided the bulk of materials needed. The facility will be available for use by the industry and initial work will focus on existing equipment commonly used on American railroads.



ELECTROMAGNETIC COMPATIBILITY TEST FACILITY AT THE TRANSPORTATION TEST CENTER, PUEBLO, COLORADO

ELECTRIC TRACTION/ELECTRIFICATION BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

The lack of a PB number following the citation means that the report may not have been published in sufficient quantity for general distribution or had not yet been entered into the NTIS system when this publication went to press. However, they may be obtained by writing or calling the persons listed as the technical contacts for the contracts.

Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Cost Effectiveness of Research and Development Related to Railroad Electrification in the United States
Transportation Systems Center
F.L. Raposa and C.H. Spenny
Report No. FRA/ORD-77/62 Dec. 1977
PB 276-373

Electromagnetic Interference Impact on Railroad Classification Yards
W. Cracker and P. Speh
IEEE Technical Paper
No. 78CH13, 45-81A April 1978

EMC Considerations in Classification Yard Design
U.S. Dept. of Defense, Electromagnetic Compatibility Analysis Center
Report No. FRA/ORD-80/12 July 1980
PB 80-176621

Energy Costs for Railroad Electrification
Arthur D. Little, Inc.
Edward G. Schwarm May 1977

Engineering Cost Data Analysis for Railroad Electrification
Arthur D. Little, Inc.
Edward G. Schwarm Oct. 1977

Existing Catenary Condition and Recommendations for Improvement; Washington DC to New Rochelle NY
DeLeuw, Cather-Parsons and Assoc.
Report No. FRA/NECPO-79/5 Dec. 1978
PB 291-527/OWT

Northeast Corridor High Speed Rail Passenger Service Improvement Project. Task 5: Electrification
Bechtel, Inc. Apr. 1975

Northeast Corridor High Speed Rail Passenger Service Improvement Project. Task 16: Electrification Systems and Standards
V.W. Pehrson et al
Report No. FRA/NECPO-76 Dec. 1976
PB 262-237

Northeast Corridor High Speed Rail Passenger Service Improvement Project. Task 17: Northeast Corridor Rail System Power Demand Analysis
Transmission and Distribution Associates, Inc.
Oct. 1975

Parametric Analysis of Railroad Electrification Economics. Volume I, Equations and Assumptions
Booze, Allen & Hamilton
William M. Hart Nov. 1980

Parametric Analysis of Railroad Electrification Economics. Volume II, Procedures
Booze, Allen & Hamilton
William M. Hart Nov. 1980

A Parity Simulation Study of A Current Source Inverter Induction Motor Drive
J.G. Kassakian, D.M. Otten, and B.R. Rhodes
Contract No. DOT-TSC-1646 July 1980

A Prospectus for Change in the Railroad Industry — A Preliminary Report to the Secretary of Transportation
Oct. 1978

Railroad Electrification Activity North America — A Status Report: 1976-1978
John M. Clarke
Report No. FRA/ORD-80/81 Nov. 1980

Railroad Electrification: Areas Which Require Additional Analysis, Development, or Study
Arthur D. Little, Inc. Oct. 1976

Railroad Electrification: The Issues Conference held in Washington DC June 13-15, 1977
Transportation Research Board
National Research Council
Special Report 180

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R.J. Buck, H.B.H. Cooper, P. Elliot, J.N. Martin, and A. Purcell
Report No. FRA/ORD-77/67 Oct. 1977

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S. Storonzum, P. Speh
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Alexander Kusko, Inc.
Jeffrey J. LaMarca, Charles M. King, and Alexander Kusko
Report No. DOT/TSC-1452-3 Jan. 1979

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Project Memorandum
C.H. Spenny
Report No. PM-742-C-14-83 April 1980

SECTION 3
IMPROVED PASSENGER SYSTEMS

IMPROVED PASSENGER SYSTEMS PROGRAM

SUBPROGRAM	PROJECTS
11. Train Technology Evaluation	AEM-7 Evaluation and Failure Analysis Tilt Equipment Evaluation Systems Technology New Truck Development
12. Railbus	

SECTION 3
INTRODUCTION

The Department of Transportation (DOT) is deeply involved in rail passenger systems. The Department was instrumental in preparing the legislative package establishing the National Railroad Passenger Corporation (Amtrak); the organization through which the Federal Railroad Administration's (FRA) national rail passenger goal is implemented.

The Rail Passenger Service Act of 1970, as amended (84 stat. 1327; 45 U.S.C 541), created Amtrak to provide a balanced transportation system by improving and developing intercity passenger rail service. Amtrak was organized on a "for profit" basis, with investment capital and operating losses being supported by Federal financing.

The FRA oversees the Northeast Corridor Improvement Project. Mandated by Congress, this project will provide regularly scheduled and dependable intercity rail passenger service between Boston and New York and Washington.

Within FRA, the Improved Passenger Systems Program's objectives are to:

1) Evaluate train technology to support the Department of Transportation and Amtrak in equipment procurement decisions; and
2) Develop performance requirements for intercity railroad passenger equipment and components.

Descriptions of the subprogram, projects, supporting contracts and a bibliography of published reports follow.

CHAPTER 11
TRAIN TECHNOLOGY EVALUATION

The goal of the Train Technology Evaluation subprogram is aimed at assuring that Amtrak equipment purchases contain optimum designs consistent with their mission, and at reducing the risk of major error in system development. R&D will be accomplished in the areas of equipment reliability improvements, techniques for reducing trip time, and system analysis studies. A major effort will be made to stay abreast of foreign technological advances to negate the possibility of duplicating R&D already accomplished.

To improve operations through lower maintenance costs for rolling stock and fixed plant, ride quality tests will be conducted using radial axle trucks. Radial axle trucks have the potential of reducing wheel and rail wear, improving ride quality, increasing stability and reducing noise in curves. They also have the potential of reducing dynamic lateral track forces.

