RAILROAD SAFETY

RESEARCH AND DEVELOPMENT

1987 PROSPECTUS

Office of Research and Development
Office of Safety
Federal Railroad Administration

Preface

This Prospectus was assembled with the intent to provide a document that would serve as the basis for informing interested parties of the contemporaneous research being conducted by the Office of Research and Development, Office of Safety, Federal Railroad Administration.

Those desiring more in-depth information concerning the projects contained herein may contact the Office of Research and Development and be directed to the appropriate contracting officer's technical representative, where contracts are involved. The main OR&D telephone number is 202-366-9601.

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Office of Safety
Federal Railroad Administration
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TABLE OF CONTENTS

1987 R&D Project Prospectuses

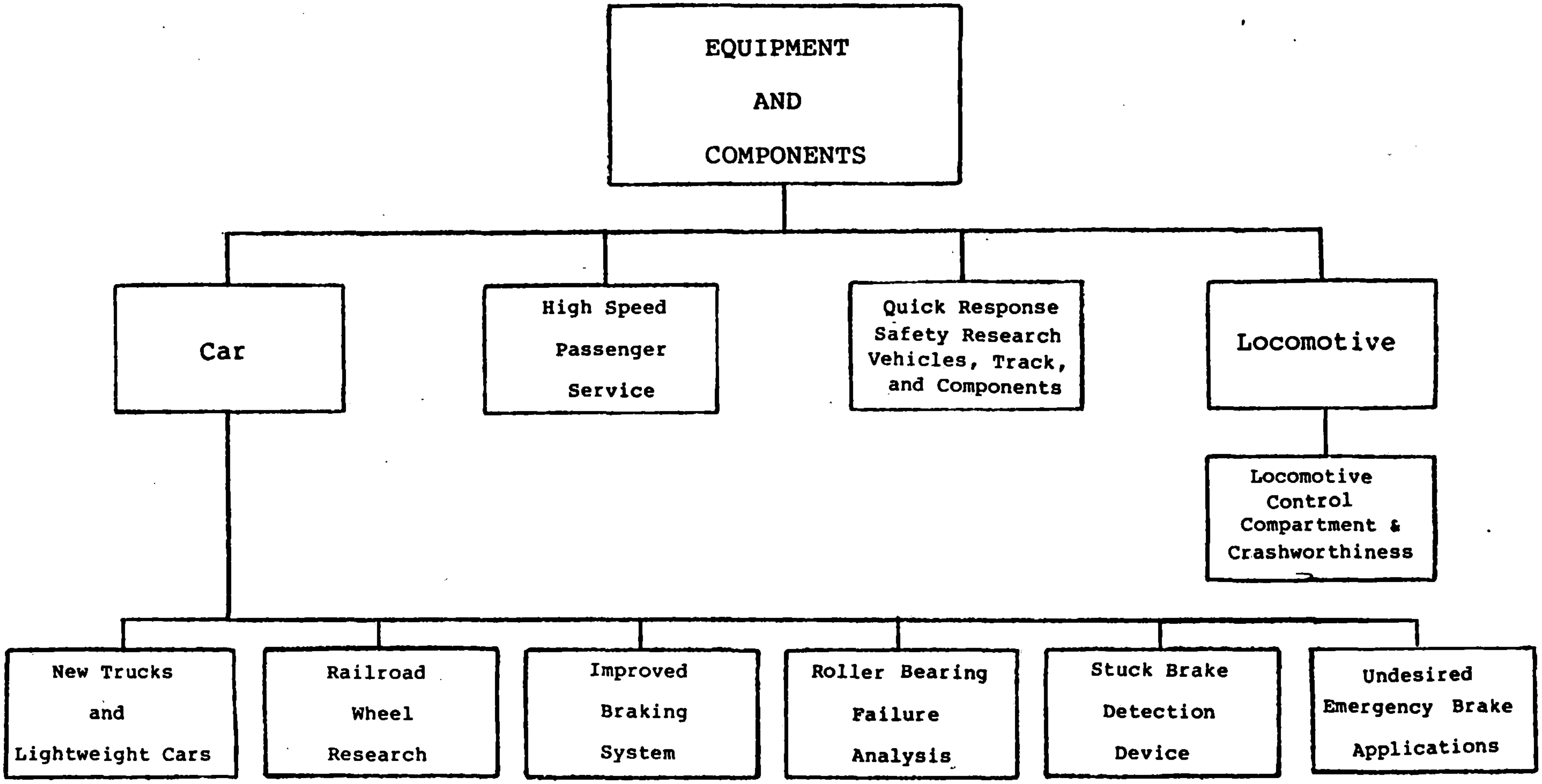
Equipment, Operating Practices, and Hazardous Materials Safety Research

TABLE OF CONTENTS

1987 R&D Project Prospectuses

(Continued)

Track Safety Research


EQUIPMENT AND COMPONENTS
Car
High Speed Passenger Service
Quick Response Safety Research Vehicles, Track, and Components
Locomotive
Locomotive Control Compartment & Crashworthiness
New Trucks and Lightweight Cars
Railroad Wheel Research
Improved Braking System
Roller Bearing Failure Analysis
Stuck Brake Detection Device
Undesired Emergency Brake Applications

A

12/29/86

New Trucks & Lightweight Cars

1. Background

There has been a significant increase in the rate of introduction of new designs of freight cars and trucks. This has occurred for a number of reasons, including the requirement to carry increased loads at higher speeds and also because of the large increase in demand for carrying intermodal traffic. This latter requirement often results in relatively low vehicle loadings and, as a result, has led to the development of a number of single axle suspension designs as well as articulated vehicles with a single three-piece truck beneath each articulated joint. In order to minimize energy consumption and maximize the lading-to-tare ratios, vehicle bodies are being designed with lightweight structures, which may include new materials untested in the railroad environment.

For many years, the vast majority of freight cars running on the American freight railroads have been equipped with two conventional three-piece trucks. Accordingly, there has been considerable experience with regard to the performance of these cars and trucks. With the introduction of the new designs of intermodal cars, the AAR Mechanical Division introduced its Chapter VIII (of the M1001 Volume I Standard) on Design and Test Requirements for Articulated and Multiple Unit Trailer/Container Transport Cars. In addition, the AAR formed an ad hoc committee for the purpose of applying recent technology to the approval process for new freight car designs. This New Trucks and Lightweight Cars Project (Lightweight Test Project) has worked in parallel and to a certain extent in support of the work of the ad hoc committee. In this regard, recommendations of the committee are similar in many respects to this Project. Two specific recommendations have had a significant impact on the testing and analysis techniques that are being proposed. These involve the initial development and partial validation of a general computer model for predicting the time response of any design of vehicle to track perturbations. Also involved is the influence of buff and draft forces on the likelihood of derailment.

2. Current Status

The New Truck and Lightweight Cars Project is a current program funded for two cars for simplified tests and model validation. The program started in May 1984. The results from the first car are expected to be available in May 1987 with the Car-2 efforts starting shortly thereafter. The AAR has committed multiyear funds to the project along with FRA funding. The supply industry has provided cars and equipment.

3. Related Research

Related research includes efforts to test, analyze, understand, quantify, and specify acceptable vehicle dynamics as found in Vehicle/Track Interaction Assessment Techniques (Report DOT/FRA/ORD-84/01), the AAR Track Train Dyanmics Project, the locomotive testing and analysis of the 1970's (E-60, SDP-40, E-8, etc.), the university research efforts at MIT, etc., and the locomotive-caboose impact tests of the 1970's to name just a few. Also, more recently, the AAR has drafted a Chapter XI of Specifications for Design, Fabrication, and Construction of Freight Cars entitled Optional Track Worthiness Tests and Analysis for New Freight Cars that presents guidelines for dynamic testing and analysis to determine the trackworthiness of new and untried types of freight cars.

4. Objectives

The New Trucks and Lightweight Cars Project has two objectives. The first is to determine whether relatively inexpensive test procedures, including improved analytical and modeling methods can be devised which can be used for the analysis and testing of the safety aspects of new designs of lightweight cars and trucks. The second objective is to evaluate the safety aspects of new innovative lightweight cars.

5. Scope

The single axle 45' Front Runner flat car was selected for Car-1, has been modeled, and is in test. The car has been extensively characterized (stiffness, damping characteristics, transfer functions, etc.) for modeling purposes. The Chapter XI track conditions have been installed and the Front Runner is currently in track tests at TTC. The Buff and Draft Test Car (one end only) has been designed, built, and checked out. At the conclusion of the track test, the Buff and Draft Test will be conducted. Car-2 will have the benefit of the Car-1 results, a partially validated model, and use of a new vehicle characteristic laboratory, at substantially lower program costs. The laboratory will be constructed at TTC by the AAR. Substantial costs were incurred on Car-1 with the vehicle characterization including use of the Rail Dynamic Laboratory Vibration Test Unit (VTU). The Chapter XI track conditions, or variations thereof, will be in place at TTC for use by Car-2. Car-2 will further validate the tests and model. The program is a joint FRA/AAR program and appropriate progress reports are being disseminated to the FRA, AAR, and supplier organizations.

6. Interfaces

With the guidance of the FRA/AAR Safety Aspects of Advanced Freight Car Equipment Committee, consisting of AAR staff, railroad personnel, and an FRA member, the FRA project task 20 is being conducted at the Transportation Test Center (TTC) managed by the AAR. The testing is being conducted exclusively at TTC, however, the modeling efforts are being directed by the TTC with assistance from a consultant and the Transportation Systems Center/Massachusetts Institute of Technology. Instrumented wheelsets (28" diameter) are being obtained by AAR/TTC through the AAR Technical Center from IITRI. Trailer Train Corporation is providing the Car-1 Front Runner 45' single-axle car and technical advice on the car. Trailer Train is also expected to provide Car-2. The type has not been determined.

7. Potential Benefits

A determination will have been made as to whether inexpensive test procedures can be used for the analysis and testing of the safety aspects of new and untried designs of lightweight cars and trucks. A determination will be made as to how well the Front Runner car dynamically performed under the draft Chapter XI track conditions and how well the Chapter XI track conditions represent good test conditions. Also, as a tool to predict vehicle dynamic performance, the model will be partially validated. The resulting model will be a generalized model to judge vehicle responses to perturbed tangent and curve track and will be further adapted in 1987 by AAR for use with the three-piece truck and other new designs.

Implementation of these tests and analyses should permit a safety assessment of new and untried cars in a shorter time and less costly process than is now required. This will give the railroad industry an opportunity to more quickly respond to changing market conditions and assess new equipment performance prior to its widespread use.

New Trucks & Lightweight Cars

1. Schedule

Car 1 May 1984 - May 1987

Car 2 May 1987 - May 1989

2. Costs

Car 1

Basic Program		$1,173,968
Simuloader installation		300,000
		$1,473,968
Plus AAR funding	$440,000	

Car 2

		$500,000
Plus AAR funding	$268,000	
Project Total	$708,000	$1,973,968

B

12/30/86

Railroad Wheel Research

1. Background

For the three years preceding the inception of this project, an average of 20 percent of the railcar equipment failures were caused by wheels. A primary factor contributing to these failures is the unsafe buildup of residual stress in the wheel. Current visual inspection methods (wheel discoloration inspection) are considered by the industry to be inadequate and result in the removal of more than 100,000 suspect wheels per year. Many wheels have been removed prematurely and the cost is over $100 million per year.

Though wheels have been defined as unsafe when they exhibit 4 inches of discoloration from the rim, significant correlation of wheel discoloration with unsafe stress conditions is lacking. There are approximately 100 accidents per year caused by wheel failures. In some instances the severity of the accident is increased due to the involvement of cars carrying hazardous materials. There is not a good understanding of which inservice conditions cause wheel failures and dangerous wheel conditions, nor an understanding of the manner and mode of wheel failures. There is presently no means of nondestructively determining if a wheel has a dangerous level of residual stress.

Railroad wheels are manufactured with compressive stresses in the rim area. The stress level is determined by the heat treatment received by the rim toward the end of the manufacturing process. In a rim treated wheel, the rim of the still hot wheel is water cooled. This causes the rim to shrink toward the plate and the hub. As a result of this cooling sequence, high compressive stresses are introduced into the wheel rim that can retard the propagation of small thermal cracks.

Train operating characteristics create the conditions that cause both thermal cracking and tensile stresses. Most rail vehicles have tread brakes. Severe brake application causes a heat input to the wheel. Often, these inputs are large enough to gradually relieve the compressive stresses in the wheel. The current criteria used to judge the nature of the residual stresses in the wheel rim are based on visual inspection of conditions associated with overheating. Typical conditions experienced are oil and dirt on the wheel that appear to be burned, a blue metal color, and a reddish-brown color near the rim. In addition to discoloration, wheels are also removed from service because of thermal cracks.

In June 1981, the Rail Vehicle Safety Research Division, Office of Rail Safety Research (ORSR) of the Federal Railroad Administration, sponsored a symposium on "Nondestructive Measurement of Wheel/Axle Residual Stress." This symposium was attended by personnel from railroads, the Association of American Railroads, wheel/axle manufacturers, inspection/detection equipment suppliers, and researchers. The presentations at this conference reviewed all available stress measuring techniques. This review showed that:

a. Current usage of acoustic, ultrasonic, x-ray eddy current, and magnetic techniques were not adequate to determine residual stress in railroad wheels;

b. There are no stress measurement calibration techniques;

c. Recent advances in x-ray, acoustic, ultrasonics, and magnetics measurement techniques were made by the NBS, NASA, and UCLA; and

d. Efforts should be initiated to utilize these measurement advances in the determination of railroad wheel/axle residual stress.

2. Current Status

A contract with the National Aeronautical and Space Administration (NASA), Jet Propulsion Laboratories (JPL) was initiated in April 1980 to develop a research program plan.

Another contract, with the Association of American Railroads (AAR), Transportation Test Center (TTC), is investigating the wheel failure mechanisms of railroad cars.

This is an ongoing project with current work nearing completion. The main items left to be completed are cold weather braking tests at TTC and the preparation of a final report. Overall, this project has benefitted significantly through cost sharing with the AAR. The Illinois Institute of Technology Research Institute (IITRI) is providing technical support for the test program.

A cooperative effort (joint funding) with the National Aeronautics and Space Administration (NASA) was launched to evaluate residual stress in railroad wheel steel. The NASA method used utilizes advanced acoustics and ultrasonics developed at the Langley Research Center. The equipment developed under this contract is ready for shipment to the AAR Technical Center in Chicago, where it will be used to further evaluate residual stress in railroad wheels. The contract is near completion and a final report is in preparation.

The National Bureau of Standards (NBS) is using a noncontacting electromagnetic-acoustic transducer (EMAT), developed jointly with the Japanese, to measure residual stresses in railroad wheels. This process measures the change in the acoustic transmission characteristics of ultrasound. Four drag-braked wheels have been measured. Future work will develop the additional components necessary for the complete EMAT based velocity measurement system.

3. Related Research

Prior FRA wheel research projects have involved the United States Steel Corporation, Applied Research Laboratories, NASA/Marshall Spaceflight Center, Southwest Research Institute, and the Illinois Institute of Technology Research Institute. The projects involved nondestructive testing of wheels before and after being subjected to emergency stop tests on a wheel dynamometer. The wheel dynamometers were unable to cause failures in wheels simulating actual train operations.

An extensive technology search was launched to cover the areas involved in this project. A literature search was conducted and contact made with other experts to identify appropriate research sources. A list of pertinent research reports or information sources was made that could support the research. A library of applicable documents was established for this particular project and a limited but comprehensive evaluation of the research was conducted. The results of that evaluation were documented, concisely noting which research could be used in the research project and why other available information could not be used.

The projects on Improved Braking Systems and Roller Bearing Failure Analysis also relate to this project.

4. Objectives

The overall objective of this project is to increase the safety performance of railcar wheels by developing technically sound wheel removal criteria and guidelines for safe design and operation based on well planned and coordinated laboratory and track tests and analyses. These wheel removal criteria are expected to reduce discolored wheel removal rates without interrupting the downward trend of wheel failure rates.

Another objective is to develop a methodology for the destructive testing of railroad wheels, validate this methodology, and develop a test plan to simulate service conditions leading to wheel failures.

5. Scope

The contract with NASA/JPL developed concepts and procedures for inducing heat and load inputs that are high enough to develop thermal cracks and change compressive stresses to tensile stresses in wheels.

To promote the safety performance of railcar wheels, research is being conducted with the AAR to more fully understand wheel failure mechanisms and develop technically sound wheel removal criteria and guidelines for safe operation. Encompassed in this research are 14 technical tasks ranging from a technology survey through a national study of wheel removal guidelines to individual technical project-oriented tasks that include laboratory and track testing and analyses. To support these technical tasks there are 12 planning tasks oriented toward test facilities and methodology. These tasks have been assembled into four subprojects (SP). They are:

a. SP-1: Overview and Program Control
b. SP-2: Failure Mechanisms, Verifications, and Countermeasures
c. SP-3: The State of Safety Risks Due to Overheated Wheels
d. SP-4: Nondestructive Methods to Detect Overheated Wheels

SP-1 is intended to provide an overview of the relationship of each of the 12 original planning tasks and plans.

SP-2 is for determining the mechanisms of wheel failure, to demonstrate these mechanisms by causing a wheel failure under controlled conditions, and to suggest methods for preventing wheel failure.

SP-3 represents the planning task group covering overheated wheels and residual stresses in order to determine the means to minimize the threat to safety of railcar wheels.

SP-4 is intended to investigate nondestructive methods to detect overheated wheels and to test and evaluate these methods.

The contract with NASA/Langley includes measurement of both surface stresses and internal stresses. The accuracy of these measurement techniques has been assessed using calibration standards developed by the National Bureau of Standards. The overall effort developed a model for the natural velocity thermal derivative, experimentally determined the natural velocity thermal derivatives, developed and evaluated instrumentation and techniques for measuring magnetic strain derivatives, measured magnetic strain derivatives, and measured stress in Stress Calibration Discs.

The contract with NBS is composed of two phases. The first is the completion of a test series on drag-braked wheels supplied by TTC. An attempt will be made to separate the effects of stress and texture and compare ultrasonic results with destructive tests performed at TTC. In the second phase, dependent on the success of Phase I, a stress measurement system will be constructed that can be used at TTC for measuring residual stress.

6. Interfaces

Government:

FRA - Office of Research and Development technical staff, Office of Safety Maintenance Programs Division, Office of Chief Counsel.

NASA Langley - Chief, Instrumentation and Materials Characterization Section

NBS - (Boulder, Colorado) - Fracture and Deformation Division

Industry:

AAR - At both the Chicago Technical Center and Transportation Test Center the program manager, senior engineers, engineers and technicians in charge of all phases of research, testing and development.

Wheel Manufacturers - Managers and chief engineers

Railroads - General managers, chief engineers, research personnel

7. Potential Benefits

This project will produce a better understanding of the stress changes occurring in wheels due to various braking applications such as drag braking or emergency braking that leads to conditions capable of causing wheel failures. As a result, techniques are being developed that will be useful for nondestructive evaluation of critical conditions. This evaluation of failed wheel conditions will lead to the identification of what wheel conditions are most important to monitor or detect. Once these critical wheel conditions and failure mechanisms are known, the requirements for preventive wheel failure detection technology can be established.

Guidelines and criteria will be developed for the safe removal of discolored wheels. This should result in enhanced safety of operation through the decreased probability of derailments and catastrophic accidents. Substantial cost benefits should also accrue to the railroads through elimination of the unnecessary removal of wheels considered safe for continued operation. The identification of unsafe wheels should, in itself, be self implementing. The guidelines developed will also aid the Office of Safety Enforcement in evaluating recent waiver requests for wheel inspection.

The device being developed under this program will be suitable for field use in inspecting railroad wheels for unsafe stress levels. The equipment developed will permit reliable magnetoacoustic inspection of railroad wheels and detection of wheels with dangerously high residual stresses. The subsequent replacement of these wheels will result in improved railroad safety. Ready identification of bad wheels in the field should enhance implementation of the results of this program.

Railroad Wheel Research

Concept Development

Cost: $100,000

Schedule: 4/80--1/87

Contractor: NASA/Jet Propulsion Laboratory

Wheel Failure Mechanisms of Railroad Cars

Cost: FRA $3,539,948
AAR $462,000

Schedule: 9/83--7/87

Contractor: Association of American Railroads

Residual Stress Measurements

Cost: FRA $530,000
NASA $440,000

Schedule: 11/82--7/87

Contractor: NASA Langley Research Center

Cost: $100,000 (estimated)

Schedule: 6/84--7/87

Contractor: National Bureau of Standards

Technical Support

Cost: $239,489

Schedule: 11/84--3/88

Contractor: IIT Research Institute

C

Improved Braking System

1. Background

There are approximately 100 railroad accidents per year caused by the failure of wheels on railroad cars. A major program "Railroad Wheel Research," is being conducted to examine many facets of this problem. Stress built up in the wheel as a result of heat is one factor contributing to these wheel failures. Tests conducted under the Railroad Wheel Research project indicate that one source of heat leading to stress in the wheels is uneven braking forces within a freight car braking system. The thermal inputs to wheels resulting from uneven braking action can vary substantially within a railcar truck and from car to car. Wheels can easily become severely overheated and fail causing catastrophic accidents. Since examination of the reasons for and limits of this behavior in the brake system was beyond the scope of the Railroad Wheel Research project, the participants (Federal Railroad Administration, Association of American Railroads, and consultants) concurred that this course of investigation should be initiated as a new project.

2. Current Status

This project is a Task Order (28) to be performed at the Transportation Test Center at Pueblo, Colorado. This task order was signed September 30, 1986, and work is in preliminary development stages.

3. Related Research

See: Railroad Wheel Research; Undesired Emergency Brake Applications; reports from brake shoe performance tests under the Track Train Dynamics Program; Freight Train Brake System Safety Study, IIT Research Institute, 1984; and Freight Car Brake Shoe Performance Testing, American Society of Mechanical Engineers Paper, 1984. Other work has been published by Westinghouse Air Brake Company and other manufacturers which should also be useful.

4. Objectives

The overall objective of this project is to identify and quantify the reasons for:

a. Braking energy input variations on account of variations in brake shoe location on the wheel;

b. Wheel to wheel brake force variations within the same truck; and

c. Variations on braking forces due to brake rigging variations.

These findings can then be applied to making brake system improvements leading to safer train handling.

5. Scope

The effects on braking force variations and heat transfer of brake shoe positioning and friction coefficients will be examined under a variety of conditions. Differences between types and makes of brake shoes will also be noted. Rigging types, positioning and components will be analyzed to determine their contribution to variations in braking force and to heat buildup in wheels.

Data will be derived from both analytical techniques and testing. The sources identified under "Related Research" will provide the starting point. Data will also be obtained from controlled laboratory conditions at the Rail Dynamics Unit (RDU) at the Transportation Test Center (TTC) and from field observations.

6. Interfaces

AAR/Chicago Technical Center - Program manager, engineers and technical personnel responsible for dynamometer testing and thermographs of wheels braked on the dynamometer.

AAR/TTC - Local program managers, senior engineers, engineers and technicians for RDU and track testing.

Consultants - As required.

Suppliers - Brake shoe and brake component manufacturers, representatives such as engineers and field service personnel.

Railroads - Possible interface with managers, chief engineers and technicians.

FRA - R&D Program managers and staff, Office of Safety Maintenance Programs Division.

7. Potential Benefits

Upon completion of the work covered by this project, a major contributing source of overheated wheels, wheel failures, and potential catastrophic accidents should be better understood. When the potential benefits of this research are fully realized, implementation should readily follow through incorporation of the results in new car brake rigging improvements and through retrofitting of older cars as occasion dictates.

Improved Braking System

Cost: $350,000

Schedule: 9/86--7/87

Contractor: Association of American Railroads

D

12/31/86

Roller Bearing Failure Analysis

1. Background

Freight car roller bearing failures caused 76 accidents in 1985, with resulting reported damage of over $12,000,000. Roller bearing failures frequently cause catastrophic accidents and occur with only minutes of warning. The number of roller bearing failures has increased in recent years despite an overall reduction in accidents caused by equipment failures. This project is to reduce accidents by providing additional knowledge of the characteristics of failing bearings prior to total failure, and by developing the means for providing improved inspection to detect early warning signs of failure.

The work in this project is being coordinated with the Research and Test Department of the Association of American Railroads (AAR), with the major roller bearing manufacturers, and with individual railroads.

2. Current Status

This is an ongoing research project being conducted with the support of the AAR, individual railroads, and the major roller bearing manufacturers. Contracts were awarded in 1986.

3. Related Research

This project relies on the results of bearing failure investigations conducted on commuter cars in the New York City and Philadelphia metropolitan areas. The AAR is conducting a complementary program and is cooperating in this project.

4. Objective

The objective of this project is to improve operating safety in the railroad industry by reducing the number of roller bearing failures which lead to train accidents. This will be achieved by a systematic identification of failure modes, causal factors, and corrective actions.

5. Scope

Current tasks underway in this project include a laboratory test of the consequences of impacts on roller bearing integrity and a field test of the behavior of press-fit bearing components.

The laboratory test of impact consequences is being directed by the Transportation Systems Center (TSC) with support from Ensco, Inc. This test will study the loads applied to the bearing by impacts such as those produced by wheel or track irregularities. These impacts can be extremely severe and are believed to be sufficient to cause failure of roller bearing cages, with subsequent total bearing failure and derailment.

The field test of bearing press-fits is focused on the bearing inner races, or cones, which are assembled onto the axle using interference fits. The test will be conducted by the Transportation Test Center (TTC) and Ensco, Inc. The cones occasionally become loose in service and begin to wear into the axle surface. This condition is not outwardly noticeable or detectable with present inspection methods.

The loosened cones and resulting wear lead to uneven loading of the bearing thereby accelerating the wear process. Prior testing of commuter cars and field experience with freight cars indicates that ultimate thermal failure occurs within minutes after a bearing experiences jamming or seizes. The field test will be conducted to document the loosening of cones and the ultimate failure behavior under freight service loads and operating conditions. Bearings with known defects and substandard fit will be used in this test.

This project provides technical support to the Federal Railroad Administration Office of Safety Enforcement in monitoring the unusual bearing behavior observed on double-stack container cars. Large numbers of bearings have been observed to leak substantial quantities of grease and concern has arisen that the bearings may eventually fail due to lack of lubricant. These cars are of a new articulated design and experience very high mileage use at sustained high speeds. The roller bearings on these cars are of conventional design and according to normal practice no lubricant is added throughout the operating life of the bearing on a given wheelset.

6. Interfaces

This project is conducted cooperatively with the AAR's Research and Test Department, with individual participating railroads, and with roller bearing manufacturers. Coordination is maintained with the FRA Office of Safety Enforcement.

7. Potential Benefits

This project will result in a reduction in the number of accidents by providing improved detection of defective roller bearings prior to total failure and derailment. This will occur through better understanding of the causes of bearing defects and the characteristics of failing bearings. Documenting the characteristics of failing bearings will allow the development of more effective inspection equipment and methods so that railroads will not have to rely on the few minutes of warning provided by conventional hotbox detectors. It is anticipated that the results of this research will be used voluntarily by the railroads and suppliers. A subsequent review will be made to determine if further action is required.

Roller Bearing Failure Analysis

Laboratory Test of Impact Consequences

Cost: Prior year funding only. No FY 1987 funds.

Schedule: 7/87

Contractor: Transportation Systems Center
Ensco, Inc.

Field Test of Press-Fit Failures

Cost: $125,000 FY 1987 plus prior year funds

Schedule: 3/88

Contractor: Transportation Test Center
Ensco, Inc.
Participating railroads
Bearing manufacturers

Monitoring of Double-Stack Bearings

Cost: $35,000 FY 1987

Schedule: 12/88

Contractor: Ensco, Inc.

E

Stuck Brake Detection Device

1. Background

When railroad freight car brakes do not release, they cause the wheels to which they are applied to drag in a moving train. Such a "Stuck Brake" condition causes wheels to overheat, which may produce sufficient stress to cause the wheel to break. Damaged and broken wheels cause train accidents and are a major safety concern to FRA and railroads. In an effort to keep such accidents to a minimum, railroads are spending millions of dollars annually replacing wheels which show evidence of overheating. However, existing criteria for wheel replacement is suspected to require wheel replacement more frequently than necessary. Major railroads also have hot wheel detectors on main lines to detect problems early. Therefore, a cooperative wheel research program funded by the Federal Railroad Administration and the railroad industry was begun in 1983 to establish better requirements for wheel removal.

The development of a stuck brake detection device was conceived as a way of identifying the cause before wheels are damaged and become a safety problem. The concept is to detect dragging wheels with stuck brakes as an assembled train leaves a yard. When detected, the brakes can be released with little or no damage to wheels.

2. Current Status

A breadboard Stuck Brake Detection Device was satisfactorily tested at the Transportation Test Center (TTC) at Pueblo, Colorado, in the spring of 1985. A preprototype processor has been designed, built, and programmed. The device is being tested (November 1986 - January 1987) at the Richmond, Fredericksburg and Potomac (RFP) Railroad's Potomac Yard in Alexandria, Virginia. Results from the test will be analyzed and a final report is expected to be completed by April 1987.

The device has successfully demonstrated that stuck brakes or hand brakes not released can be detected. The device is only in a pre-prototype configuration and is not a developed item ready for production. Other potential applications for this device, consisting of rail sensors, microprocessor, and radio voice transmitters, are as a gross ton accumulation record, excessive axle weight alarm, a car weighing record, a truck (axle) misalignment detector, and a locomotive motive power malfunction detector.

3. Related Research

In the background Section 1, above, reference is made to a related research project on wheel replacement. That project emphasizes the determination of replacement criteria after the problem of overheating the wheels has taken place. This project is directed toward eliminating the situation of wheel overheating <u>before</u> it becomes a problem.

4. Objective

The objective is to demonstrate that it is possible and economically feasible to detect stuck brakes early, when a train is pulling out of a yard, thereby eliminating the problem of overheated wheels and the threat of a derailment from this cause.

5. Scope

The Stuck Brake Detection Device will detect dragging wheels with stuck brakes or a partially released hand brake as an assembled train leaves a yard. The device design consists of two parts, the sensors, and the processor. The sensors in this case are two parallel 18" long rail sections inserted into the running track, each machined so that the wheel loads are supported by two vertical beams within the rail section. Strain gages on the vertical beams are used to sense vertical, lateral, and longitudinal forces independently. The force signals are sent to the processor to interpret the loaded track condition. The processor must distinguish small brake drag forces from large locomotive thrust and axle torsion forces. It also performs axle counting and corrections for mechanical thermal variations and long term electronic signal drift. The processor will be capable of independently calling the locomotive engineer and/or yard personnel by radio and telling them that, for example, axles 24 and 65 have stuck brakes.

6. Interfaces

Ensco, Incorporated, the engineering support contractor, took the rail test sections previously fabricated and developed sensors and the signal processing unit. A breadboard configuration was tested at TTC. The RF&P Railroad, Potomac Yard, Alexandria, has agreed to test the device on a departure track of the yard. The RF&P has provided the test site, space for and power to the instrumentation trailer, track installation with the instrumentation test sections being in and taken out several times, suggestions in operational use of the device, and direct support and involvement in the final test of the device. The Office of Safety Enforcement has been informed of the progress made to date with this device.

7. Potential Benefits

Since it has been shown that the Stuck Brake Detection Device will accomplish the objective of detecting dragging brakes early, it will provide railroads with a safer operation, reduce unncessary equipment losses because of failure, and lower operating costs through reduced drag.

The device though not fully developed can quite easily be brought to fruition, now that the pre-prototype version has proven the practicality of the device. Final reports indicating the results obtained thus far will be published and disseminated to the Association of American Railroads, railroads, and suppliers that may be interested in further developing and deploying a similar device.

It has not been determined if there is anything patentable in this device. It has been developed on Government funds and is licensable as discussed with a DOT patent attorney.

Stuck Brake Detection Device

1. Schedule:

   June 1984 - April 1987

2. Cost:

Ensco, Inc.	$264,000
Transportation Test Center	97,000
TOTAL	$361,000

Industry Support: RF&P Railroad, Potomac Yard, has provided support to the current test at no cost to FRA

F

12/29/86

Undesired Emergency Brake Applications

1. Background

Undesired emergency (UDE) brake applications have been a problem for the railroad industry almost since the inception of the air brake. Many railroads and air brake suppliers have performed research in this field, but due to the sporadic and seemingly random nature of UDE's, their efforts have been unable to provide adequate solutions.

Any brake application is expected to result in an on-track stop. However, emergency applications, particularly undesired emergency applications, result in unpredictable track-train interactions and in-train forces that cannot be controlled by the engineer. Unintended emergency application of the brake system caused by a malfunction of brake system components are the cause of derailments and sudden loss of train control. The UDE may recur more than once during a train's travel to its destination, placing the railroad system in repeated high-risk situations. An UDE may uncontrollably stop a train and prevent further movement of the consist while on mainline track, across turnouts or crossings, and may interfere with signals, block patterns, or other system safeguards. While the number of UDE's reported to FRA under cause codes 405 and 405L - Brake Valve Malfunction (undesired emergency application) is small, i.e., seven in 1984 and eight in 1985, those numbers do not represent the many UDE's which occur at accident severity levels below the FRA reporting threshold. Nor do those numbers include occurrences that were attributed to a more specific brake system component failure cause code. The undeterminable nature of the UDE's has generated increased concern to railroads transporting hazardous materials and operating at higher traffic densities. Previous research has been done independently by railroads experiencing high UDE incident rates. Lack of information on vehicle maintenance and operating histories, nonownership of affected rail cars, and the broad range of operating conditions have contributed to minimal success. This project will set a uniform, industry-wide approach to resolution of UDE safety problems.

2. Current Status

Under the Track Train Dynamics Program - Phase III, a Task Order provides for the Investigation of the Occurrence of Undesired Emergency Brake Applications. This task, approved September 30, 1986, has just begun. Complementary funding for this project is $250,000.

3. Related Research

A portion of this project is to seek and bring together available research performed by independent parties such as the Union Pacific RR, the Canadian National RR, and brake system suppliers. The results of that research and methodologies used will be reviewed for possible use in a uniform approach to resolution of UDE occurrences. Recent testing by AAR has provided improved in-train UDE locating devices for isolating affected rail cars and has some cause categories for further study which may be helpful in a more detailed evaluation of this safety problem.

4. Objective

The objective of this project is to determine the probable causes of unexplained and undesired emergencies through the use of computer studies and field tests and then to make recommendations to railroads and the supply industry concerning corrective action to be taken.

5. Scope

With the cooperation of six to twelve railroads, a study will be made to identify those cars that have been involved in at least five UDE's. A computer data base will be developed and used to examine and determine if any patterns of UDE occurrence exist that are related to car types, types of valves, lengths of brakepipes, etc.

Some cars involved in UDE will be inspected by qualified AAR personnel on railroad property in an effort to determine UDE cause and select a limited number of the UDE-prone cars for further testing at TTC. Train tests will then be performed at TTC with UDE-prone cars placed in various positions in the train. Operation will be under typical conditions in an attempt to determine if UDE's can be duplicated. When a UDE does occur, cause and any trend will be identified and documented. In addition, stationary vibration tests will be conducted for further examination of possible cause. Individual air brake valves will be thoroughly tested and tear down inspections performed.

6. Interfaces

AAR - Project manager, staff engineers, technicians.

Industry/Railroads - Managers, engineers, shop foremen, testers, and laborers.