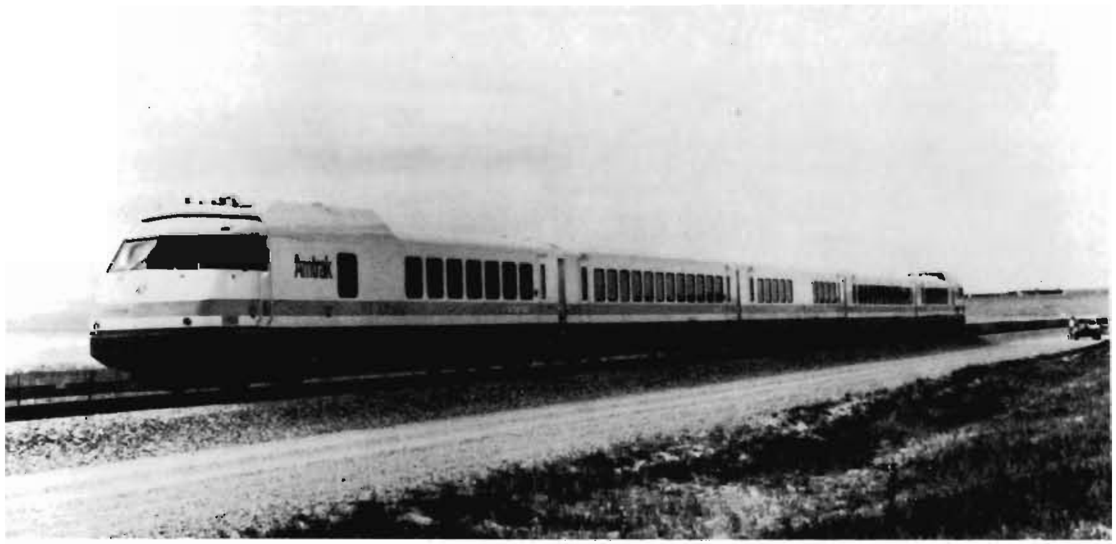
Life cycle and reliability testing has begun at the Transportation Test Center using AEM-locomotives. The focus of this study is to reduce major performance deficiencies and to identify maintenance cycles for enhanced operating reliability and reduced maintenance cost. Cost benefit analysis of vehicle modifications using tilt-body concepts will be applied to existing track systems.

Foreign suppliers have new trains in experimental service which could greatly reduce development costs provided they can be modified to operate on existing U.S. track structure. The next step is to advance the trade-off studies to develop design modifications which will satisfy U.S. requirements. These applications will then be used to compare new train system designs against modifications to existing Amtrak equipment.

Each project is carried out by the FRA through contracts with private and Federal research organizations. Descriptions of each project, supporting contracts and a bibliography of published reports follow.

There are four projects included in the Train Technology Evaluation subprogram. These projects include:

1) AEM-7 Evaluation and Failure Analysis;
2) Tilt Equipment Evaluation;
3) Systems Technology; and
4) New Truck Development.



AMTRAK TURBINE DRIVEN ROHR TURBOLINER (RTL) IN TEST AT TRANSPORTATION TEST CENTER

AEM-7 EVALUATION AND FAILURE ANALYSIS PROJECT

The AEM-7 is a newly designed electric locomotive manufactured by General Motors, Electro Motive Division for Amtrak. In conjunction with the Amfleet cars, it will provide high-speed passenger service between Washington, D.C. and Boston at speeds of up to 120 mph. The electrified sections of the Northeast Corridor operate on 11 kV, 25 Hz power. The system is scheduled for conversion to 25 kV, 60 Hz power. Since the conversion will be gradual, the rolling stock must be capable of dual-voltage, dual-frequency operation. The control system of the AEM-7 locomotive is designed to sense the voltage and frequency in the catenary, or overhead wires, and make automatic adjustments. This new feature replaces the manual voltage changeover presently used on the electric vehicles operating over the Northeast Corridor.

In order to test its performance before operation on Amtrak, the AEM-7 will undergo testing at the Transportation Test Center (TTC) in Pueblo, Colorado. The train will be tested for conformity with performance specifications and for endurance. The Railroad Test Track (RTT) has a catenary system which can provide voltage differences to test the locomotive's dual-voltage capability.

A Failure Reporting and Analysis System (FRAS) has been developed to collect, code, and analyze failure data on the AEM-7 locomotive during the testing at TTC. Early evaluation of equipment failures will allow modifications to the AEM-7 that will increase the reliability of its operations on the Northeast Corridor.

CONTRACTS

Locomotive Failure Reporting and Analysis System (FRAS)
Contract No.: PPA-032
Funding: $55,000
Schedule: February 1979 – October 1980
FRA Technical Contact: T.P. Woll
(202) 426-9564
Agency/Contractor: Transportation Systems Center

In conjunction with the testing of the AEM-7 locomotive at the Transportation Test Center, a Failure Reporting and Analysis System (FRAS) was developed. The purpose was to collect, code, and analyze the maintenance and operational history, including failure and repair history, of the AEM-7 during the endurance testing. This complete service history can then be used to assess the locomotive's reliability and to correct chronic problems. Four types of information were input: operational data, maintenance data, inventory data, and accounting data. Discussions with Amtrak, the Port Authority Transit Corporation (PATCO), and a locomotive supplier (EMD) helped determine specific data to be used as input.

The FRAS system devised for the TTC testing involves manual entry and manipulation of the data. However, the system is designed for easy computerization for application to large-scale failure reporting and analysis, such as fleet maintenance operations. Following the TTC testing, the FRAS system will be presented to Amtrak for further tracking of AEM-7 performance and for possible application to fleet maintenance operations.

AEM-7 Locomotive Test at TTC
Contract No.: Not Applicable
Funding: $1,133,110
Schedule: May 1980 – May 1981
FRA Technical Contact: M.C. Gannett
(202) 426-9665
Agency/Contractor: Transportation Test Center

The testing of the AEM-7 locomotive, begun in April 1980 at the Transportation Test Center in Pueblo, Colorado, was conducted using the Railroad Test Track (RTT) catenary system. The RTT traction substation was modified to provide two voltage levels, 12.5 kV and 25 kV, in order to test the locomotive's dual-voltage capability.

Basic locomotive operating characteristics were investigated as part of the testing. Temperatures of locomotive equipment and components were measured, and catenary current harmonics were analyzed for different operational conditions. These characteristics tests indicated the ability of the locomotive to meet performance specifications.

A 250,000-mile endurance test is being completed to determine whether the locomotive and Amfleet cars can operate at high speeds over the Northeast Corridor for an extended period of time. A number of equipment failures have occurred during the endurance testing that require solutions before the AEM-7 begins high-speed service on Amtrak.