Suppliers - Managers, engineers, and technicians

Government - FRA/R&D staff and program managers, Office of Safety Maintenance Programs Division

7. Potential Benefits

This program is the most systematic research yet undertaken to solve an important railroad industry safety problem. In the context of increased movement of hazardous materials, this problem has great emphasis.

The probability of identifying the causes for UDE's is good. When they are identified, the particular components, operating parameters, or other anomalies causing UDE can be redesigned if necessary, changed or adjusted to implement the results of the research.

Undesired Emergency Brake Application

Cost:

FRA	$124,000
AAR	$250,000
Total	$374,000

Schedule: 9/86 - 10/88

Contractor: Association of American Railroads

G

January 29, 1987 Scharr:366-0454

ACTION: High Speed Passenger Service
(File 6325.6)

Richard L. Scharr
Task Monitor

Arne J. Bang
Program Coordinator

Since the "Prospectus" on our current and future projects was recently written, the January 1987 TRB Conference has taken place. I have corrected the "High Speed Passenger Service" project write-up (attachment) and extensively rewritten Section 3., Related Research, based on information gathered from this conference.

Additional information will be gathered on this potential project area. With Florida issuing their RFP for a franchised system this month, it is hard to believe that any of several proposers would submit their proposal in about a year without some additional safety regulations for high speed systems "on the books" (CFR). FRA has stated at the June 1986 High Speed Rail Conference that there will be Federal involvement in these state projects. It was restated at the Conference in one of the papers presented.

#

cc: M. C. Gannett
W. R. Paxton
R. L. Krick

High Speed Passenger Service

1. Background

Today, Canada and the United States are considering high speed rail projects in more than 17 states and provinces. Two of these projects (Los Angeles-Las Vegas and Miami-Orlando) include trade-offs between rail and magnetic levitation (MAGLEV) vehicles. There are no U.S. developed trains or vehicles being considered. There are none available. All have been developed to foreign national standards to operate in non-U.S. environments. No U.S. standards exist that specifically address maintaining safety at the high speeds being considered. Passenger equipment requirements, as stated in U.S. Code of Federal Registration (CFR), do not specifically address high speed passenger equipment safety requirements. Track standards only address speeds up to 110 mph. The high speeds to be considered in this effort are in the range of 125-200 mph for wheels on rails, and 200-300 mph for non-contact requirements (MAGLEV). Before CFR-type requirements can be specified, a major investigation must be organized and undertaken.

Some initial work was done on the potential problems of new passenger equipment in the mid-1970's by the Office of Research and Development. It was called the Improved Passenger Engineering Evaluation Program (IPEEP). This initial effort was completed in 1978. It was simple, but extensive, an effort to identify, categorize and evaluate (first look) what high speed trains and equipment were available and in development. Another source of information is the High Speed Rail Association, organized in 1983 to promote the expansion of high speed rail passenger service. This is a group of individuals, unions, and corporations who share an interest in furthering the development of high speed rail passenger transportation systems, including MAGLEV.

None of the foreign high speed trains and equipment have been demonstrated in the United States. Production trains are being built in Japan, Germany, France and Italy. Experimental MAGLEV vehicles are running in Japan and Germany. The German MAGLEV passenger vehicle may be considered to be in the developmental stage.

2. Current Status

This effort is a renewed initiative to pickup where IPEEP stopped, bring that study up-to-date, collect information that has been gathered since by the Transportation Research Board Committees, identify where the safety issues require more study, test and evaluation, and safety requirements formulation. The effort should immediately branch into contact (wheel/rail) and non-contact (MAGLEV) investigations. There are no commitments made or received from any organization. However, with so much U.S. and worldwide effort going on, a ready-made audience is available to explore safety issues.

3. Related Research

The IPEEP reports are extensive and are available for review in the Department of Transportation's library, and for purchase through the National Technical Information Service. The University of Carnegie-Mellon Transportation Center has the IPEEP reports which are now dated and plans to update this information as it becomes available. The National Academy of Science/Transportation Research Board (TRB) Committee on Intercity Passenger Guided Transportation (A2M05) formed a safety subcommittee to gather, assimilate, and distribute safety related information. The Subcommittee has four subgroups: track/guideway, vehicles, systems (control, communications, signals, electrification), and operations.

Another subcommittee under A2M05 has recently completed a working paper (implying that it is a strawman from which to proceed) considering the technology areas and work needed associated with high speed intercity passenger guided transportation. The matrix includes fixed plant, rolling stock safety, environment, operations and maintenance, personnel, and systems engineering/economics. Those states (principally Pennsylvania, Ohio, Texas, Florida, California, and Nevada) studying the use of high speed passenger service have contracted for extensive economic, technical, and operational feasibility studies and analysis. Florida has just issued (January 1987) an RFP for the Florida Franchise System, which will run between, in general, Tampa, Orlando, and Miami. Initial proposals will be submitted around March 1988 and after several complicated steps, a franchise award is expected in 1990 with initial operations to begin in 1995.

4. Objective

The objective of this project is to provide the technical bases upon which safety requirements for ultra-high speed (125-200 mph) and super high speed (200 mph and higher) passenger vehicles and trains can be determined.

5. Scope

This project will consist of information gathering on worldwide existing equipment and safety requirements, identifying missing elements and information, identifying U.S. needs, and specifying what test and evaluation must be done before the technical bases for safety requirements can be determined. FRA will scope, plan and specify funding requirements for tests and evaluations. The project will be a competitive procurement placed with a contractor who has no conflict of interest. This contractor will call upon the consultants and organizations that have the expertise to provide the desired information. A small government/industry steering committee consisting of FRA/AAR/unions, and possibly the National Academy of Science/Transportation Research Board Committees should be established early to critique the scope and direction, and to review progress. Within FRA the Offices of Research and Development, Safety

Enforcement, and Safety Analysis should be active participants. There will be tests identified for safety evaluation. Identification of what needs to be tested and the funding mechanisms will be conducted under this project. Oversight of the test projects and analysis of the results of the safety tests that are conducted will be evaluated in this effort.

6. Interfaces

A contractor will be selected competitively to assist FRA in conducting this study. Also a Government/industry steering committee should be formed to provide overall guidance and review of results. Within FRA all three offices within the Office of Safety will be involved: Office of Research and Development, Office of Safety Enforcement, and the Office of Safety Analysis.

7. Potential Benefits

The potential benefits are safe deployment of high speed passenger surface transportation in the U.S. Only the economic viability of new high speed transportation will bring about the actual development and deployment of a system. The results of this project, including safety evaluation tests, will be disseminated to any appropriate committees, industry and union groups, and the Office of Safety Enforcement. Recommendations may be made, as well as changes or additions to FRA or industry rules, that may be needed to accommodate changing technologies, while assuring their consistency with sound safety practices. The project results will provide timely support to the issuances of notices of proposed rulemaking should that be a determination as a result of the findings.

Prepared by: ______________________
Contracting Officer's Technical Representative — Date

Concurrence: ______________________
Director, Office of Safety Enforcement — Date

Approval: ______________________
Division Chief — Date

Concurrence: ______________________
Director, Office of Safety Analysis — Date

Concurrence: ______________________
OR&D Program Coordinator — Date

Approval: ______________________
Associate Administrator for Safety — Date

Approval: ______________________
Director, Office of Research and Development — Date

High Speed Passenger Service

Cost: $1,000,000 (does not include testing)

Schedule: 9/88 - 9/91
Contractor(s): To be determined

12/23/86 subsequent followed

High Speed Passenger Service

1. Background

Today, Canada and the United States are considering high speed rail projects in more than 17 states and provinces. Two of these projects (Los Angeles-Las Vegas and Miami-Orlando) include trade-offs between rail and magnetic levitation (MAGLEV) vehicles. There are no U.S. developed trains or vehicles being considered. There are none available. All have been developed to foreign national standards to operate in non-U.S. environments. No U.S. standards exist that specifically address maintaining safety at the high speeds being considered. Passenger equipment requirements, as stated in U.S. Code of Federal Registration (CFR), do not specifically address high speed passenger equipment safety requirements. Track standards only address speeds up to 110 mph. The high speeds to be considered in this effort are in the range of 130-180 mph for wheels on rails, and 180-300 mph for non-contact requirements (MAGLEV). Before CFR-type requirements can be specified, a major investigation must be organized and undertaken.

Some initial work was done on the potential problems of new passenger equipment in the mid-1970's by the Office of Research and Development. It was called the Improved Passenger Engineering Evaluation Program (IPEEP). This initial effort was completed in 1978. It was simple, but extensive, an effort to identify, categorize and evaluate (first look) what high speed trains and equipment were available and in development. Another source of information is the High Speed Rail Association, organized in 1983 to promote the expansion of high speed rail passenger service. This is a group of individuals, unions, and corporations who share an interest in furthering the development of high speed rail passenger transportation systems, including MAGLEV.

None of the foreign high speed trains and equipment have been demonstrated in the United States. Production trains are being built in Japan, Germany, France and Italy. Experimental MAGLEV vehicles are running in Japan and Germany. The German MAGLEV passenger vehicle may be considered to be in the developmental stage.

2. Current Status

This effort is a renewed initiative to pickup where IPEEP stopped, bring that study up-to-date, identify where the safety issues require more study, test and evaluation, and safety requirements formulation. The effort should immediately branch into contact (wheel/rail) and non-contact (MAGLEV) investigations. There are no commitments made or received from any organization. However, with so much U.S. and worldwide effort going on, a ready-made audience is available to explore safety issues.

3. Related Research

The IPEEP reports are extensive and are available for review in the Department of Transportation's library, and for purchase through the National Technical Information Service. The High Speed Rail Association has a committee categorizing equipment and component issues as to what is generally known and feasible at various speeds. Those states studying the use of high speed passenger service have contracted for extensive economic, technical, and operational feasibility studies and analyses.

4. Objective

The objective of this project is to provide the technical bases upon which safety requirements for high and ultra-high speed passenger trains can be determined.

5. Scope

This project will consist of information gathering on worldwide existing equipment and safety requirements, identifying missing elements and information, identifying U.S. needs, and specifying what test and evaluation must be done before the technical bases for safety requirements can be determined. FRA will scope, plan and specify funding requirements for tests and evaluations. The project will be a competitive procurement placed with a contractor who has no conflict of interest. This contractor will call upon the consultants and organizations that have the expertise to provide the desired information. A small government/industry steering committee consisting of FRA/AAR/unions, and possibly the National Academy of Science/Transportation Research Board should be established early to critique the scope and direction, and to review progress. Within FRA the Offices of Research and Development, Safety Enforcement, and Safety Analysis should be active participants. There will be tests identified for safety evaluation. Identification of what needs to be tested and the funding mechanisms will be conducted under this project. Oversight of the test projects and analysis of the results of the safety tests that are conducted will be evaluated in this effort.

6. Interfaces

A contractor will be selected competitively to assist FRA in conducting this study. Also a Government/industry steering committee should be formed to provide overall guidance and review of results. Within FRA all three offices within the Office of Safety will be involved: Office of Research and Development, Office of Safety Enforcement, and the Office of Safety Analysis.

7. Potential Benefits

The potential benefits are safe deployment of high speed passenger surface transportation in the U.S. Only the economic viability of new high speed transportation will bring about the actual development and deployment of a system. The results of this project, including safety evaluation tests, will be disseminated to any appropriate committees, industry and union groups, and the Office of Safety Enforcement. Recommendations may be made, as well as changes or additions to FRA or industry rules, that may be needed to accommodate changing technologies, while assuring their consistency with sound safety practices. The project results will provide timely support to the issuances of notices of proposed rulemaking should that be a determination as a result of the findings.

Prepared by: ______________________
Contracting Officer's Technical Representative — Date

Concurrence: ______________________
Director, Office of Safety Enforcement — Date

Approval: ______________________
Division Chief — Date

Concurrence: ______________________
Director, Office of Safety Analysis — Date

Concurrence: ______________________
OR&D Program Coordinator — Date

Approval: ______________________
Associate Administrator for Safety — Date

Approval: ______________________
Director, Office of Research and Development — Date

High Speed Passenger Service

Cost: $1,000,000 (does not include testing)

Schedule: 9/88 - 9/91

Contractor(s): To be determined

H

12/29/86

Quick Response Safety Research Vehicles, Track, and Components

1. Background

The Office of Safety has responsbility for accident investigation, railroad safety, regulations and guidelines. In many cases, the necessary information is not readily available and timely technical support is required. This project provides a quick response task order contract to perform safety research pertaining to railroad vehicles, track, and components. These tasks will typically involve railroad safety concerned with vehicles or components such as wheels, bearings, or brakes and track or track components such as rail, ties, fasteners, or subgrade. This work provides the capability to perform tests, or analyses, or conduct studies to respond rapidly to requests from the Congress, the National Transportation Safety Board, the Offices of Safety Enforcement and Analysis or other concerned agencies.

2. Current Status

The contract to perform this work was recently awarded. The only task assigned to date is the management task which provides 800 manhours of management functions to be expended through the duration of the contract. Subsequent tasks will be assigned when the requirements for specific tasks are known or when so directed by authorized agencies or individuals.

3. Related Research

The type of work to be performed and the methods of execution under this program will be similar to that provided by Illinois Institute of Technology Research Institute under a similar contract that will expire in February 1987.

4. Objective

The primary objective of the overall task order contract is to provide technical support to FRA's Office of Research and Development in its function of making technical recommendations concerning railroad safety that may have influence on guidelines, regulations, and emergency orders.

5. Scope

Within the scope of the preceding objective, the contractor will provide on a task order basis, the personnel, materials, and facilities to develop a research plan to conduct the appropriate study, analyze the data collected and draw conclusions from the data, and make recommendations to the FRA. Tests and analysis of railroad vehicles, track, or their associated components will be performed in the context of safety performance issues.

6. Interfaces

AAR - Program managers, senior engineers, engineers and test personnel at both Technical Center in Chicago and Transportation Test Center in Pueblo.

Railroads - General managers, senior engineers, test personnel, shop and yard employees.

Suppliers - General managers, engineering personnel.

FRA - Office of Research and Development staff; Office of Safety Maintenance Programs Division.

7. Potential Benefits

Quick response action will be provided for resolution of safety issues and problems confronting the railroad industry. A high potential exists for a reduction in the number of accidents, fatalities, injuries, and property damage. Implementation of the results of this program will be a function of the particular research performed. Once required research is identified, an implementation plan can be designed and executed. The research could result in support for waivers or other regulatory action or be implemented voluntarily by the industry.

Quick Response Safety Research Vehicle, Track, and Components

Cost: $688,948

Schedule: 9/86--10/88

Contractor: Battelle; Columbus, Ohio

I

12/30/86

Locomotive Control Compartment and Crashworthiness

1. Background

There are a significant number of injuries to railroad crew members in locomotives due to collisions with highway vehicles at grade crossings. Between the years 1979 and 1985, there were 789 crewmen injured and 14 crewmen killed at grade crossing accidents. Statistics on those killed or injured in collisions and derailments are not readily available. The Locomotive Control Compartment Committee (LCCC), established in 1971, consisting of representatives of the Brotherhood of Locomotive Engineers, United Transportation Union, Association of American Railroads, Union Pacific Railroad, and the Federal Railroad Administration, has been investigating the possibility of making safety improvements to the arrangements of equipment in the control compartment and to the locomotive cab's crashworthiness. A number of studies were done on cab safety in the 1970's and early 1980's. Unconventional and radically different equipment and cab structures, compared to those on today's freight locomotives, were proposed; and, mockups--models were built. The Canadian National Railroad (CN) had the Diesel Division of GM Canada build locomotives with full width, thicker steel short hoods and stronger collision posts (Model SD50F, SD60F). Because of the movement to remove cabooses from trains, it has become desirable to design locomotives with additional crew space for additional train crew members and the equipment formerly carried in cabooses. A prototype expanded cab has been designed and built for the Seaboard System several years ago although a safety assessment was never applied in the context of present studies.

2. Current Status

A draft "straw-man" test plan has been prepared for the conduct of a comparative test at TTC between an existing U.S. road locomotive with conventional short hood, collision posts, and cab arrangement, and SD50F type collision posts and cab arrangement. Both locomotives have been provided by the Union Pacific Railroad (UP). This test plan is presently being reviewed by the LCCC and may be modified as a result of review and will also be dependent upon a formal Safety Inquiry concerning locomotive crashworthiness to be held in 1987.

3. Related Research

A number of studies, analyses, tests, and mockups were performed in the 1970's. The organizations associated with this previous research were:

- o Boeing Vertol
- o Stanford Research Institute (SRI)
- o Calspan Corporation
- o ElectroMotive Division (EMD), General Motors (GM)
- o General Electric (GE)

- o Dynamic Sciences
- o Illinois Institute of Technology Research Institute
- o National Space Technology Laboratories

An excellent bibliography identifying some of this work is located in the appendix of "Analysis of Locomotive Cab," Report DOT/FRA/ORD-81/84 (PB 83150631). Locomotive collision testing was reported by EMD in 1972 on SD 40 and E-7 locomotives to show collision effects at slow (30 mph) speeds.

- Locomotive-caboose collision tests were performed to determine impact effects by DOT/FRA at TTC in 1975.

SRI analyzed Boeing Vertol studies, conducted scale model locomotive-caboose impact tests, and recommended a slant-nosed (inclined deflection shield) cab design. Scale models were used to develop a locomotive cab structure that would protect the train crew in a train-to-train impact. Two cab designs were developed: a complete cab structure weighing 12,000 pounds that included an inclined shield nose and a cab structure; and, a lightweight inclined deflection shield weighing 4,000 pounds that replaces the short hood on road switcher locomotives. One-fourteenth scale experiments were performed with both cab structures in which a caboose or a caboose and a loaded hopper car struck the locomotive above the coupler line at the deflection shield. The experiments showed that both structures would protect the train crew but that the lightweight shield produces a better overall response. A series of 1/20 scale experiments were also performed to determine the path of freight cars that were deflected over the locomotive by the lightweight shield.