RTT ELECTRIFICATION – AMTRAK AEM-7 LOCOMOTIVE STANDS READY ON RTT TO BEGIN TEST

TILT EQUIPMENT EVALUATION PROJECT

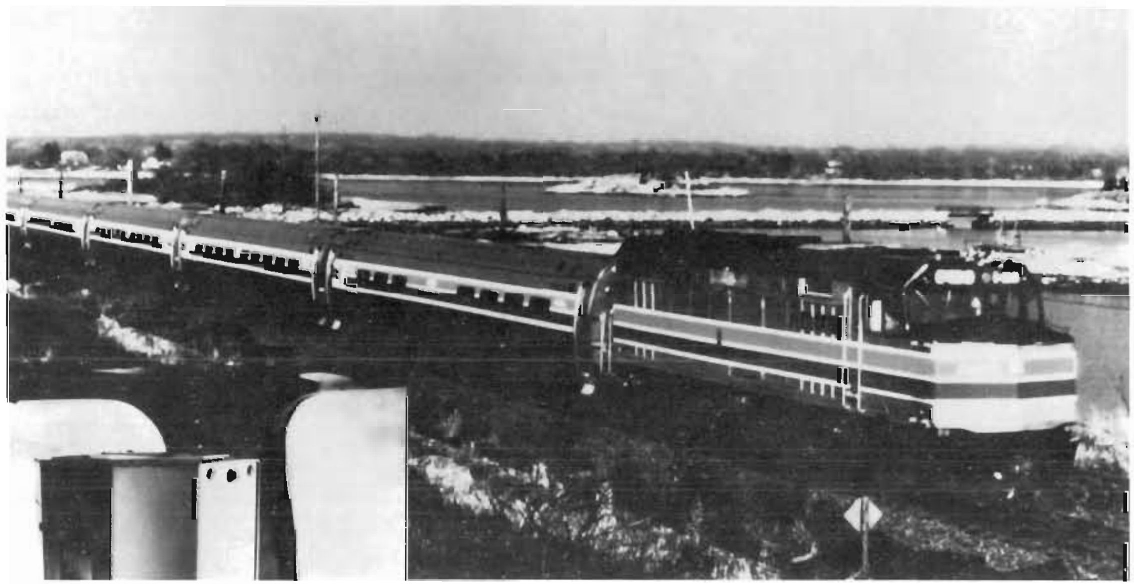
The Amtrak Improvement Act of 1978 amended the Rail Revitalization and Regulatory Reform Act of 1976 to require the Secretary of Transportation to develop vehicles capable of providing a 2½-hour trip time between Washington, D.C. and New York, and a 3-hour trip time between New York and Boston. A possible interim step in the development of this scheduled service is the utilization of the Lightweight, Rapid, Comfortable (LRC) tilt coaches, or Amcoaches with tilt modifications in order to increase allowable speeds in curves without sacrificing passenger comfort. Tests of the Canadian LRC were conducted during the summer of 1980.

In January of 1977, Amtrak signed a 2-year lease/purchase option agreement with Bombardier-MLW, the LRC manufacturing firm for two five-car, LRC tilt-body trains. The LRC was first proposed to run in the Vancouver-Portland Corridor between Vancouver, B.C. and Seattle, WA. Now, however, it is being considered for prime use in the Midwest and Northeast corridors.

ASEA, Inc.'s experience in the high-speed train field goes back to the 1950's, when it developed a very lightweight express locomotive. This development was followed by other high-speed locomotives and multiple-unit trains and in the late 1960's, the first ASEA tilting vehicle was tested. Results from this test program were so successful that Swedish State Railways and ASEA signed an agreement in 1973 to modify a multiple-unit train for extensive high-speed testing on existing track. This test train was designated the X15 and since 1975, more than 1200 test runs have been made at speeds of 85 mph and more on different types of track and with varying combinations of tilt system parameters.

One of the overall objectives of this project is to evaluate the existing Budd Company and ASEA, Inc. designs for a carbody tilt system for the Amcoach. The evaluation will include testing, data acquisition, data analysis, and recommendations for improving the design.

The tilt equipment evaluation project will involve close cooperation between FRA and Amtrak. FRA will encourage Amtrak participation and assistance throughout the project in such areas as project planning, progress reviews, tilt



AMTRAK GENERAL MOTORS/ELECTROMOTIVE DIVISION DIESEL F40PH LOCOMOTIVE IN REVENUE SERVICE WITH BUDD COMPANY AMCOACHES system installation and checkout, road testing, and a review of technical reports and materials.

In addition, the FRA Office of Safety will be provided with sufficient information to allow a waiver for LRC, Amfleet, and AEM-7 operation at higher cant deficiencies.

AMTRAK GENERAL ELECTRIC E-60 LOCOMOTIVE ALONG WITH THE FRA TEST CAR T-7 AND BUDD COMPANY AMCOACHES IN TEST ON NEC MILE POST 44.2, SEPTEMBER 28, 1976

CONTRACTS

LRC Cant Deficiency Test
Contract No.: DOT-FR-64113, Task 475
Funding: $1,257,000
Schedule: February 1979 – December 1980
FRA Technical Contact: M.C. Gannett
(202) 426-9665
Agency/Contractor: Ensco, Inc.

The goals of this contract were to provide engineering data to be used in the determination of the maximum safe running speed of various passenger equipment on the NEC track structure. Upon reviewing impact of present NEC passenger train equipment against the mandated trip time goals and the cost projections of track structure realignment, and realizing that all planned realignments were not possible, the Northeast Corridor Project (NECP) and Amtrak agreed that it would be desirable to increase curve speeds above those now permitted. Amtrak, NECP, and Office of Research and Development jointly agreed to run a series of tests at selected points on the Northeast Corridor (NEC) to confirm that safety and comfort would not be compromised at cant deficiencies in excess of 3 inches.

Tests were run on NEC trackage between New Haven, CT and Providence, RI on a 2-degree 52-minute curve with 5-3/4 inches superelevation. The test program will be in the following three phases:

1) LRC locomotive and Amcoach;
2) LRC locomotive and coach; and
3) AEM-7 locomotive and LRC coach.

Modern passenger trains may be capable of negotiating curves at higher speeds without compromising passenger comfort or safety. Recent studies indicate that the cost of straightening the curves on the NEC is greater than anticipated, and that all of the planned curve realignments in the NEC are not practical. Therefore, the NECP and Amtrak have recommended that the feasibility of increasing maximum curve speeds in the United States be reassessed.