GE and EMD designed and built full-scale mockups of the clean cab design. The clean cab design is limited to the control console area and equipment in the cab and not to the structural strength of the nose and cab.

4. Objectives

The objectives are to improve locomotive crashworthiness, control compartment equipment arrangement and egress thereby reducing railroad crew injuries and fatalities attributed to poor design.

5. Scope

The Locomotive Control Compartment and Crashworthiness project consists of modifying a Union Pacific Railroad provided scrap road locomotive's nose, cab, and control console area with specified crashworthy improvements. A strength test and a collision test will be conducted at TTC to determine the estimated survivability of the modified configuration as compared to an unmodified locomotive cab and nose.

6. Interfaces

The LCCC committee has assisted FRA in the planning of studies directed toward improving the occupant safety of the cab and crash-worthiness of the locomotive. This committee recommended a comparative test and has been apprised of the progress to date on this project. Also participating at various meetings of the above committee have been GE and EMD locomotive manufacturers' representatives. Contacts have also been made with the Diesel Division of GM, Canada to obtain cab features of the SD-50F locomotive cab. Contacts are also being maintained with the Canadian National Railroad concerning their experience with the new cab.

7. Potential Benefits

The results of a locomotive cab comparison test that demonstrate the effectiveness of proposed safety improvements will be disseminated to the LCCC, AAR Mechanical Division, the manufacturers, and the Office of Safety Enforcement. Recommendations may be made suggesting changes or additions needed in FRA or industry rules needed to accommodate changing operating practices and technologies that assure consistency with sound safety practices. The research results may also support the issuance of a notice of proposed rule-making in one or more areas concerning the cab nose and compartment, control console and equipment in the cab, anticlimb devices, couplers, locomotive centersill strength, etc.

Prepared by:
Contracting Officer's Technical Representative — Date

Concurrence:
Director, Office of Safety Enforcement — Date

Approval:
Division Chief — Date

Concurrence:
Director, Office of Safety Analysis — Date

Concurrence:
OR&D Program Coordinator — Date

Approval:
Associate Administrator for Safety — Date

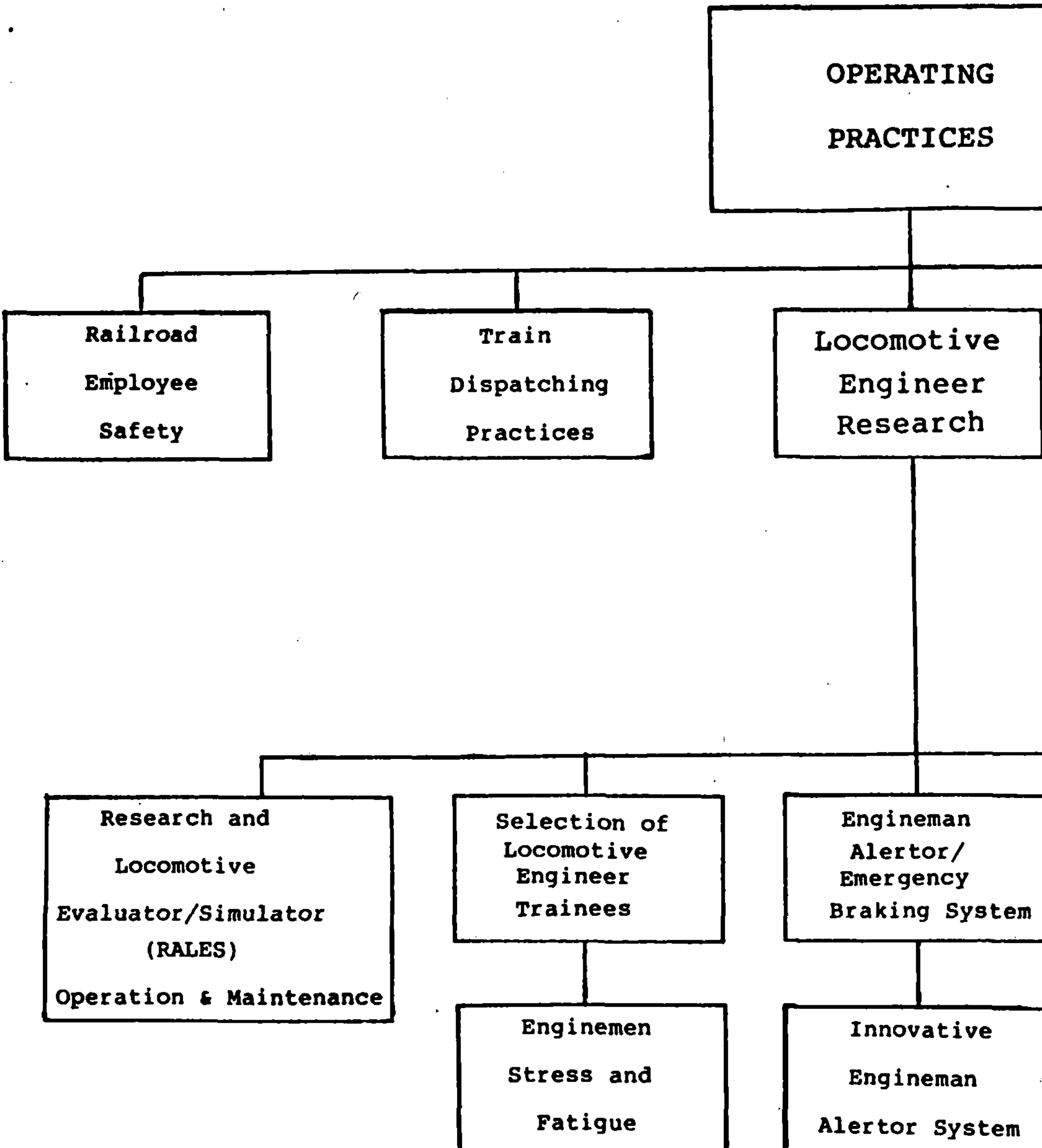
Approval:
Director, Office of Research and Development — Date

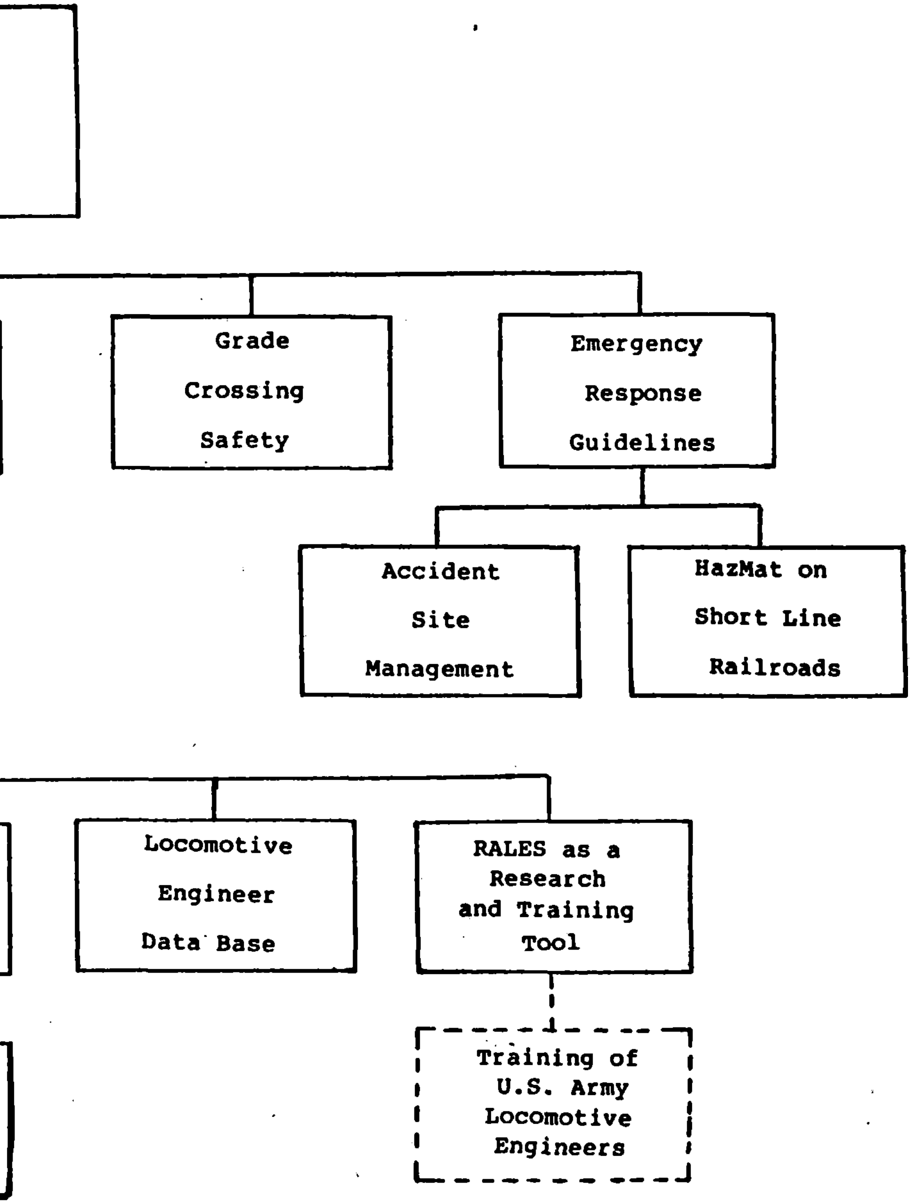
Locomotive Control Compartment and Crashworthiness

Cost: $656,166

Schedule: 5/87--11/89

Contractor: Association of American Railroads, Transportation Test Center


OPERATING PRACTICES
Railroad Employee Safety
Train Dispatching Practices
Locomotive Engineer Research
Research and Locomotive Evaluator/Simulator (RALES) Operation & Maintenance
Selection of Locomotive Engineer Trainees
Enginemen Stress and Fatigue
Engineman Alertor/ Emergency Braking System
Innovative Engineman Alertor System


Grade Crossing Safety
Emergency Response Guidelines
Accident Site Management
HazMat on Short Line Railroads
Locomotive Engineer Data Base
RALES as a Research and Training Tool
Training of U.S. Army Locomotive Engineers

J

Railroad Employee Safety

1. Background

Motivational techniques have been the center piece of various management styles in a variety of industries over the past twenty years (or more) to improve productivity, to reduce machine and merchandise damage, and to reduce accidents and injuries to employees.

The current project grew out of pilot studies on the Southern and Illinois Central Gulf (ICG) Railroads designed to improve employee safety performance using motivational techniques. Over an 8-month period (June 1982 - February 1983), the study showed 41 percent and 49 percent reductions respectively in observed unsafe behavior as a result of using the techniques to be demonstrated in this effort. Discussions leading to initiation of this FRA/AAR joint effort began in late 1983 and the contract was executed in September 1985.

The primary railroad participants are the Burlington Northern (BN) and the Duluth, Missabe and Iron Range (DMIR). The BN was targeted to be one of the participating railroads to reinforce the goals of the Safety Assessment that was performed by the Office of Safety Enforcement in 1984. In addition, the ICG sits on the study coordinating committee in an advisory capacity and is expected to provide some assistance in training and data evaluation. The participating railroads evolved from discussions within the AAR Safety Steering Committee, and are volunteers in the program. Other railroads expressed interest but because of the length of time involved in getting the project under contract decided to be observers only. Other railroads considering participation were Chessie, Chicago and North Western (C&NW), and the Union Pacific (UP).

2. Current Status

The Safety Program Inventory to determine perceptions of each railroad's safety program at various employee levels has been completed and the data are being analyzed. Safety personnel have been trained to gather information on safe and unsafe behavior on the BN and observations are underway. This activity will begin in March 1987 on the DMIR. Supervisor training in motivational techniques is scheduled for January 1987 on the BN.

3. Related Research

See "Background." Also, substantial work has been done to define the proper way to do many tasks such as mounting and dismounting a railroad car or throwing a switch. One example is, "Human Factors in Railroad Operations: Initial Studies," TSC, 1972.

4. Objectives

a. To clearly demonstrate the value of the management, training, and motivational techniques to be used for improving the effectiveness of railroad employee safety programs.

b. To document the approach, in the railroad environment, sufficiently to permit and encourage other railroads to use these techniques.

c. To improve the effectiveness of safety programs on the participating railroads, particularly the BN.

5. Scope

The projected study is divided into two phases. Phase I consists of an exercise during which data is collected from a sample of the participating railroad's employees concerning perceptions of their railroad's safety program, policy and performance. Phase II includes observations and recording of safe and unsafe employee behavior, supervisory training and implementation of the behavior modification techniques.

The study is proposed to run simultaneously on the two railroads, each setting up a "control" and "experimental" group of employees. Only the experimental group will be exposed to the behavior modification techniques. Recordings of unsafe acts will be made by observing both groups of employees at work before and after the experimental group's exposure to the techniques. There will be two cycles of training and observations at six-month intervals. The difference in the experimental group's performance after exposure will provide the measure of success of the applied techniques.

6. Interfaces

The study is being conducted under the scrutiny of the AAR Safety Steering Committee. In addition to involving the management of the participating railroads, local labor representatives have been briefed concerning the purpose and structure of the study.

7. Potential Benefits

a. The availability of a methodology for improving safety performance that has been demonstrated and documented in the railroad environment.

b. Improved employee safety performance on the participating railroads.

c. Through the Safety Steering Committee, it is anticipated that once demonstrated, the methodology will be incorporated into the safety management of other railroads.

Railroad Employee Safety

Cost:

FRA:	$221,442
AAR/Railroad:	$747,618

Schedule: 09/85 - 03/88

Contractor: Association of American Railroads, Safety and Operating Rules

K

12/30/86

Train Dispatching Practices

1. Background

As a result of railroad mergers, reorganizations, and consolidations, more trains are moving over fewer lines. In high-volume territory, this situation will substantially increase the workload of dispatchers. Further, dispatching territories are being consolidated resulting in larger areas of responsibility for each dispatcher. Some railroads are installing or experimenting with high technology communications and control equipment that will present even greater challenge.

Computer dependent centralized traffic control (CTC) systems have been one key to the consolidation of dispatcher territories. Advanced Train Control Systems (ATCS) are receiving great attention in Canada and in the United States through the Railway Association of Canada and the Association of American Railroads (AAR). The Union Pacific Railroad (UP) is actually operating 183 miles of experimental ATCS territory. The Burlington Northern Railroad (BN), in conjunction with Rockwell International, is experimenting with a system using satellites to identify train location. This sytem is currently called the Advanced Railroad Electronics System (ARES). The Chessie and Guilford Systems are looking at similar approaches.

The ATCS, ARES, and similar systems are, at best, in the experimental stage. Depending on whose level of optimism is most accurate, they are from four to ten years from being fully operational on the lines where their sponsoring railroads expect to use them. This provides FRA sufficient, but not excessive, time to examine the safety implications of those systems as they evolve. Such an approach is both more efficient and more desirable than having to respond to waiver requests or rule change requests with insufficient data or analysis for guidance.

Even without considering the implications of ATCS, ARES, and similar systems, substantial changes have occurred in train dispatching operations since the last time FRA examined this safety-critical railroad function in a reasonably comprehensive manner. The report, "An Analysis of the Job of Railroad Train Dispatcher," was prepared by the Transportation Systems Center (TSC) for FRA in 1974. It was a rather thorough examination of dispatcher functions as they existed at that point in time and contained ten recommendations for FRA action and four recommendations for railroads. Developments since then on CTC, ATCS, ARES, and the control centers for those systems is, at least in part, responsive to the recommendations relating to the use of automation and improved conditions in the work place. There is, however, little evidence of response to the recommendations concerning aptitude, knowledge, skills, training, stress, and physical and mental health having been attempted.

Investigations continue to identify dispatchers, or those who report to a dispatcher, as causing or contributing to the cause of an accident. In some instances, their actions or lack thereof, contribute to the severity of an accident rather than the cause. Selected report titles are listed under Related Research.

Since the decisions of the dispatcher are a key ingredient in safe and efficient railroad operations, it is appropriate to ensure that such decisions are: made on the basis of accurate information received when needed; not unduly influenced by counterproductive stressful situations; and, accurately transmitted to operating personnel in a timely manner. It is also necessary to ensure that the dispatcher is properly trained to perform his tasks in the environment and with the equipment assigned.

2. Current Status

This is a new initiative, proposed to begin during FY 1987.

3. Related Research

An Analysis of the Job of Railroad Train Dispatcher, TSC, 1974; Evaluation of Technologies for Advanced Train Control Systems, ARINC Research Corp., 1985; Discussion Paper, Basic System Architecture for Advanced Train Control System, ARINC Research Corp., 1985; Advanced Railroad Electronics System, a briefing, with handouts, by Burlington Northern Railroad and Rockwell International, December 1986; other ATCS and ARES information, as it becomes available; the findings of the Special Safety Inquiry on Radio Communications scheduled for the end of January 1987 will also be relevant; as will the findings of several National Transportation Safety Board railroad accident reports. Some of the more recent reports are: RAR-86/03; RAR-85-13; RAR-85/12; RAR-85/09; RAR-85/06; SIR-85/01; and, RAR-83/02.

The proposed Signals and Train Control project is also expected to provide a useful source of data.

4. Objectives

The broad goal of this project is to provide for safer train operations in all aspects where the dispatcher function is involved. The more specific objectives are:

a. To provide the basis for FRA decisions concerning potential waiver of rules or rules changes (particularly, 49 CFR Parts 220, 228, 233, and 236), or the issuance of new rules that may be needed as the technology of and management approach to train control change.

b. To determine the knowledge, skills, and ability needed by individuals to safely and efficiently perform the dispatcher function under both current and anticipated future railroad operating scenarios.

c. To develop aptitude screening tests for selecting candidates for the job of dispatcher.

d. To develop standards for dispatcher training programs and both job knowledge and skill tests to ensure that the training has been successful.

e. To evaluate areas of dispatcher stress and develop recommendations for mitigation therefrom.