Tilt Systems Design
Contract No.: DOT FR53-81-C-00155
Funding: $85,000
Schedule: November 1980 – June 1981
FRA Technical Contact: A.F. Lampros
(202) 426-9665
Agency/Contractor: Japan Railway Technical Service (JARTS)

This effort will result in a feasibility analysis and a preliminary design for a carbody tilting system modification for the Amcoach based on the passive tilting system used by Japanese National Railways (JNR). Pending results of the study, follow-up phases may include hardware development and a research test program.

The Budd Company Tilt System Demonstration
Contract No: DTFR53-80-C-00111
Funding: $475,000
Schedule: September 1980 – October 1981
FRA Technical Contract: A.F. Lampros
(202)426-9665
Agency/Contractor: The Budd Company

For any specified lateral acceleration limit, a tilt-body passenger coach will negotiate a given curve with greater passenger comfort than a non-tilt passenger coach. Curve negotiations of passenger trains at speeds higher than presently allowed are thus possible. For this reason, tilt-body technology has the potential to significantly reduce passenger train trip times, not only on the NEC, but on any passenger route in the country which possesses a significant number of curves.

LRC TEST TRAIN

The Budd Company, under this contract, has independently conducted analyses of carbody tilting systems developed by other manufacturers throughout the world. Their purpose was to determine if an existing tilt system could be adapted to Amcoach to increase its curving performance. As a result of this research, the Budd Company ultimately developed an independent design having the potential of simplicity as well as offering improved curving performance for the Amcoach. Unlike other tilt systems investigated by the FRA, it would not reduce the seating capacity of Amcoach because of equipment volumetric requirements. The Budd design is an active type, and is unique in that it is an electrical/pneumatic system as opposed to the electrical/hydraulic type characterizing all other existing active tilt systems.

SYSTEMS TECHNOLOGY PROJECT

A wide range of activities are covered under this project. Its objectives are to assure that new Amtrak equipment purchases contain designs consistent with their mission, and to reduce the risk of major error in systems development. This project covers basic research and assessments, both domestic and foreign, of the state-of-the-art in railroad technology.

The descriptions of contracts that follow indicate the variety of research and development studies being undertaken by FRA in this project.

Advanced Rail Technology Assessment & R&D
Contract No.: FR-9097
Funding: $69,000
Schedule: September 1979 – October 1981
FRA Technical Contract: N. Kamalian (202)426-9564
Agency/Contractor: Massachusetts Institute of Technology

The objective of this contract is to provide FRA with the necessary information that will allow a technical assessment of the options available for planning future intercity passenger transportation systems.

One of the primary factors limiting applications of new systems is the need for large investments of capital. To make new systems economically feasible and competitive with existing systems, it is desirable to reduce the cost of the new systems by utilizing existing infrastructure, where possible.

With the wide range of current ground transportation research activities worldwide, it is important that the FRA remain abreast of these activities in order to provide the transportation community with a current analysis of the long-term research and technology developments.

To make rational choices among alternatives first requires an assessment of the current state of technology in the U.S. and other countries and, second, the development of basic knowledge for systems for which adequate data does not exist. Accordingly, this contract will review intercity ground transportation R&D programs in the U.S. and abroad, evaluate the technical factors influencing hybrid guideway systems performance, and provide reports which discuss all activities, data used and methodologies used along with all results and conclusions.

Assessment and Evaluation of Signal/Control System Equipment and Technology
Contract No.: DOT-FR-773-4236
Funding: $739,376
Schedule: September 1977 – September 1980
FRA Technical Contract: T.P. Woll (202) 426-9564
Agency/Contractor: STV, Inc., with Kentron (LTV) and T.K. Dyer

The FRA Signal/Control System program has been established to support the upgrading of signalling systems on U.S. railroads.

The Signal/Control System program will assess present technology, develop a specification for a state-of-the-art demonstration system, and certify requirements for cost-effective proposed systems to be used on intercity passenger rail routes. The FRA program will also provide for: 1) the fabrication and testing of sufficient hardware/software to determine the operational characteristics of the system; 2) the design development and testing of a demonstration system; and 3) publication of results and the possible procurement by Amtrak of operational systems for use on railroads over which Amtrak operates.

STV, Inc., in conjunction with Kentron (LTV) and T.K. Dyer, has completed four of the tasks of their contract covering the first phase of a multi-phased program directed at the upgrading of signal and control systems on Amtrak intercity routes for high-speed 255-kmph (160-mph) passenger trains.

The four completed tasks are as follows.

Task 1 – "Assessment of Signal/Control Technology and Literature Review"
Survey and assessment of the technologies incorporated in current signal and control practice; literature review and reference.

Task 2 – "Status of Present Signal/Control Equipment"
Review and analysis of the current signaling systems of the major domestic and foreign railroads; discussion of candidate systems for adoption by Amtrak; recommendations for further activity.

Task 3 – "Standardization, Signal Types, Titles"
Analysis with emphasis on standardization of domestic operating rules and equipment, including signal types, aspects, titles and standards; analysis of impact of FRA Rules, Standards and Instructions (RSI) on development of improved systems; recommendations for standardization.

Passenger System Technical Analyses and Development of Management Communication Packages
Contract No.: DTFR 53-80-C-60001
Funding: $24,925
Schedule: December 1979 – December 1980
FRA Technical Contract: T.P. Woll (202)426-9564
Agency/Contractor: Virginia Research Institute, Inc.

This contract was designed to provide the Office of Passenger Systems with specialized communications packages on certain programs in response to specific type inquiries. The contractor reviewed technical program information as related to the overall goals and objectives of the Office of Passenger Systems.

To meet the information needs of top level management, both during formal budget and program review, management communications packages were developed, presenting: 1) the status of electrification in the United States, and 2) a fact book on railroad electrification. This material contains background and description information for railroad electrification in the United States. Included are benefits and overall rationale for railroad electrification including issues such as energy, cost, research and development and environmental concerns.

Task 4 — "Electrical Noise Disturbance" Study of causes of electrical noise disturbance or EMI (Electromagnetic Interference) as it relates to signaling; recommendations on both rolling stock and wayside signaling equipment to reduce and contain EMI radiation to acceptable levels.

Task 5, 6, & 7 — ("Economic Studies," "Specification Development," and "Final Report") will conclude the findings of the first phase of this contract.

Fundamental Studies of Phenomena Related to Wheel-Rail Contact Stresses (File No. 7114)

Contract No.: DOT-OS-60144

Funding: Phase 1: $67,745
Phase 2: $140,840
Phase 3: $245,482

Schedule: Phase 1: Aug. 1, 1974 – Nov. 1, 1976
Phase 2: July 6, 1976 – Sept. 30, 1980
Phase 3: Oct. 1, 1980 – Sept. 30, 1983

FRA Technical Contract: T.P. Woll
(202) 426-9564

Agency/Contractor: Dr. B. Paul
University of Pennsylvania

This project has been conducted by the University of Pennsylvania as a joint effort with other agencies.

The objective of this research is to provide fundamental information on an important group of engineering problems relating to stresses at the wheel/rail interface. That is, it is proposed to solve problems related to the forces and deformations at the contract surface between the wheel and rail. This research is fundamental to solving problems on wear, fracture, and plastic flow of wheels and rails. Furthermore, it will aid in understanding the dynamic behavior of rail vehicles, including hunting and stability, ride quality, derailment, reliability, adhesion, etc. This research will be of prime importance to those involved in vehicle dynamics research; rail vehicle manufacturers; railroad operators; wheel, rail, and track designers; and regulatory agencies concerned with rail technology safety, reliability, and maintenance.

A computer program called CONFORM has been developed, the usefulness of which will be improved by incorporating a better characterization of the creepage forces and including additional degrees of freedom for penetration of a wheel into a railhead as well as kinematic coupling effects of wheelset as influenced by various track perimeters.

Because the most critical stresses (those which induce fatigue and spalling failure of wheel and rail) lie just beneath the surface, it is important to have a means of surveying the stresses at all points just below the surface of the contact patch. For this purpose, the Computer Subroutine Program SUBSIG was developed. This subroutine can be loaded into the previously developed program (CONFORM and COUNTACT) which were designed to find the contract pressures on the surface of the loaded patch. The new subroutine then surveys a network of subsurface points, calculates all six stress components at each such point, evaluates the severity of the stress state with respect to plastic yielding, selects the most critically stressed point, and gives the effective stress at that point which determines whether or not plastic yielding occurs.

Additionally, the theory for longitudinal creepage (the controlled slippage of wheels over the rails which always accompanies steady rolling) for closely conforming wheel and rail contact (e.g., flange throat contact) has been developed. This is the first known prediction of the force/creepage relationship for situations where the contact patch is known to be non-elliptical.

Specific tasks to be undertaken include the development of:

- Generalized procedures for finding wheel force/creepage relations;
- Improvements in the stability and efficiency of needed calculations;
- Methods to include all necessary degrees of freedom in wheel/rail penetration;
- A procedure to include the effect on wheel penetration of coupling between two wheels of a wheelset;
- Methods to find the extent of subsurface plastic deformation;
- A procedure to describe the effects of load history on residual stresses in wheels; and
- Applications of the research to predict wheel failure modes (fractures, fatigue, wear).

The deliverables of this contract study consist of technical reports, published papers, and the development of computer programs. In addition, oral presentations are made periodically at Professional Society meetings (e.g., ASME), and at special seminars conducted by FRA. All computer programs developed are made available to the general public through the NTIS.

AMTRAK Locomotive Joint Fuel Consumption Tests

Contract No.: Task 1: DTPR-80-C-40002
Task 2: DTFR-53-80-C-0084
Task 3: RR-032
Task 4: Not available

Funding: Task 1: $30,000
Task 2: $80,000
Task 3: $27,000
Task 4: $24,000

Schedule: Task 1: October 1980 – October 1981
Task 2: October 1980 – October 1981
Task 3: June 1980 – September 1980
Task 4: To be awarded

FRA Technical Contact: T.P. Woll
(202) 426-9564

Agency Contractor: Task 1: ENSCO, Inc.
Task 2: L.T. Klauder & Associates
Task 3: Transportation Systems Center
Task 4:

The task objective is to install on an Amtrak EMD-40 locomotive a system that monitors fuel consumed as a function of time, speed, throttle position, tractive power, dynamic braking, shoe braking, and hotel power. These data will be collected and stored on a magnetic tape. The data will be reformatted into engineering units via down stream processing.

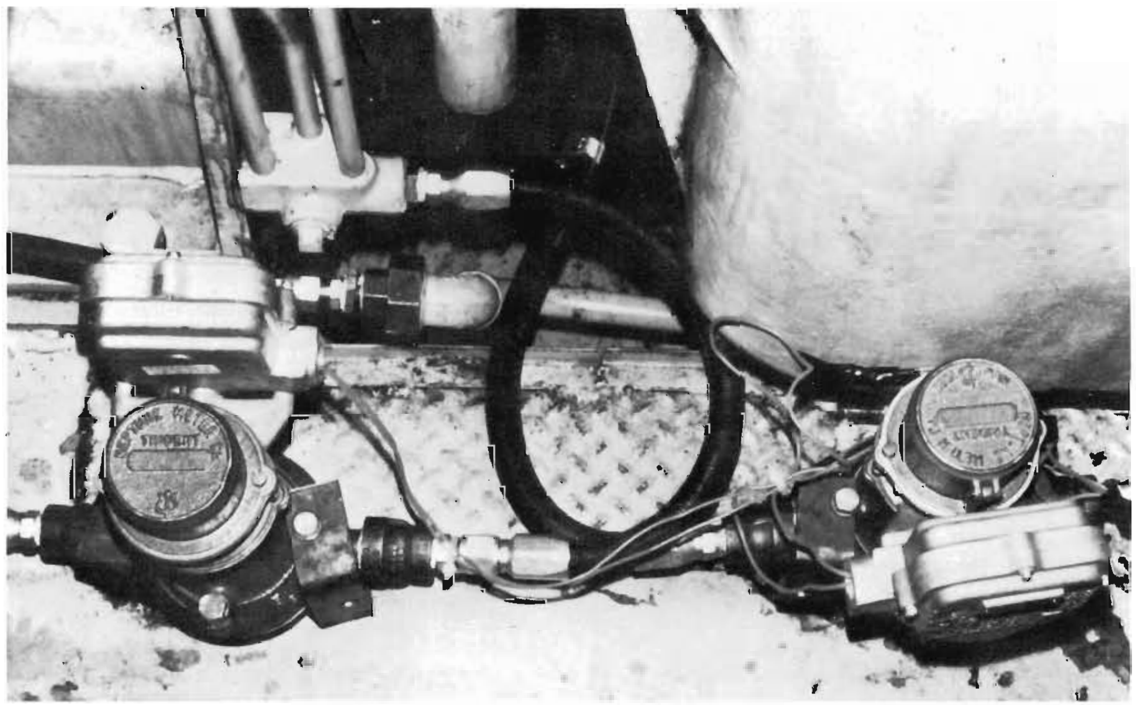
Through joint conferences with FRA, Amtrak and L.T. Klauder & Associates, the minimum requirements have been established for a fuel consumption data collection system. Trade-offs were made with respect to government-furnished equipment to minimize the cost of assembling the data collection system. Current status is that the data collection system interface is being assembled.