All findings and products of this project not translated into rule-making would be recommended to railroad management for voluntary use.

5. Scope

Considerations of hardware reliability, function, applicability, and integration are expected to occur in the Signals and Train Control Project. This project will concentrate on the operating practices and human factors implications of both existing and future approaches to train control as they affect railroad safety.

To achieve the stated objectives of the project, the findings of the work cited under related research will serve as a beginning point. The environment in which the dispatcher currently functions and will function in the future will be evaluated. These evaluations will span the range of conditions existing from the operation of "dark territory" to those expected to exist in the operation of ATCS and similar systems. Job analysis will be performed under each of these scenarios and the knowledge, skills, and ability required for the job of dispatcher will be determined. This work will provide the basis for developing aptitude screening tests for dispatcher job applicants as well as training standards. In addition to providing the beginning point for job analysis, the evaluation of the dispatcher environment will provide the basis for examining situations contributing to dispatcher stress and the potential for relief.

The most likely working structure to accomplish this project is to acquire an appropriate contractor through the competitive procurement process and establish an advisory group consisting of FRA, AAR, railroad and labor representatives to provide counsel as the work progresses. If AAR and/or the railroad industry wish a broader role, a cooperative agreement approach may be recommended.

6. Interfaces

AAR Research and Test Department (ATCS) and Operations and Transportation Committee (Operating Rules)

Railroads desirous of participating

American Train Dispatchers Association

Office of Safety Enforcement

Suppliers of dispatching equipment

Contractors, as required

7. Potential Benefits

It is anticipated that safer train operations will occur as a result of developing more apt, better trained dispatchers who perform their function in a less stressful environment. It is anticipated that the research results will be voluntarily implemented by the railroads; no certification of employee capabilities is being considered.

Prepared by: ______________________
Contracting Officer's Technical Representative — Date

Concurrence: ______________________
Director, Office of Safety Enforcement — Date

Approval: ______________________
Division Chief — Date

Concurrence: ______________________
Director, Office of Safety Analysis — Date

Concurrence: ______________________
OR&D Program Coordinator — Date

Approval: ______________________
Associate Administrator for Safety — Date

Approval: ______________________
Director, Office of Research and Development — Date

Train Dispatching Practices

Estimated Cost:

FY 1987	$200,000
FY 1988	200,000
FY 1989	200,000
Total	$600,000*

Schedule: 9/87--9/91

Contractor: To Be Determined

*Cost to FRA may be reduced by industry participation

L

Research and Locomotive Evaluator/Simulator Operation & Maintenance

1. Background

The need for a locomotive and train handling simulator for research and training was identified in the early 1970's. Substantial work was done from 1974 through 1978 to detail desired performance requirements and in 1979, a contract to build the Research and Locomotive Evaluator/Simulator or (RALES) was issued to Teledyne Ryan Associates (TRA), following a competitive procurement process.

By 1981, TRA was substantially behind schedule and producing heavy cost overruns. Therefore, the TRA contract was terminated and the work transferred to IIT Research Institute in Chicago. RALES was completed and placed into operation at IITRI in early 1984.

The IITRI contract for RALES has two phases. Phase I, to build RALES, is completed. Phase II, to operate and maintain RALES for a period of 10 years following completion, at no cost to the Government began in 1984. All users, including FRA, pay a user's fee which is currently $250 per hour. During Phase I, several railroads gave assistance to ensure the realism of operating characteristics.

2. Current Status

Since Phase II began, several railroads and the Navy have used RALES for upgrade training of engineers. Amtrak and AAR have also used RALES to perform small research projects in train handling using the facility.

3. Related Research

In the early 1970's, research into improving the safety and comfort of the locomotive cab interior was used, to a degree, to support the need for a locomotive simulator. Other work leading to the conceptual design of the simulator included research into train handling characteristics and a detailed definition of the locomotive engineer function. Two current FRA task orders issued under Phase II of the IITRI contract and a joint FRA/ICG Railroad project using RALES are decribed as separate projects. They are: "Locomotive Engineer Data Base," "Engineman Alertor/Emergency Braking System," and "RALES as a Research and Training Tool."

4. Objective

The RALES was built to provide a unique, state-of-the-art tool for conducting research and training in train handling, operating practices, cab design and instrumentation, and related human factors issues. It is intended to be used by both Government and industry on a self-sustaining basis.

5. Scope

Phase I of the RALES project built a state-of-the-art locomotive and train handling simulator that replicates, as near as possible, the look, feel and performance of an actual lead locomotive in a wide variety of train consist conditions. Phase II provides for the operation and maintenance of the facility at no cost to the Government. It also permits FRA to issue task orders for specific research projects, necessary to meet its safety mission.

6. Interfaces

Several railroads provided advice leading to improved realism in the operating characteristics of the final RALES product. Individually and through participation in the Track Train Dynamics Program, these railroads included: Chicago and North Western; Seaboard; Illinois Central Gulf; Grand Trunk; Burlington Northern; and Soo Line. Most of these railroads have used or are periodically using the facility for the upgrade training of engineers and road foremen.

Technical support to FRA for various projects using the RALES is provided by the Transportation Systems Center using Project Plan Agreements.

7. Potential Benefits

Safer and more efficient engineer performance and train handling methods are expected to result from both the training and research uses of the RALES facility. The ability to safely examine, in a controlled setting, under a variety of simulated typical operating conditions, a wide range of safety issues related to human factors, train handling, and locomotive control compartment, or cab, design will prove useful in the future.

RALES: Operation & Maintenance

	Phase I	Phase II
Cost	$10 million *	Per Task Order **
Schedule	09/79 - 02/84	02/84 - 02/94

TSC Technical Support for FY 1987 - $50,000

* Nearly $8 million to Teledyne Ryan before that contract was terminated 09/79 to summer 1981)

** See Task Order 1, "Locomotive Engineer Data Base," and Task Order 2, "Engineman Alertor/Emergency Braking System." Funds under an interagency agreement to train U.S. Army locomotive engineers are expected for FY 1987 ($200,000) and FY 1988 ($300,000).

Contractor: Illinois Institute of Technology Research Institute (IITRI)

M

Selection of Locomotive Engineer Trainees

1. Background

The need for a battery of "aptitude tests" for candidates for locomotive engineer positions was first stated, in early 1983, by a special committee on training under the Track Train Dynamics Program. This committee consisted of representatives of the following railroads: Chicago and North Western; Southern; Seaboard System; Grand Trunk; Santa Fe; and Canadian National. The Research and Test Department, Association of American Railroads was also working with the committee.

Other railroad officials who have expressed support for the project include: Mr. N. J. Andrews, General Manager, Safety and Training, Illinois Central Gulf (now retired); Mr. Louis Steinkirch, Director of Training, ICG; Mr. Richard Micek, former manager of Training, Southern Pacific; Mr. James Fitzsimmons, Manager of Training, and Mr. Gary McLean, Assistant Manager, Training and Development, Southern Pacific.

Mr. Ed McCulloch, Vice President, National Legislative Representative, Brotherhood of Locomotive Engineers (now retired) felt strongly that the project should be done and urged Chris Rooney to approve it. Mr. Gene Plourd, United Transportation Union was also contacted and provided a copy of the proposed work statement for the project. He was neither positive nor negative. He said he had not given it any real thought, but it was worth further discussion.

The initial procurement request was prepared in early 1984. After several reviews by Chris Rooney, Bill Loftus, Bob Collins, and Office of Policy staff, the often revised version of the procurement request and its accompanying work statement was approved in April 1985.

The procurement was done competitively. Proposals were received November 26, 1985. Reviews and a series of negotiations followed, culminating in execution of the contract with the contractor on September 15, 1986. The contractor obtained the support of the Union Pacific Railroad which is participating in the project.

2. Current Status

The contract was awarded September 15, 1986. The contractor has visited the Union Pacific at both their headquarters and training center to obtain data and to establish schedules for UP participation. Other railroads have been contacted for information. The job analysis task is currently underway.

3. Related Research

Much of the foundation work done for the design and construction of RALES and nearly all of the information used in and derived from the study to determine the effectiveness of "RALES as a Research and

Training Tool," is relevant. Also important is the contractor's experience in similar efforts for a wide variety of Government and industrial clients.

4. Objectives

   a. Conduct and document an analysis of the job activities of locomotive engineers to determine the knowledge, skills and abilities required of incumbents.

   b. Develop and validate a set of tests to predict applicants who will succeed in training and eventually become safe and effective train handlers.

   c. Document the results and procedures used in the validation of all tests to ensure that selection procedures are fair, valid, and in accordance with technical and legal standards. Particularly applicable are the Uniform Guidelines on Employee Selection, adopted by the Equal Employment Opportunity Commission, Civil Service Commission, Department of Labor, and Department of Justice in 1978.

5. Scope

The project is designed in two phases. The first is to develop the desired screening tests and perform a concurrent validation using experienced engineers (part of the Union Pacific participation). The second phase is intended to provide a predictive validation by testing candidates for locomotive engineer training and tracking those selected through the training program and their first year or two as operating engineers.

6. Interfaces

In addition to the participation of the Union Pacific Railroad, and those discussed under "Background," other railroads are being consulted for advice. The Locomotive Control Compartment Committee has been briefed and will be advised of progress, as appropriate.

7. Potential Benefits

   a. An increase in productivity, safety, and efficiency is expected because the capabilities of engineers will more adequately meet the demands of the job.

   b. A decrease in legally indefensible hiring practices may be achieved by replacing subjective estimates of a candidate's employability with more standardized, job-related assessment procedures.

   c. A decrease in work-related accidents and injuries that result from an interaction between existing worker capabilities and the demands of the job should also occur.

In addition, the railroad industry will be provided the following tools to obtain the potential benefits:

d. A screening test battery validated according to technical and legal guidelines.

e. A manual to be used in administering and scoring the test battery.

f. A final report describing the project goals, history, methodologies, and findings.

When the project is completed, the test battery and guidance documentation will be made available for voluntary railroad use. Rulemaking is not a contemplated result of this project nor is any effort toward government certification of engineers.

Selection of Locomotive Engineer Trainees

Cost:

FRA: $243,352 *
Union Pacific: Not Estimated

Schedule:

Phase I: 09/86 - 03/88
Phase II: 04/88 - 12/91

* Most of the expenditures will be in Phase I.

Contractor: Advanced Research Resources Organization

N

01/02/87

Enginemen Stress and Fatigue

1. Background

"On the basis of the data used in this study, 73.3 percent of railroad accidents are locomotive engineer performance-related." This observation is presented on page 3-6 of the draft report "Analysis of Human Factors and Safety in Railroad Transportation" prepared for the Federal Railroad Administration (FRA) in December 1980 by B&M Technological Services, Inc. (B&M). The data base used consisted of railroad accident investigation reports of the National Transportation Safety Board (NTSB) from 1970 to 1980.

Train handling is a complex job requiring a wide range of rather well-defined skills. Complying with a multitude of operating rules such as speed control, acceleration and deceleration, signal observance, buff and draft control, communications, and knowing the mechanical condition of every part of the train requires the full-time attention of the engineer. These conditions, coupled with irregular work hours, occasional adverse weather conditions, continuous noise and vibration, and a host of other outside influences add up to a work environment which has many similarities to that of the military or commercial pilot.

Considerable research has been done in the physical and training areas of train operations to make them safer. Work continues in such areas as track, equipment, operating rules, and train handling techniques. Unlike plane handling, little work is documented on stress and fatigue effects on the operator's performance even though there appear to be many similarities. Researchers concerned with pilot performance are examining such issues as: shift duration, irregular work schedules, work/sleep cycles, flight conditions (weather, night, traffic delays, etc.), boredom, the relationship of vibration to muscle fatigue and low back pain, stress due to family or financial problems, effects of job/-career dissatisfaction, task difficulty and saturation, thermal and noise effects, and relationships between many of these factors. References are listed under Related Research.

Informal discussions with locomotive engineers and road foremen leads to the conclusion that they are concerned with many of the same issues in the railroad environment as are being researched for pilots. While not always well-defined, a review of NTSB accident reports leads to the conclusion that such factors may be significantly relevant to the efficient and safe performance of locomotive engineers. This project is proposed to identify and evaluate those factors that are suspected to have the most adverse impact on locomotive engineer performance.

2. Current Status

This is a new initiative proposed to start during FY 1987.

3. Related Research

Past FRA sponsored research which can provide some data and insight for this project includes: Studies of Freight Train Engineer Performance, Transportation Systems Center (TSC), 1976; Maintaining Alertness in Railroad Locomotive Crews, TSC, 1977; Train Generated Air Contaminants In The Train Crew Working Environment, TSC, 1977; Health and Safety Implications of Diesel Locomotive Emissions, Naval Personnel Research and Development Center, 1978; Assessment of Locomotive Crew In-Cab Occupational Noise Exposure, National Bureau of Standards (NBS), 1980; and Analysis of Human Factors and Safety In Railroad Operation (draft), B&M Technological Services, Inc., 1980.

For more contemporary and proposed FRA projects relevant to this effort, see: RALES As A Research and Training Tool; Locomotive Engineer Data Base; Enginemen Alertor/Emergency Braking System; and, Selection of Locomotive Engineer Trainees.

Research related to pilot performance includes: Human Factors Survey: C-5 Pilots, U.S. Air Force School of Aerospace Medicine, 1984; Effects of Helicoptor Vibration on the Spinal System, Vermont University, 1984; Thermal Control Problems in Military Helicoptors, Royal Air Force Institute of Aviation Medicine, 1984; Military Aircrew Work Environment, Foesvarets Forskingsanstalt (Sweden), 1984; Job and Family Stress as Predictors of Pilot Health, Job Satisfaction and Performance, University of Manchester Institute of Science and Technology, 1984; Physiological Assessment of Aircraft Pilot Workload in Simulated Landing and Simulated Hostile Threat Environments, Arizona State University, 1984; Sustained Intensive Air Operations: Physiological and Performance Aspects, Advisory Group for Aerospace Research and Development (France), 1983; Biomedical Measurements of the Human Stress Response, Arizona State University, 1984; Sleep and Wakefulness Handbook for Flight Medical Officers, Advisory Group for Aerospace Research and Development (France), 1983; Avoidance of Excessive Fatigue in Aircrews: Guide to Requirements, Civil Aviation Authority (England), 1982; Subjective Workload Assessment Technique, U.S. Air Force Flight Test Center, 1982; Estimating Aircrew Fatigue: A Technique With Application to Airlift Operations, U.S. Air Force School of Aerospace Medicine, 1982; The Evaluation of Studies of Flight Personnel of the German Lufthanza on the Question of Stress During Flights on the Short European Routes, National Aeronautics and Space Administration (NASA), 1982; Fatigue Stressors in Simulated Long-Duration Flight. Effects on Performance Information Processing, Subjective Fatigue and Physiological Cost, U.S. Air Force School of Aerospace Medicine, 1980; Aeromedical Factors in Aviator Fatigue, Crew Work/Rest Schedules and Extended Flight Operations: An Annotated Bibliography, U.S. Army Aeromedical Research Laboratory, 1981; and, Evaluation of Army Aviator Human Factors (Fatigue) In a High Threat Environment, U.S. Army Aeromedical Research Laboratory, 1980.

Relevant work has also been done with regard to industrial equipment operators and automotive vehicle drivers. A literature search, similar to that done for pilots, needs to be an early effort of this project.

4. Objective

The goal of this project is to improve the safety and efficiency of performance of locomotive engineers by identifying those stress and fatigue factors most likely to adversely affect performance and recommend actions to minimize these adverse conditions.

5. Scope

This project is planned to be undertaken in two phases. Phase I will consist of four basic activities. They will be: (1) an extensive literature search involving all of the work cited under Related Research, other related work which is expected to be identified, and all potentially relevant railroad accident reports; (2) the preliminary identification of stress and fatigue factors that appear most promising for study in the railroad environment; (3) discussions, possibly in a safety inquiry format, with railroad management and labor representatives, road foremen, and locomotive engineers to determine the perceived importance of the factors identified from the literature and accident report evaluation; and, (4) the preparation of a list of factors recommended for detailed examination in Phase II. This list, and the methods proposed to perform the evaluations, would have to be approved by FRA before Phase II would be started.

Phase II would evaluate the effects of the factors identified in Phase I on locomotive engineer performance. Those factors most likely to be included are: work/sleep cycles; noise; vibration; irregular work schedules; conditions at away-from-home layovers; boredom; and cab environment (fumes, temperature, etc.).

Because of the sensitivity, at all levels of both railroad management and labor, to some of the issues which may be addressed, it is imperative that an FRA/railroad/labor advisory group be available for frequent consultation throughout the project. The Locomotive Control Compartment Committee may be a suitable forum.

The contractor for this project is expected to be selected through the competitive procurement process.

6. Interfaces

Locomotive Control Compart Committee;
Association of American Railroads, Operating and Transportation Committee and Research and Test Department;
Brotherhood of Locomotive Engineers;
United Transportation Union;
railroads--several operating department heads, road foremen and engineers;
Office of Safety Enforcement, Operating Practices Division;
Office of Safety Analysis, Planning and Evaluation Division; and
consultants, as required

7. Potential Benefits

The ultimate goal and expected benefit of this project is to reduce the frequency and severity of locomotive engineer performance-related train accidents by improving the operating environment of locomotive engineers. The recommendations expected to come from this project will provide FRA and railroad management and labor additional tools to achieve this goal. These benefits are expected to be achieved through voluntary implementation by the railroads and labor without Federal regulatory actions.

Prepared by:
Contracting Officer's Technical Representative — Date

Concurrence:
Director, Office of Safety Enforcement — Date

Approval:
Division Chief — Date

Concurrence:
Director, Office of Safety Analysis — Date

Concurrence:
OR&D Program Coordinator — Date

Approval:
Associate Administrator for Safety — Date

Approval:
Director, Office of Research and Development — Date

Enginemen Stress and Fatigue

Cost:	FY 1987	$130,000
	FY 1988	$100,000
	FY 1989	$120,000
	Total	$350,000

Schedule: Phase I 9/87--10/88

Phase II 10/88--12/90

Contractor: To Be Determined

0

Engineman Alertor/Emergency Braking System (EA/EBS)

1. Background

At various times over the past four years, Mr. O. L. Williams, a former Seaboard System locomotive engineer, has approached the Administrator, the Associate Administrator for Safety, the Director of the Office of Research and Development, and the Locomotive Control Compartment Committee to have FRA test a brake pedal device he invented. His request was somewhat reinforced by inquiries from the offices of (now) Senator Tim Wirth of Colorado and columnist Jack Anderson.

There are approximately four models of vigilance safety devices in current use on locomotives. They differ in some respects but are basically of two types. The oldest is generally known as the "dead man's pedal" and requires the engineer to keep a foot pedal depressed while the train is in motion. If the pedal is not depressed, the brakes are applied to stop the train. The other type of vigilance device gave rise to the term "alertor." It requires the engineer to touch any one of several controls (throttle, brake handle, etc.) at specified intervals (usually in the range of 15 to 45 seconds). If the interval is not observed, a light or a buzzer or one followed by the other is activated. If the engineer does not respond after a specified interval (usually 15 or 20 seconds) the brakes are applied. The alertor in this test is a current model of this type. Because of this constant intrusion, the devices are often bypassed or disabled by the engineer. This means that if the engineer falls asleep or has a medical emergency which renders him incapable of operating the train, there is no automatic way of stopping the train.

In an emergency, the engineer must set the brake, ring the bell, blow the horn, and in most instances, try to get out of the cab as quickly as possible. Mr. Williams claims that the pedal frees the engineer's hands for other tasks in busy areas and that it can be used to activate all required systems in the event of an emergency and allow the engineer to leave the cab more quickly. He also indicated that its use in emergencies could be enhanced by linking it with an alertor. It was the Locomotive Control Compartment Committee's recommendation that such a linkage be made for testing. Therefore, Mr. Williams contacted Vapor Systems and arranged for one of their alertors to be linked to his brake pedal for this series of tests.

The tests are to be run using RALES. This is Task Order 2 under the IITRI contract.

2. Current Status

Arrangements have been made by IITRI for locomotive engineers of the Soo Line to operate RALES during the EA/EBS tests. The Vapor alertor and Mr. O. L. Williams brake pedal have been installed on RALES and are linked into the electrical and air brake systems for operation. Appropriate film and test scenarios have been prepared. The film is of approximately 60 miles of Soo Line trackage near Chicago, and will also be used in a Soo training program. Full simulation of operations on this territory are provided in addition to emergency situations. A different approach to measuring task performance is being proposed by IITRI. If, when the written proposal is received, it proves desirable and acceptable, additional funding of approximately $10,000 will be required to implement and document the new methodology. Testing should be completed during the first quarter of 1987.

The Vapor alerter and the prototype brake pedal have been donated for the test. The Soo Line engineers are being provided at cost.

3. Related Research

See RALES: Operation and Maintenance project making available to FRA this unique testing facility and RALES as a Research and Training Tool.

4. Objective

This project is designed to objectively test and evaluate the usefulness of the alertor and brake pedal to maintain engineer vigilance, to permit the engineer to operate in busy areas more efficiently, and to react to an emergency situation more rapidily, in a safe setting.

5. Scope

Sixteen experienced engineers will operate RALES over approximately 60 miles of simulated Soo Line territority with and without use of the Vapor/O. L. Williams engineer alertor/braking system. Emergency situations will be included. All train handling performance with and without the system in use will be recorded and differences in vigilance levels, train handling efficiency, and emergency reactions, if any, documented. Opinions concerning the system in use will be solicited from the engineers operating RALES during the tests. Human factors experts from the University of Illinois (Chicago) have developed the form, structure, and the approach to performance measurement to be used in the tests.

6. Interfaces

The Locomotive Control Compartment Committee recommended that the tests be done including the alertor. They were briefed on the proposed test approach and provided advice on such aspects as the type of territory to be considered. And, they will be briefed on the research findings.

7. Potential Benefits

An objective appraisal of both the brake pedal and engineer alertor components will result. Research findings and conclusions will be useful in responding to NTSB recommendations, Congressional and press inquiries, and inquiries from Mr. O. L. Williams. In addition to being able to arrive at a specific decision concerning the utility of this device, the project will advance the overall understanding of the techniques of measuring locomotive engineer performance under inpaired operating conditions.

Engineman Alertor/Emergency Braking System

Cost:

Funded to date - $98,868
Estimated to Finish - $10,000

Schedule: 09/85 - 03/87

Contractor: Illinois Institute of Technology Research Institute

P

Innovative Engineman Alertor System

1. Background

Under the Small Business Innovation Development Act of 1982, the Department of Transportation has established the Small Business Innovative Research Program. The purpose of the program is:

a. To stimulate technological innovation.

b. To use small business to meet Federal research and development needs.

c. To increase private sector commercialization of innovations derived from Federal research and development.

d. To foster and encourage minority and disadvantaged participation in technological innovation.

The program is managed by the Transportation System Center. Each year every research and development office in DOT is required to provide funds for the SBIR program. Also each year, every office is requested to recommend research topics which might be pursued under the program. If a research office does not have topics to be considered, their funding will be applied to other projects.

In FY 1985, FRA proposed several research projects for inclusion in the SBIR program. One was for an innovative alertor device. Several types of alertor devices exist. Many locomotive engineers find them objectionable in some way. Therefore, they often find ways of defeating the device. Some railroads insist on operable alertor devices in their locomotives, others operate without them. Engineers tend to agree, however, that a non-intrusive, reliable alertor would improve vigilance in the cab and reduce accident risk. This is the feeling of the Locomotive Control Compartment Committee and, for several years, the National Transportation Safety Board has been recommending the use of alertors in all locomotives. Examples are found in NTSB accident report numbers: R-73-8; R-83-6; R-83-9; R-84-2; R-84-31; and R-85-4.

The SBIR program provided the opportunity to determine, at a reasonable cost, if a more acceptable alertor could be built.

2. Current Status

A Phase II contract for the development and testing of an innovative alertor system was awarded in September 1986. Testing is expected to begin in September 1987 and is planned to be performed both on RALES and on locomotives in revenue service. The Union Pacific has volunteered some of their locomotives for these tests.

3. Related Research

See "Engineman Alertor/Emergency Braking System"

4. Objective

The objective of this project was stated in the SBIR solicitation as follows: "...An innovative device is sought which is simple, tamper-proof, and inexpensive, ensuring the locomotive engineer's remaining alert. The device may have a source of electricity provided from conventional power available on a locomotive. It may be inter-connected also to the train air brake system, if deemed necessary. The device should not be objectionable to the engineer nor cause him/her fatigue or stress."

5. Scope

The Phase I study verified the feasibility and practicality of a device using multiple low cost ultrasonic sensors to survey cab workstations with a microprocessor as monitor. Phase II includes design and test modules. Design considerations include: tying the device to train speed, reverser control, and on-board electrical power; refinement of response time parameters; optimum selection and configuration of sensors; investigation of need for backup procedures in the event of a malfunction. Testing will include: system reliability; component reliability; and human factors considerations.

SBIR program and contractual conditions require that Phase III, production, be entirely the responsibility of the contractor. This contractor has a capital investment commitment for production and marketing of the device, if the results of Phase II are favorable.

6. Interface

The Locomotive Control Compartment Committee is following the progress of this work and the Union Pacific Railroad has indicated a willingness to have some of the devices installed on their locomotives for testing. The Office of Safety Enforcement assisted in review of the original proposals.

7. Potential Benefits

An inexpensive, unintrusive means of maintaining vigilance in the locomotive cab, as a step in reducing accident risk, is the expected result. If testing proves this to be the case, the device will be manufactured and marketed to the railroad industry as an improvement over existing approaches to maintaining vigilance.

Innovative Engineman Alertor System

Cost:

Phase I:	$47,340
Phase II:	$265,648
Total	$312,988

Schedule:

Phase I:	09/85 - 03/86
Phase II:	09/86 - 09/88

Contractor: Tesa Design, Inc.

Q

Locomotive Engineer Data Base

1. Background

Aptitudes, skills, training, alcohol and drug abuse, stress levels and stress management, operator environment, cab configuration and instrumentation, and other factors affecting the safety and efficiency of locomotive engineer job performance are or are likely to be subjects of research efforts. These efforts may be initiated by Government, universities or the private sector. Each will use information from the same general data base, i.e., the universe of locomotive engineers.

Data gathering quickly becomes expensive and time consuming. Substantial economies can be achieved for all potential researchers if all data relevant to every aspect of the function and individual can be obtained from the source (locomotive engineer) at one time rather than revisiting the source each time an aspect of the function is to be examined. With the beginning of the operation of the Research and Locomotive Evaluator/Simulator (RALES), a unique opportunity presented itself to properly design and initiate the building of such a multipurpose data base and capture relevant data as it became available.

The pioneer project to use RALES was a joint effort of the Federal Railroad Administration (FRA) and the Illinois Central Gulf Railroad (ICG) (RALES as a Research and Training Tool), to train locomotive engineers and evaluate their train handling performance. One aspect of the evaluation required that the demographic and operating history of each engineer be recorded and considered. Approximately 70 locomotive engineers were trained and evaluated in this project.

Since many research and training efforts involving locomotive engineers and train handling were expected to use RALES during the useful life of the facility, and since train handling and locomotive engineer performance continue to be areas where improvements are sought, the ready availability of data to address these concerns are both desirable and possible. This was the opinion of individuals in the Association of American Railroads, Research and Test Department, and members of the Track-Train Dynamics Sub-committee on training in early 1984 when the future uses of RALES was being considered.

It should be noted that the following railroads are maintaining ongoing programs to upgrade the train handling skills of their locomotive engineers: Union Pacific (UP); Southern Pacific (SP); Santa Fe (ATSF); Soo Line (Soo); Illinois Central Gulf (ICG); and Burlington Northern (BN). There are probably others. Some of these programs began before 1984.

The project was initiated in the fall of 1984.

2. Current Status

Computer storage capability has been established and the data from the ICG project entered. Software to use the data has been selected and tested. A manual for potential users of the system is being finalized.

3. Related Research

See: Research and Locomotive Evaluator/Simulator; Operation and Maintenance; RALES As A Research and Training Tool; Engineman Alertor/Emergency Braking System; Selection of Locomotive Engineer Trainees; and Innovative Engineman Alertor System.

4. Objective

The intent of this project is to create a data base on locomotive engineers that will permit current and future researchers to examine all facets of this job and relevant factors and conditions which affect job performance, thus, providing a basis for acquiring and/or developing better qualified and safer train handlers.

5. Scope

The locomotive engineer data base is made up of two general categories of information concerning each engineman. This includes background and performance data. Each of these general categories are further divided into a number of sources. In the case of background data two separate sources were defined. The first source is a biographical and employment history (including age, education, work history, safety record, etc.) data input form which can be completed using information generally found in corporate employment records. These data for the enginemen involved in the ICG project are in the existing data base. The second source is a personality data input form (including attitudes towards work, personality characteristics, tolerance toward stress, etc.). A form to obtain this information was designed to be completed by the locomotive engineer himself. This is a data field designed into the system. No data of this type were obtained from the ICG enginemen.

A number of sources of data describing skill or performance levels of enginemen are also available. The most comprehensive set of performance measures is provided by RALES in the form of the run summary. This summary can be produced at the end of any selected RALES session and provides a nine section report of the various actions taken by the engineman and the results of these actions. The user can establish criteria specific to a railroad or even a type of train which are used as thresholds of reporting. When a group of engineers operates over the same segment of track, the run summary becomes a particularly sensitive way to compare performance. For the purposes of the engineer data base, RALES software was modified such that the data included in the run summaries can be automatically transferred from RALES to the data base host computer.

In all cases, however, RALES performance summaries may not be available or as in the case of the ICG program, it was desirable to compare RALES results to field collected data. A convenient source of field performance data was provided by the ICG from a standard on-board, tape recorder, locomotive status report. A data set was designed and an input program written to accept this form of performance data from actual runs in the field.

A final source of performance data is a simple three variable, subjective rating of performance by a supervisor of the engineers. This data set was collected to determine how closely objective skill measures compared to more general and subjective assignments made by recognized authorities such as a supervisor or trainer.

Performance data for the enginemen participating in the ICG project for all of these fields have been placed in the data base.

The data, in whole or in part, may be passed from the host or storage computer to another computer over telephone wires. The requesting party must establish an account number with IIT Research Institute before access will be granted. A user's fee will be charged. This fee is intended to cover computer costs and the maintenance of the data base.

The computer software selected to both maintain and access the system is known as SAS. The package contains a library of almost fifty statistical procedures ranging from simple descriptive statistics to complex multivariate techniques. The user can develop programs for use in several procedures, and pass the results of one procedure as input to another. In addition to statistical functions, SAS has two significant data input and editing functions which allows SAS to maintain, as well as perform, processes upon the data base.

The data base configuration, software, and user instructions have been tested by experts at the Transportation Systems Center and found functional. The final user's manual is being prepared.

6. Interfaces

The original idea for this project was suggested by individuals from AAR's Research and Test Department, members of the Track Train Dynamics sub-committee, researchers from the University of Illinois (Chicago), and IITRI staff who market the services of RALES, as well as maintain the facility.

7. Potential Benefits

This project will make available a source of inexpensive information for use in conducting research into many aspects of train handling and locomotive engineer performance. A current example is the project on Selection of Locomotive Engineer Trainees.

Locomotive Engineer Data Base

Cost: $98,077

Schedule: 08/84 - 01/87 (Draft user's manual being revised)

Contractor: Illinois Institute of Technology Research Institute

R

RALES as a Research and Training Tool

1. Background

As Research and Locomotive Evaluator/Simulator (RALES) was nearing completion during 1983, a cost-shared project was being planned to evaluate the effectiveness of RALES as a research and training tool. This evaluation was suggested by members of the Track Train Dynamics Committee on training and railroads interested in the successful development of RALES as a means of: (a) minimizing skeptism concerning the value of this tool; (b) encouraging railroads to use the facility; and (c) identifying any problems which might surface in an operating environment that were not found in acceptance testing. The FRA and the Illinois Central Gulf (ICG) Railroad agreed to share the cost of the project. The contract for this project was signed in May 1984. ICG engineers and trainers were used. Within the overall objective, 70 ICG engineers received training to improve their train handling skills; criteria and measures of locomotive engineer performance were developed and applied; and, alternative training methods compared.

2. Current Status

A second draft of the final report is in preparation.

3. Related Research

All of the research on train handling and the locomotive engineer function developed for the design and construction of RALES were used in addition to: A Demonstration Project for Locomotive Engineer Training, Phase I, L&N-BLE, 1981; Track Train Dynamics to Improve Freight Train Performance, Track Train Dynamics Program, 2nd Edition; and human factors experts from the University of Illinois, Chicago.

4. Objectives

a. To evaluate RALES as a research and training tool.

b. To develop objective, measurable criteria for evaluating the performance of locomotive engineers.

c. To evaluate the effectiveness of different training methods.

d. To improve the skills of the ICG engineers trained.

5. Scope

Seventy locomotive engineers were put through the program in teams of two. Each team received an orientation concerning the purposes of the program and the features and operation of RALES. After orientation each engineer operated RALES over a territory designed to permit the measurement of performance in a variety of situations and terrain. From this evaluation, instructors identified operating practices needing improvement and provided instruction in the classroom and on the Train Dynamics Analyzer (TDA); RALES; or the TDA and RALES. Following this training, a second evaluation run was performed to measure train handling performance, with the objective of identifying differences from original operating habits. A second round of training was conducted and an exit evaluation was performed. These data were analyzed with work history and demographic information to draw conclusions relating to the initial objectives of the project.

6. Interfaces

In addition to the full participation of ICG, locomotive engineer trainers from several railroads have been consulted. These include: Burlington Northern; Chicago and North Western; Santa Fe; Southern Pacific; and Union Pacific. Formal or informal briefings have been given to the Locomotive Control Compartment Committee, local representatives of the Brotherhood of Locomotive Engineers and the United Transportation Union; and, various FRA officials, including the Administrator.

7. Benefits

The ability of RALES to simulate train operations in almost every type of situation is no longer in doubt. It is being used by several railroads and the Navy to improve the skills of their locomotive engineers. FRA is using it to test an engineer alertor and braking device and may use it for a wide variety of research, including accident reenactment where train handling and human factors issues are involved. ICG has seventy engineers with improved train handling skills enabling them to operate safely and efficiently. They have also, as a spin-off of this project, developed a methodology for efficiently analyzing data from event recorders which are installed on most of their locomotives. This permits continuous monitoring of each engineer's performance.

RALES As a Research and Training Tool

Cost: FRA $350,000
ICG $376,647 *

Schedule: 05/84 - 03/87

* This is the contract amount. They have spent more, but the amount is not fully documented.

Contractor: Illinois Central Gulf Railroad

Major Sub-contractor: Illinois Institute of Technology Research Institute

S

12/30/86

Training of U.S. Army Locomotive Engineers

1. Background

Until approximately 1960, the U.S. Army Transportation Corps maintained the capability to operate railroads in both domestic and hostile foreign environments. Around 1960, the conclusion was reached that domestic railroads could and would continue to operate their systems during national emergencies and that similar arrangements could be made in foreign countries, if needed. Therefore, the uniformed elements of the Army were directed to discontinue support of independent railroading capability. However, since the Army owns and uses a fleet of cars for domestic military shipments, some car repair and hostler capability was retained. This represents the current status of U.S. Army railroading activity.

During the summer of 1985, FRA learned through the Transportation Systems Center (TSC) that the Army had a renewed interest in railroading on nearly all fronts. This interest has evolved into an interagency agreement between the Army and TSC to: inspect and repair track on 30 to 40 Army installations in the U.S.; provide expertise and guidance in the repair or replacement of equipment owned by the Army and used on military bases and in domestic revenue service; and, provide training in a variety of railroad crafts to uniformed military personnel, primarily reservists.