FRA's Amtrak train energy measurement program has been underway for approximately 6 months. Initially, TSC instrumented two F40 diesel locomotives which operated between Boston and New Haven on a variety of trains during the summer of 1980. Data were collected primarily to compare actual fuel consumption with that predicted by train performance simulators. This program was limited as to the route and also as to the amount of data collected.

Following this work, ENSCO was engaged to instrument at least one diesel electric locomotive for system-wide Amtrak energy consumption measurement. ENSCO has designed the test instrumentation and is currently awaiting the imminent arrival of hardware for application of the instrumentation package. L.T. Klauder & Associates began work in September to prepare for the monitoring of the data collection. Normally, Amtrak riders will accompany the test locomotive to manually log significant events during the run and collect the tapes and fuel samples. After processing, the reduced data will be transmitted to L.T. Klauder & Associates for analysis and eventual development of a report for each train consist and route.

Concurrent with this effort for the diesel-hauled trains, L.T. Klauder & Associates have been investigating the means available for the measurement of energy consumed by electrically propelled vehicles operating in the Northeast Corridor. An initial review of the instrumentation options available has disclosed a number of potential pitfalls and areas of difficulty which must be avoided in developing this instrumentation package. Briefly, the types of instrumentation available are:

1. Induction Watt-Hour Meter;
2. Recording Dynamometer Watt-Meter;



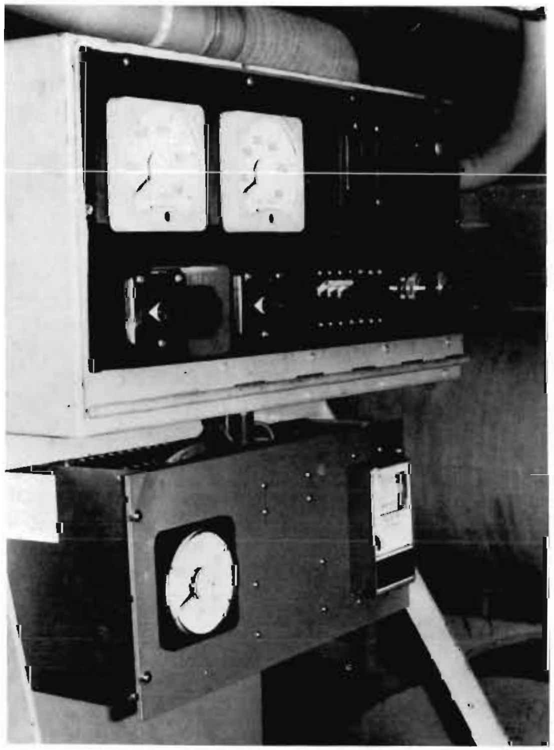
FLOW METERS INSTALLED ON F-40 PM LOCOMOTIVE TO MEASURE DIESEL FUEL CONSUMPTION

3. Direct Recording of Voltage & Current;
4. Analog Multiplication of Voltage & Current;
5. Three Current Method; and
6. Calorimetric Method.

The problems which may be encountered which can affect the measurement techniques and instrumentation are:

a. High concentrations of strong electric and magnetic fields;
b. Poor wave shapes;
c. Low power factor (less than .6); and
d. Severe mechanical shock and vibration environment.

Selecting the measurement technique that will be least affected by these potential pitfalls is the target of the current work. At the moment, it appears that analog multiplication of instantaneous voltage and current will provide the most accuracy. It has also been determined that in order to be sure that the data are repeatable and accurate, another method should be used to validate initial results.



ELECTRICAL INSTRUMENTATION FOR MEASURING SERVICE POWER GENERATED FOR LOCOMOTIVE

A secondary goal of the program is to validate certain Train Performance Calculator (TPC) considerations. To this end, a number of TPC programs have been examined to determine which of the test parameters used in TPC's may be easily collected by the available instrumentation.

Design Criteria for Railroad Test Track (RTT) Signal/Control (S/C) System at Transportation Test Center (TTC)

Contract No.: PO #9113
Funding: $10,000
Schedule: August 1979 – May 1980
FRA Technical Contact: T.P. Woll
(202) 426-9564
Agency/Contractor: T.K. Dyer, Inc.

This contract has provided the Federal Railroad Administration with the design criteria and costs to install a signal and communications system on the Railroad Test Track at Pueblo, Colorado. The recommended signal and communications system utilized equipment similar to that being installed on the Northeast Corridor today.

The purpose of this system is to provide a test facility to observe the operating characteristics of a cab signaling system in an electrified environment similar to the Northeast Corridor. From these observations the following items were to be obtained, developed, or maintained:

- Reliability and safety not to be compromised by Corridor environmental conditions;
- Comprehensive test procedures to be used for acceptance testing on the Northeast Corridor Project;
- Effects of Electromagnetic Induction (EMI) to be tested on the components and the subsystems of the signal and communications systems; and
- Recommended levels of EMI to be maintained that would be acceptable on the signal and communication system.

Although not installed at the RTT, the recommended system would still be of great value to test equipment to be used in future electrification projects. It could also be utilized to research and develop new equipment or refine existing equipment to be or now being used in electrified environments within the United States and throughout the world.

Railroad Prime Mover Analysis

Contract No.: DTRF53-80-P-00138
Funding: $9,950
Schedule: June 1980 – June 1981
FRA Technical Contact: N. Kamalian
(202) 426-9564
Agency/Contractor: J.O. Spriggs

Technical expertise will be provided from FRA in a joint DOT/DOE project which is investigating technical alternatives to the present diesel-electric locomotive to conserve petroleum.

This contract is a continuation of a contract to have Mr. Spriggs available as an expert to help DOT and DOE during the course of a joint study. The study is being done by Jet Propulsion Laboratory (JPL) under contract to DOE, and is designed to investigate alternative fuels for, and modifications that can be made to, the present diesel locomotives to conserve petroleum, as well as all new prime movers that do not use petroleum. The FRA involvement in the project is through the support services of Mr. Spriggs.

NEW TRUCK DEVELOPMENT PROJECT

The objective of this project is to test and evaluate the radial axle concept for possible high-speed passenger applications, determine performance characteristics, and define specification for future truck development. The claimed benefits of the radial axle, which by the name implies that the axles would ideally take the position of the lines of radii in a curve, are less wheel tread and flange wear, increased high-speed stability, better ride quality, less rail wear, less component wear and lower noise levels in curves.

It is expected that when two radial axle trucks under one Amcoach have successfully completed the running test at the Transportation Test Center (TTC) and the fatigue test has been completed on a separate truck, Amtrak will place the prototype trucks into a revenue demonstration service. A test report will be prepared.

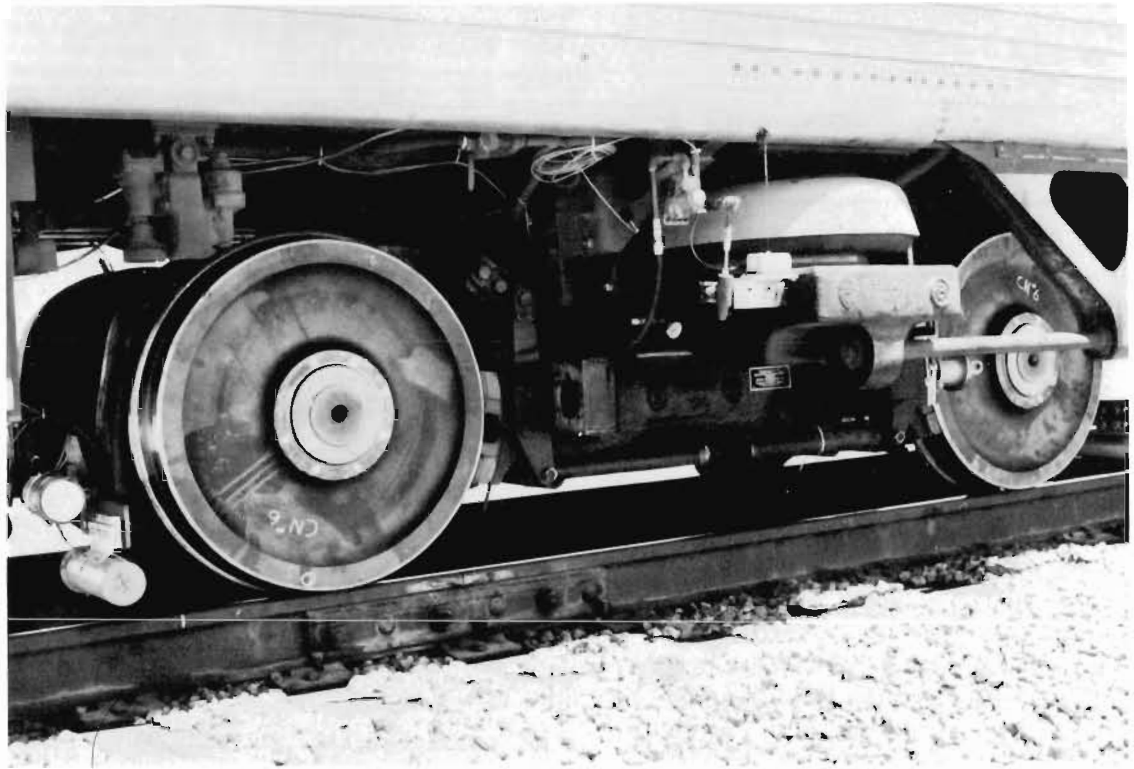
Several members of the supply industry have recently started development projects with alternative design concepts. The FRA will therefore limit its involvement in this project to the completion of the single contract it has initiated:

RADIAL AXLE TEST TRAIN ON RTT AT TRANSPORTATION TEST CENTER (TTC)

Radial Axle Truck Test and Evaluation
Contract No.: None
Funding: $1,420,000
Schedule: April 1980 — December 1980
FRA Technical Contact: R.L. Scharr
(202) 426-9665
Agency/Contractor: Joint FRA/Amtrak
General Steel Industry, Inc.

This contract was begun at TTC in April of 1980. The performance tests were completed in October 1980. They consisted of shop, shakedown/cutaway brake tests, and performance tests. After extensive schedule slips caused by a series of truck-related irregularities, the radial truck did perform satisfactorily in a radial manner. An evaluation will now be made to determine how well it performed in a radial manner and in relation to a regular truck on an Amcoach.

A life test of 100,000 miles is currently being conducted to determine maintainability of the radial axle in comparison with regular trucks. This pair of cars—one with radial axle—one with a regular axle, are running in the AEM-7 Locomotive endurance test at TTC.



RADIAL AXLE TRUCK IN TESTING AND EVALUATION AT TTC

TRAIN TECHNOLOGY EVALUATION BIBLIOGRAPHY

The following alphabetical list contains reports and papers prepared for the subprogram shown above from 1975 through September 1980. Many of these reports are available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. To order reports from NTIS, use the order number ("PB" number) listed following the report citation. Inquiries about the availability or price of these reports should be addressed by writing to NTIS, rather than the FRA, or by calling the NTIS Order Desk at (703) 487-4650.

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Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

AMTRAK Fuel Consumption
Transportation Systems Center
John S. Hitz
Sept. 1980

Contact Stresses for Closely Conforming Bodies — Application to Cylinders and Spheres
W. Woodward and B. Paul
Report No. DOT/TST-77/48 Dec. 1976
PB 271-033/AS

Contact Stresses in Bodies with Arbitrary Geometry, Applications to Wheels and Rails
B. Paul and J. Hashemi
Report No. FRA/ORD-79/23 April 1979
PB 299-409/AS

Evaluation of Signal/Control System Equipment and Technology — Task 1: Assessment of Signal/Control Technology and Literature Review
S.F. Taylor, et al
Report No. FRA/ORD-78/39.1 Dec. 1980

Evaluation of Signal/Control System Equipment and Technology — Task 2: Status of Present Signal/Control Equipment
S.F. Taylor, et al
Report No. FRA/ORD-78/39.2 Jan. 1979

Evaluation of Signal/Control System Equipment and Technology — Task 3: Standardization, Signal Types, Titles
S.F. Taylor, et al
Report No. FRA/ORD-78/39.3 Dec. 1979