The new policy direction of the Army is to develop and maintain, in designated Army Reserve units, the capability to operate railroads in hostile foreign environments. FRA and TSC representatives have held several discussions during 1986 with staff of the 757th Transportation Battalion of Milwaukee, Wisconsin, the Transportation Corps Training Center at Fort Eustis, Virginia, and headquarters staff at the Pentagon concerning training needs, possibilities, opportunities, and funding mechanisms. The capabilities of the Research and Locomotive Evaluator/Simulator (RALES) for training locomotive engineers was also demonstrated for several of these individuals at the Illinois Institute of Technology Research Institute (IITRI) in Chicago.

RALES is a tool the Army wants to use in their training program for locomotive engineers. Since they cannot negotiate a sole source contract directly with IITRI and they want the benefit of FRA expertise, they have included funds for this purpose in their interagency agreement with TSC. These funds are to be transferred to FRA by interagency agreement and a task order will be issued to IITRI. The training department of the Burlington Northern Railroad has agreed, informally, to assist IITRI in this effort.

2. Current Status

A proposed interagency agreement is expected from TSC in the near future.

3. Related Research

See: RALES: Operation and Maintenance; RALES as a Research Training Tool; and, A Demonstration Project for Locomotive Engineer Training, Phase I, L&N-BLE, 1981.

4. Objective

To support training of U.S. Army locomotive engineers for their military mission.

5. Scope

Individuals with little or no experience in train handling will be trained to a level of competence to qualify as locomotive engineers.

6. Interfaces

U.S. Army, various units and levels

Transportation Systems Center

IIT Research Institute

Burlington Northern Railroad

7. Potential Benefits

Productive utilization of RALES

Prepared by: Contracting Officer's Technical Representative — Date	Concurrence: Director, Office of Safety Enforcement — Date
Approval: Division Chief — Date	Concurrence: Director, Office of Safety Analysis — Date
Concurrence: OR&D Program Coordinator — Date	Approval: Associate Administrator for Safety — Date
Approval: Director, Office of Research and Development — Date	

Training of U.S. Army Locomotive Engineers

Cost: By Reimbursement

FY 1987	$200,000
FY 1988	300,000

Schedule: 6/87--10/88

Contractor: Illinois Institute of Technology Research Institute

Primary Sub-Contractor: Burlington Northern Railroad

T

12/30/86

Grade Crossing Safety

1. Background

Operation Lifesaver was started many years ago by the Union Pacific Railroad (UP) to educate the public concerning hazards at railroad/highway grade crossings with the goal to reduce accidents at these locations. In 1978, the National Safety Council (NSC) took over the program and promoted it on a nationwide basis. Funding was provided to NSC by Amtrak, the Association of American Railroads (AAR), and the Railway Progress Institute (RPI).

When Amtrak's FY 1986 budget was reduced from the amount requested, Amtrak reduced the level of funding provided to NSC for Operation Lifesaver. This reduced level of funding barely maintained the continuation of the Operation Lifesaver program to the end of June 1986. At this point, NSC elected to discontinue their role in the program.

In anticipation of the reduced Amtrak funding, possible reductions of funding from other sources, and the effect these events would have on the Operation Lifesaver program, the AAR sought and obtained through Congressional contacts language in FRA's Office of Research and Development budget for FY 1986 which earmarked $200,000 in the Operating Practices subprogram for grade crossing safety. While the language did not specify Operation Lifesaver by name, it was clear that the intent was to support the type of work traditionally done under this program. Of the $200,000 earmarked in FY 1986 for grade crossing safety, $140,000 remains available in FY 1987. The balance was used to support grade crossing research done by the Transportation Systems Center (TSC) for FRA during FY 1986.

Because the 1986 appropriation language did not specify either Operation Lifesaver or the NSC as recipient, a sole source contract could not be entered into with NSC to support the Operation Lifesaver program. The Chief Counsel's Office also ruled that language generic to the type of appropiration (research and development) prohibited FRA from granting the funds. For these reasons, the project did not go forward in FY 1986.

During the summer of 1986, to resolve the problems of appropriation language and the NSC decision, three actions were taken. First, language was drafted for inclusion in the FY 1987 appropriation bill permitting FRA to grant funds appropriated for research and development. Secondly, AAR succeeded in getting an additional $200,000 earmarked in the FY 1987 appropriation for grade crossing safety. Third, with strong assistance and encouragement from the Administrator, Operation Lifesaver, Inc. was formed by Amtrak, AAR, and RPI. Operation Lifesaver, Inc. is a non-profit corporation formed for a public education purpose. It is, therefore, eligible as a grant recipient.

Since reductions in the number of accidents from year-to-year and from place-to-place may usually be attributed to a variety of factors, statistics to specifically support the effectiveness of Operation Lifesaver are relatively nonexistent. However, it has been noted that during the year following the initial introduction of the program in a state grade crossing accidents were reduced by approximately half. This experience was repeated in several states and presents a strong argument for continuing the mainly educational program.

The Administrator, through statement and action has indicated his intent to continue the program and the language of the FY 1987 appropriation bill earmarking the funds for grade crossing safety leaves little doubt that this is the intent of Congress.

2. Current Status

Meetings have been held with the Board of Directors of Operation Lifesaver, Inc., to: (1) outline those steps it needs to take (such as establishing an accounting system) that will make it acceptable to the Office of Management and Budget as a grant recipient organization; and, (2) discuss the need for a grant request outlining the work to be undertaken and provide the basis for a grant agreement. A proposed outline of work is expected to be available for review in February 1987. A procurement request is in process.

3. Related Research

The project will build on the work accomplished under Operation Lifesaver since the early 1970's.

4. Objective

To reduce the frequency and severity of accidents at railroad/highway grade crossings through improved public education and awareness, particularly for groups that have not been adequately covered in the past.

5. Scope

Materials will be developed for distribution to a variety of targeted public groups to increase the awareness of grade crossing hazards and to provide guidance on how to avoid such hazards. In past efforts, coloring books, brochures, leaflets, and workshops have been targeted toward school children, bus drivers, people receiving driver's licenses, civic and public service organizations, etc. These efforts will continue. In addition, it is expected that special emphasis will be placed on law enforcement, drivers of trucks hauling hazardous materials, senior citizens, and school bus drivers. The nature of the materials to be developed and the groups to be targeted will be more fully developed and implemented when the grant agreement is consumated.

6. Interfaces

Operation Lifesaver, Inc. (AAR, RPI, Amtrak) staff will perform the work and will be the primary contact. They, in turn, have a vast network of contacts in railroads, state and local government, and service organizations who participate in the program. The Office of Safety Analysis and Chief Counsel's Office will be intimately involved as the program moves forward.

7. Potential Benefits

There are at least three benefits to be derived from this effort. The first, and the primary objective of all involved, is the reduction of the frequency and severity of accidents at grade crossings. Second is an improved public image for the railroad industry and FRA's safety efforts. Third is a positive image for the Office of Safety with its appropriate response to the intent of Congress.

Prepared by: ____________________
Contracting Officer's Technical Representative — Date

Concurrence: ____________________
Director, Office of Safety Enforcement — Date

Approval: ____________________
Division Chief — Date

Concurrence: ____________________
Director, Office of Safety Analysis — Date

Concurrence: ____________________
OR&D Program Coordinator — Date

Approval: ____________________
Associate Administrator for Safety — Date

Approval: ____________________
Director, Office of Research and Development — Date

Grade Crossing Safety

Cost:

FY 1987 $340,000

FY 1988 Depends upon new appropriation language. The program is not in the FY 1988 budget as currently submitted.

Schedule: 6/87--12/88

Performing Organization: Operation Lifesaver, Inc.

Emergency Response Guidelines

1. Background

Discussions between FRA, other Governmental entities, railroad officials, and shippers by rail have pointed up the need for comprehensive guidelines for the safe handling of train accidents involving hazardous materials (hazmat). In a special study published in 1980, NTSB concluded with regard to the railroad industry that "there is at present no standard to define what constitutes an emergency, or methodology to be used in coping with an emergency on an industry-wide basis." NTSB further recommended that FRA develop and validate "...a model emergency response plan for the guidance of the railroad industry in formulating individual plans to be utilized by their train crew members in the event of an emergency."

In September 1981, a contract was entered into with AAR's Bureau of Explosives to produce an "Emergency Response Handbook" to serve as a guide and model to the railroad industry in dealing with accidents involving hazardous materials. Background data for this effort were to be obtained through surveys of existing railroad company and shipper practices. By May 1984, little of the work had been completed. Therefore, the scope of the contract was reduced and its intent clarified to provide for the development of guidelines which may be used by railroads to do emergency response planning. A draft of these guidelines was delivered to FRA for review in November 1986.

2. Current Status

Draft of the contract deliverable is being reviewed by FRA.

3. Related Research

See "Hazardous Materials on Short Line Railroads," and "Evaluation of Protective Clothing and Personal Equipment." EPA, FEMA, U.S. Coast Guard, and DOT's Office of Hazardous Materials Transportation have done substantial related work. The guidance document may be used to support the Office of Safety Enforcement's effort to encourage all railroads to have adequate, written emergency response plans.

4. Objective

The intent of this project is to develop planning guidance to be used by railroads to improve their programs to respond to railroad accidents involving hazardous materials.

5. Scope

The AAR has prepared a planning guidance document identifying:

a. The considerations which railroad management should take into account when preparing the rail carrier's hazmat emergency response plan;

b. The essential elements of a hazmat emergency response plan, including activities which have been shown to be useful or necessary in the past in coordinating and informing the various response groups during a hazmat emergency.

c. The interrelationships between the rail carriers, shippers, community officials, and Governmental agencies in a hazmat emergency.

d. The unique aspects of railroad hazmat emergency response.

e. Useful reference information such as sample telephone notification lists, Federal/State/local emergency response contacts, training organizations and materials, private hazmat emergency response companies, and useful reference documents.

This planning guidance document has been designed to assist railroad managers who are charged with preparing and/or upgrading railroad hazardous materials emergency response plans, evaluating the individual needs of their railroad and for developing plans for an effective railroad response.

A recommended distribution plan for the planning guidance document is also to be provided.

6. Interfaces

The draft now being reviewed by FRA (Office of Research and Development and Office of Safety Enforcement) has been reviewed by the Bureau of Explosives Steering Committee.

7. Potential Benefits

The anticipated benefit is better emergency response planning by railroads to help reduce the severity of the consequences of accidents involving hazardous materials.

Emergency Response Guidelines

Cost: $88,355

Schedule: 09/81 - 02/87

Contractor: Association of American Railroads, Hazardous Materials Systems

V

Accident Site Management

1. Background

Initially this project was designed to respond to the following concerns, as quoted from the introduction to the work statement of the task order:

"The Transportation Research Board (TRB) has reviewed a variety of issues associated with hazardous materials transportation and determined, among other findings, that availability of proper protective clothing and equipment is a problem for accident response crews. A plethora of respirators, self-contained breathing apparatus (SCBA) devices, gloves, overshoes, hoods, and coveralls are currently on the market. Present materials technology requires that a range of relatively thick, impermeable garments be used to provide complete protection against a variety of solvent (e.g., ketones, hydrocarbons), corrosion (e.g., acids), and thermal hazards. Purchasing agents are barraged with guidance on selection of appropriate equipment keyed to detection technology (viz., knowing in advance what hazards are to be expected). Since most lower-protection level items are designed for workplace use, the only option available is to purchase equipment designed for IDLH conditions (i.e., immediately dangerous to life and health). These items are very expensive and designed for working times less than one hour.

Although 29 CFR 1910 and other documents (e.g., ANSI standards) provide design and criteria selection for protective clothing, the specific environment of transportation accident response is usually not considered. Not only will chemical hazards be present, but thermal loads from on-site fires may exacerbate heat stress phonomena (e.g., heat exhaustion, heat smoke) associated with long wear of impermeable clothing. As noted by the TRB, lightweight, affordable, effective protection means customized for the transportation accident environment need to be made available. To this end, representative design and selection approaches need to be developed for such protective equipment."

After approximately six months of background investigation into what was on the market, what new developments were underway, and what the interests of both suppliers and users were, it was discovered that a similar and more advanced project was being conducted by the U.S. Coast Guard. Part of the work was being done in-house and part by contract. However, very little information about this effort was in the public domain. As a result of this finding, FRA determined to redirect the remainder of this project to other objectives and monitor the Coast Guard effort.

This project was redirected to take advantage of a major investment by the Department of Defense in some new technology and to respond to the following finding and recommendation of TRB:

> "Given that no system of regulation and enforcement can eliminate accidents, a reasoned response to such occurrences is important. The Steering Committee found that there is considerable disagreement on the procedures and adequacy of emergency response. However, there is agreement that accurate, timely, and continuous information flow is necessary at the scene of the accident in order to properly evaluate the hazard involved.
>
> Federal agencies with emergency-response duties should take action to develop required information and technology to provide accurate and fast identification and estimation (both remote and on scene) of the nature and degree of hazard in accidents and spills. The Congress should support research and development to improve evaluation of on-scene hazards and to facilitate communications between all responsible individuals and teams as well as with the general public."

(Page 9, TRB News, July - August 1983; based on "Transportation of Hazardous Materials: Toward a National Strategy," Volumes 1 and 2, TRB, 1983)

The redirection provided for the development of a real-time accident scene management capability using microcomputer-driven video disc technology. The hardware was to be off-the-shelf. The software was to be built on the work done for the Department of Defense.

2. Current Status

An initial demonstration of the accident site management tool has been given to FRA. Two more are planned. One for other Federal agencies who have related interests or programs and one for the Kanawha Valley Emergency Planning Council who have provided advice and contributed substantial data for the demonstration.

3. Related Research

The basic concept and software for this effort is derived from work done for the Department of Defense to optimize the targeting of weapons. At the time this task was undertaken, DOD had invested over $1 million in development and testing. This sum has increased substantially in the intervening months. In addition, the following agencies are working on similar projects with similar objectives: U.S. Coast Guard; Environmental Protection Agency; Federal Emergency Management Administration; National Oceanic Graphic and Atmospheric Administration; and DOT's Research and Special Programs Administration. Representatives of these agencies have been briefed on the project objective and approach and are eager to see the results. EPA has indicated a willingness to advance the concept to an operational level.

4. Objective

Using off-the-shelf hardware and modifications of software originally developed for DOD applications, it is planned to demonstrate the capabilities of a microcomputer-driven laser video disc system as a tool for minimizing the consequences of a railroad accident involving hazardous materials.

5. Scope

The capabilities of the technology are to be demonstrated using real data for a real region. The Kanawha Valley area of West Virginia was selected. It has several chemical plants with large volumes of hazardous material inbound and outbound by rail, water, highway and pipeline. When the demonstration is satisfactorily completed and documented, the technology (not the hardware) will be made available for others to use. EPA and Chessie have expressed particular interest.

6. Interfaces

The Kanawha Valley Emergency Planning Council has provided the site, the needed community interface, advice and data for the demonstration. They expect to receive a demonstration of the technology and copies of the data and software that have been prepared. Contact with Safety's Offices of Enforcement and Analysis, EPA, FEMA, NOAA, USCG and RSPA have been established and maintained. All of these agencies are interested in a demonstration of the technology and some may be interested in further development work.

7. Potential Benefits

If the technology is used by those responsible for responding to railroad accidents involving hazardous materials, it is anticipated that response times will be reduced and that responses will be more correct for the particular occasion. As a result, the adverse consequences of such accidents should be minimized.

Accident Site Management

Cost: $215,971 *

Schedule: 07/84--03/87

Contractor: The BDM Corporation

* An additional $10 thousand is needed to complete the demonstrations currently envisioned. The procurement request is being processed.

Hazardous Materials on Short Line Railroads

1. Background

Most of the benefits from the research in both management of rail transport of hazardous materials and improvements in accident response procedures have accrued to larger railroads that handle high volumes of freight including dangerous and hazardous chemicals. This is because the larger railroads are aware of the results of most studies and research (sometimes contributing to the research). In addition, they have the financial, management and personnel resources to implement the improvements which result in bettering their safety record. For example, many large railroads have a full-time group headed by a Director of Safety/Hazmat dedicated to: (1) disseminating safety information within the railroad; (2) training operational personnel; (3) developing safety procedures to handle, store and move hazmat tank cars; and (4) responding to train accidents involving hazmat. The incorporation of these groups within railroads requires knowledge, training, and above all, financial resources.

Unfortunately, the dissemination of important information on safety related to hazmat transportation to small railroads is, at best, spotty, and at worst, non-existent. It is estimated that there are approximately 375 short line railroads operating in the United States. Many of these have been formed in the past ten (10) years, emerging as a result of railroad bankruptcies and mergers. The deregulation of railroads has been a further impetus in the birth of short line railroads. These lines are the terminal and feeder carriers for shipments of all kinds of freight, including hazmat. Many of the recently formed short line railroad companies operate with very few personnel and on limited budgets. Also, some have insufficient training or knowledge to respond to accidents or even to perform routine maintenance of track and/or rolling stock. Added to these limitations on the part of the short lines is the fact that the communities in which they operate are also, in general, small and have similar resource constraints. These resource limitations, lack of knowledge and limited ability to perform basic maintenance procedures form a potentially ~~dangerous~~ combination. A railroad accident on a short line involving hazmat release may lead to a major problem for both the community and the railroad.

There exists a considerable volume of literature, information experience base, and factual incident data on hazmat related incidents in rail transportation. These need to be disseminated to short line railroads and small communities. This knowledge includes steps and procedures that can be instituted at minimal cost or manpower resource expense. Such a step can go a long way in preventing the occurrence of hazmat related accidents and releases on short lines. Furthermore, these small railroads and small communities need some basic understanding of how to deal with a train accident or a non-train related release incident. Such information and its proper use will ensure an acceptable level of safety to both short line railroad personnel and the community at large. The key factors in developing this safety consciousness are awareness, training and planning.