Evaluation of Signal/Control System Equipment and Technology — Task 4: Electrical Noise Disturbance
S.F. Taylor, et al
Report No. FRA/ORD-79/41 July 1980

Fundamental Studies Related to Wheel-Rail Contact Stresses — Final Report
B. Paul
Report No. FRA/ORD-81/05

An Improved Numerical Method for Counterformal Contact Stress Problems
B. Paul and J. Hashemi
Report No. FRA/ORD-78/26 July 1977
PB 286-228/AS

Numerical Determination of Contact Pressures Between Closely Conforming Wheels and Rails
B. Paul and J. Hashemi
Report No. FRA/ORD-79/41 July 1979
PB 80-120462

Operation of High Speed Passenger Trains in Rail Freight Corridors
DOT/TSC
R.K. Abbott
Report No. FRA/ORD-76/07 Sept. 1975
PB 247-055

Operational Test Plan LRC Cant Deficiency Test
Rail Transportation Engineering Division
March 1980

Rail-Wheel Geometry Associated with Contact Stress Analysis
B. Paul and J. Hashemi
Report No. FRA/ORD-78/41 Sept. 1979

A Review of Rail-Wheel Contact Stress Problems
B. Paul
Report No. FRA/ORD-76/141 April 1975

User's Manual for Program CONFORM (CONFORMal contact stresses between wheels and rails)
B. Paul and J. Hashemi
Report No. FRA/ORD-78/40 June 1978
PB 288-927/AS

User's Manual for Program COUNTACT (COUNTerformal contACT stress problems)
B. Paul and J. Hashemi
Report No. FRA/ORD-78/27 Sept. 1977
PB 286-097/AS

CHAPTER 12
RAILBUS

As early as the 1880's, self-propelled vehicles were tested and evaluated in revenue service in this country. Since then, gas-electric railcars, interurban cars, electric multiple-unit (MU) cars, and Rail Diesel Cars (RDC) have been successfully developed. Subsequently, however, a number of operating problems forced the railroads to discontinue their operation of self-propelled vehicles.

The Railbus Development subprogram's focus is to test the feasibility of a new type of self-propelled rail passenger vehicle, a "railbus" (actually a rebirth of the 1952 MACK FCD Car) which has the potential to provide low-cost and fuel-efficient service in low-density commuter markets. A 2-year demonstration program is underway using an experimental railbus vehicle to gather data. Should the demonstration program be successful, the initial capital cost required to provide railbus type service could be significantly reduced while simultaneously improving the fuel efficiency of railbus operations.

There are two contracts included in this subprogram area. Descriptions of each contract follow.

RAILBUS ON DISPLAY IN NEW HAMPSHIRE – 1980

CONTRACTS

Railbus Development
Contract No.: DTFR 53-80-0-00036
Funding: $19,822
Schedule: January 1980 – July 1980
FRA Technical Contact: R.A. Novotny
(202) 426-9564
Agency/Contractor: Louis T. Klauder & Associates

The Leyland Experimental Vehicle, known as the LEV-1 railbus, is a light-weight, fuel-efficient vehicle which shows promise for providing low-cost service for the commuter rail market. Manufactured by British Rail, the LEV-1 is composed of a standard bus body coupled with a uniquely-designed underframe. The vehicle is powered with a 200-horsepower diesel engine, has a two-axle railcar-type underframe, and weighs 16.75 tons.

Under this contract, the LEV-1 vehicle was tested on the Boston and Maine railroad track between Boston, Massachusetts and Concord, New Hampshire. Data gathered during the testing was used by British Rail to design a new prototype railbus. The new railbus, purchased by the FRA, is currently undergoing revenue service testing.

Lightweight Vehicle Track Shunting
Contract No.: DTFR-53-80-P-000141
Funding: $7,291
Schedule: September 1980 – March 1981
FRA Technical Contact: T.P. Woll
(204) 426-9564
Agency/Contractor: T. Dyer, Inc.

The objective of this contract is to determine the extent of the shunting problem on the railbus and other light-weight rail vehicles and to identify solutions to it. Railroads in the United States currently use a shunting technique in which the vehicle completes an electric circuit between the tracks to activate signaling and control systems such as highway crossing warning signals.

This study disclosed that special precautions must be taken before single-unit lightweight railroad cars(SULWV) can be operated on common carrier railroads. Such operation without special precautions introduces the likelihood of signal malfunctions in train protection systems and rail-highway grade crossing warning systems. Malfunctions of the signal system result from failure of the SULWV to make known its presence on a track by failing to pass sufficient current in a given time through its wheels and axles from one rail to the other. This is known as a shunt failure which has three general classifications:

1) Slow Shunting of Relay;
2) False Pick-up of Relay; and
3) Relay Shunt Failure.

The first two failure classifications can, for the most part, be remedied by change and additions in existing equipment. The latter classification is the most serious one and will be the most difficult problem to remedy. The difficulty is that the failure results from the formation of an insulating film, a few thousandths of an inch thick, on the rail head. This surface film is called ferro-ferric enamel and possesses insulating qualities of varying degrees. Further research is required to determine the most acceptable approach in developing proper shunt levels for a reliable signal system when single light-weight vehicles are operated.

Approximately one-half of the contract has been completed in an effort to define the extent of the problem and possible avenues for its solution. Tasks that have been completed in 1980 were:

1) Development of a clear statement of the problem;
2) Identification of applicable (government and industry) regulations and gathering of related data;
3) Assessment and documentation of industry developments and operational requirements; and
4) Formulation of R&D recommendations.

RAILBUS BIBLIOGRAPHY

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Finally, additional reports relating to the research in this chapter will become available during the upcoming year. For information on these reports and for suggestions on additional reference materials, call or write the technical contacts associated with each project.

Railbus Test Observations on the Boston and Maine Railroad Jan. – Feb. 1980
Klauder, (Louis T.) Assoc.

MAIL ORDER TO:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road
Springfield, Va. 22161

Date ______________________

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Attention: ______________________

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DOCUMENT NUMBER [If ordering by title or if item ordered is a magnetic tape, please see reverse side.]	USER ROUTING CODE (see reverse)	Quantity: Paper Copy	Quantity: Micro-fiche	Quantity: Other (specify)	Unit Price	Total Price
					Enter Grand Total	$

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TRACK, EQUIPMENT, AND PERSONNEL SAFETY

RAILROAD OPERATIONAL IMPROVEMENTS

IMPROVED PASSENGER SYSTEMS

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