However, there is no single source to which a resource limited short line or a community can go and obtain information on the regulations, chemical properties, proper procedures in accidents, equipment needed to handle emergencies, where personnel can be trained, etc. If short lines and small communities are to benefit, information on all aspects of handling hazmat has to be available in the collective manner, preferably from a single source. Also, such information should not be global in scope but tailored to the scale needed. It is with a view to providing the short lines and communities with such very important information that this project was initiated.

2. Current Status

The project began in March 1986. Identification of Class II and III carriers, a determination of which carry hazmat and what classes, and other relevant operational information is nearing completion. The completion and analysis of these data will provide the basis for profiling the training and preparedness needs of these railroads.

3. Related Research

Ongoing Office of Research and Development projects relevant to this effort are: Emergency Response Guidelines; Accident Site Management; and Hazardous Material Product Identification. Other recent work includes: Accident Management Orientation Guide, U.S. Air Force and FRA, 1982; Guidelines Manual for Post Accident Procedures for Chemicals and Propellants, U.S. Air Force and FRA, 1982; A Community Model for Handling Hazardous Materials and Transportation Emergencies, Kansas State University, 1981; Report to the Congress on Hazardous Materials Training, Planning and Preparedness, U.S. DOT and FEMA, March 1986; several Transportation Research Board papers; and accident reports from various sources.

4. Objectives

The goal of this project is to assemble and disseminate among short line railroads and small communities existing knowledge on the various aspects of handling hazardous materials and accident response. The specific objectives are to:

a. Determine the emergency response needs of short line railroads and the communities they serve.

b. Evaluate their requirements for training, equipment, and resources for dealing with hazmat emergencies.

c. Disseminate emergency response planning information and the most useful available information on where training can be obtained, cost, accessibility to other resources, etc.

5. Scope

Because of the elimination of reporting requirements in 1979 by the Interstate Commerce Commission, it is first necessary to identify Class II and Class III carriers and the types of operations they have. Those that transport hazardous materials will be grouped by similar characteristics. Each group is expected to represent a different level of need for emergency response preparedness and training. These needs will be defined and sources for filling the need will be identified. This information will then be provided to the affected railroads in a report structured for easy use and in a seminar planned in conjunction with an annual meeting of the American Short Line Railroad Association.

6. Interfaces

Special cooperation has been provided by the American Short Line Railroad Association. Assistance and data are also being received from: Office of Safety's Offices of Enforcement and Analysis; FRA's Offices of Policy and Federal Programs; Research and Special Programs Administration; Federal Emergency Management Administration; Interstate Commerce Commission; Association of American Railroads; Chemical Manufacturer's Association; National Industrial Traffic League; Military Traffic Management Command (Department of Defense); Environmental Protection Agency; U.S. Coast Guard; and the Norfolk Southern Corporation.

7. Potential Benefits

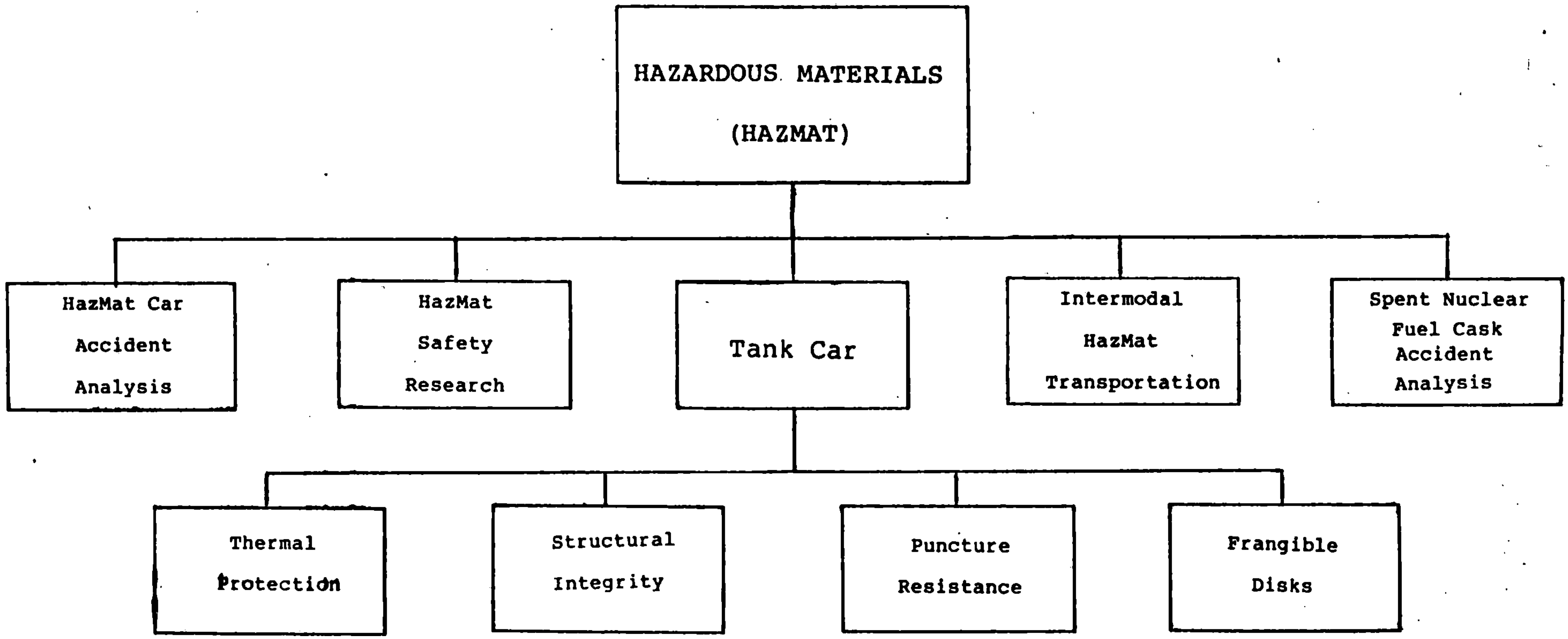
The ultimate objective is to reduce the potential for catastrophic consequences in the event of an accident involving hazardous materials on short line railroads. They will be provided easy-to-use guidance in the project's final report and in a seminar planned to not only disseminate the findings of this research but to encourage emergency response preparedness.

Hazardous Materials on Short Line Railroads

Cost: $297,511

Schedule: 03/86 - 03/89

Contractor: Technology and Management Systems, Inc.
(this is an 8a contractor)



HAZARDOUS MATERIALS (HAZMAT)
HazMat Car Accident Analysis
HazMat Safety Research
Tank Car
Intermodal HazMat Transportation
Spent Nuclear Fuel Cask Accident Analysis
Thermal Protection
Structural Integrity
Puncture Resistance
Frangible Disks

X

Hazardous Materials Car Accident Analysis

1. Background

   Current regulations for shelf couplers, head shields, and thermal insulation of certain tank cars resulted from a series of accidents in the late 1960's. Regulations currently apply only to tank cars carrying flammable gases, ethylene oxide, and anhydrous ammonia. Additional research is being conducted on chlorine tank cars and on aluminum tank cars to determine if additional thermal and/or puncture protection are required for these cars.

   An ongoing analysis of the tank cars involved in accidents and the damage sustained is necessary to ensure that research is directed to areas where problems exist, i.e., head puncture or fire. With limited research funds, not all tank cars can be evaluated. Therefore, a review of the accident reports and statistics will identify if a specific type of tank car is involved in more accidents, if a specific type of tank car is experiencing an unusual damage rate in accidents, or if a specific type of tank car is causing accidents.

2. Current Status

   The Transportation Systems Center has conducted a review of the accident statistics for the years 1981-1984 that involve tank cars. The final report is being prepared.

3. Related Research

   Another project dealing with overall freight car accident statistical analysis is being conducted by TSC. Data concerning only tank car accident statistics has not been developed for the special analysis needed.

4. Objective

   To identify tank car types that may be experiencing a high rate of release of hazardous materials in an accident or that may be causing accidents.

5. Scope

   Review of accident reports, accident data bases, 1% waybill data and the UMLER register to identify tank cars involved in accidents, commodities carried, and releases of hazardous materials. Based on the review, develop sort routines to analyze the data by car type, commodity, mode of failure, etc.

6. Interfaces

The results of this project will be of interest to the Office of Safety Enforcement.

7. Potential Benefits

The results of this analysis will be presented in a final report ranking the number of similar accidents, accident causes, tank car types, hazardous materials, and quantity of hazardous materials involved. This information will be used to establish a priority for further tank car safety research and testing.

Hazardous Materials Car Accident Analysis

Cost: $60,000

Schedule: 3/86--4/87

Contractor: Transportation Systems Center

Y

Hazardous Materials Safety Research

1. Background

Hazardous materials transportation poses problems for shippers, railroads, and public safety personnel in the event of an accident. One of the main problems is determination of what hazardous materials are involved and if any hazardous materials have been released. Placards and waybills are normally used as the means to identify hazardous materials cars. If a fire is present, the placards may be burnt or obscurred by smoke. If the cars are piled up, it may be difficult to determine the exact position of a particular tank car even if the waybills are available. Some other more reliable means of identifying hazardous materials cars and their location is necessary.

Another area of concern in an accident is the identification of released hazardous materials. Numerous monitoring devices are available, however, most can only identify a limited number of commodities and are not readily portable. Some require a mobile van set up. The U.S. Coast Guard has been evaluating state-of-the-art devices since 1978. Since monitors capable of detecting a wide range of chemicals are not available, the Coast Guard initiated a program to develop a personal portable monitor for use by emergency response teams.

Considerable interest has been displayed regarding the mitigation of hazardous materials incidents, especially since the Livingston, Louisiana, derailment in 1982. At that time, responders discussed such topics as explosive venting, transfer of products, and other emergency measures. Captain William Poe, head of the Hazardous Substance Section, Louisiana State Police, identified a void in the area of technical expertise in emergency handling of hazardous cargo. The Canadian Transport Commission and the Association of American Railroads are also interested in developing improved emergency response measures.

Both the Transportation Research Board (TRB) and the National Transportation Safety Board (NTSB) have recommended that research be conducted to improve the handling of emergency response situations when they arise.

2. Current Status

Two Small Business Innovation Research (SBIR) Phase I efforts have recently been completed in the area of identification of hazardous materials. Both efforts were successful, however, only one Phase II effort could be funded due to available resources. A Phase II contract was awarded in October 1986 to Technology and Management Systems, Incorporated, to develop a tank car transponder system. This task receives support from both railroads and the AAR, as well as the Chemical Manufacturer's Association (CMA).

A cooperative, cost sharing agreement is ongoing with the Coast Guard to develop a monitoring device capable of detecting and identifying up to 100 hazardous commodities. FRA's share is $144,440 of the total task cost of $451,100. The first prototype devices, for 25 commodities, have been developed and will undergo field testing by the Coast Guard, FRA, FEMA, and Environment Canada. The FRA's testing will start around March 1987.

A task order has been initiated with the AAR, Transportation Test Center, to evaluate various emergency response techniques such as vent and burn and hot tapping.

3. Related Research

Previous research by FRA and the Coast Guard on monitoring devices relate to this project.

Work on automatic vehicle identification relates to the task to develop a tank car transponder system. The Federal Highway Administration is participating indirectly in a project being developed by several western states to monitor heavy trucks on the highways. This project will use a weigh-in-motion concept along with a roadside interrogator and automatic vehicle identification system. However, this project will not produce a system that is capable of long range identification as will be needed when identifying a tank car in a "stand-off" fire situation.

4. Objectives

a. To develop a remote tank car identification system for use in emergency response situations.

b. To develop a monitor capability for detecting and identifying a multiple number of commodities during an accident where hazardous materials have been released.

c. To develop technical expertise in emergency handling of hazardous materials and publish guidelines for use by emergency response personnel.

5. Scope

A part of this project will use the SBIR program to develop a remote tank car identification system. A transponder device is to be positioned on a tank car and contain information as to tank car number, car type, commodity name and number, shipper name, emergency response information, etc. A portable interrogator device will be used to query information from the transponder and to directionally locate the tank car. Testing of the system for environmental effects as well as shock and vibration effects will be conducted. Additional inservice testing will be required once feasibility has been determined.

The contract with the Coast Guard to develop a portable hazardous material monitor is composed of two tasks. The first task is to design and construct a prototype hazardous chemical monitor that can detect and identify up to 25 hazardous commodity vapors. The device is to be portable and to operate a minimum of 4 hours on batteries. The second task is to expand the monitor's capabilities for the detection and identification of 100 compounds via software and minor hardware changes. Testing of the FRA's prototype monitor will be conducted at the Transportation Test Center. Testing will include effectiveness in detecting and identifying the 25 candidate commodities, ease of operation, portability, serviceability, and compliance with specifications.

The task for investigating the safe release of hazardous materials will start with a workshop of experts in wreck cleanup to identify techniques that have been used, how they were implemented, the information available upon which decisions were made, and the outcome of the effort. After the workshop, committees will be set up to determine guidelines, procedures, and techniques to be used in given derailment situations. Recommended actions will be included in a handbook. Testing of some of the techniques for validation will be conducted after the guidelines have been developed.

6. Interfaces

The Association of American Railroads will be involved in this project. The Chemical Manufacturers Association, the Coast Guard, the Federal Emergency Management Agency, Environment Canada, and various emergency response groups will be involved in the various tasks. The Office of Safty Enforcement will be kept informed of progress on this project.

7. Potential Benefits

The expected results from this project are improvements in identification and detection of hazardous materials and tank cars when they are involved in an accident. It is also expected that a handbook will be prepared for use in aiding emergency response personnel on how to safely release hazardous materials from derailed tank cars.

Hazardous Materials Safety Research

SBIR Phase II Contract:

Cost: $297,176
Schedule: 10/86--10/88
Contractor: Technology and Management Systems, Inc.

Hazardous Chemical Monitor:

Cost: $144,440
Schedule: 5/85--5/87
Contractor: U.S. Coast Guard/Argonne National Laboratory

Testing Support:

Cost $250,000
Schedule: Estimated 1/87--2/89
Contractor: Transportation Test Center

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Tank Car Thermal Protection

1. Background

On October 19, 1977, a final rule was issued requiring all existing and newly built specification 112 and 114 tank cars used to transport flammable gases such as propane, vinyl chloride, and butane to have thermal protection among other things. On January 26, 1981, a final rule was issued requiring newly built specification 105 tank cars, carrying a flammable gas or ethylene oxide to be equipped with high temperature thermal insulation.

On January 27, 1984, a final rule was published requiring specification 105 tank cars, built before September 1, 1981, with a capacity exceeding 18,500 gallons and carrying a flammable gas or ethylene oxide to be equipped with high temperature thermal insulation. Specification 111 tank cars were also required to have high temperature thermal insulation if they carried a flammable gas or ethylene oxide and if the capacity exceeded 18,500 gallons. In making the announcement of the new rules, Secretary Dole said the Department would continue to review its safety rules governing rail tank cars used for other hazardous materials.

A meeting was held in February 1983 to discuss research needs concerning chlorine tank car safety. Representatives of FRA, Canadian Transport Commission, the Chlorine Institute, the Association of American Railroads, several tank car builders and several chemical companies attended. Concern about the maximum acceptable internal temperature to be experienced in a chlorine tank car was discussed. At a temperature of 483^{o}F a corrosive reaction occurs between chlorine vapor and steel. The thermal insulation system for specification 105J tank cars in which chlorine is carried is designed to keep the back plate (inside shell) at a maximum of either 800^{o}F or 550^{o}F depending on the sizing of the pressure relief valves. Thus, the concern over this apparent disparity between corrosive reaction temperature and present design practice. As a result a cooperative research program was developed by FRA and the RPI/AAR Tank Car Safety Research and Test Project Committee to test alternate insulation material for use in chlorine tank cars. Simulated pool and torch fire tests were recently conducted on three candidate insulation materials. Each of the new materials were found to keep the back plate temperature below 483^{o}F as desired.

2. Current Status

Simulated pool and torch fire tests have been completed and the final report published on the testing of alternate insulation systems for chlorine tank cars.

The simulated pool and torch fire test sequence for steel tank car plates was applied to aluminum tank car plates. Testing of bare plates and several different insulations on aluminum plates have been completed. The final report is being written and a draft report should be delivered by the end of December 1986.

3. Related Research

The previous research conducted in the early 1970's for specification 112/114 tank cars had a bearing on this project. Reports prepared on the earlier testing were reviewed for applicable information prior to initiating this project.

A review of the accident history involving aluminum tank cars conducted by the RPI/AAR tank car committee indicated that out of 574 aluminum cars that were damaged in accidents, 21 were exposed to fire. There were three cars that ruptured due to fire. The majority of hazardous materials involved were corrosive materials, followed by flammable liquids.

4. Objective

To reduce the potential for injuries, deaths, and property damage that can result from inadvertant release of hazardous materials as a result of a rail fire accident, by identifying alternate improved insulation materials/systems for use in tank cars.

5. Scope

Simulated pool and torch fire tests were conducted on the proposed alternate insulation material/systems for the chlorine tank car. These tests were performed in accordance with 49 CFR 179.105-4.

A typical test specimen is a four-foot square steel plate with a thermal insulation material applied to one side. The back of this steel plate is instrumented with nine thermocouples. The remaining exposed outer surface of the insulation material to be tested is covered with an 11-gauge steel sheet, in effect forming a sandwich. A typical test series consists of two torch and three pool fire tests.

The same series of tests required for steel tank cars were conducted on bare aluminum plates and aluminum plates with the current 4 inches of glass fiber insulation and an 11-gauge steel outer jacket. An alternate insulation of 1/2 inch of ceramic fiber and 1 inch of mineral fiber was also tested. In this case, the back plate was 1/2 inch, 5454, H112 aluminum plate.

6. Interfaces

The RPI/AAR Tank Car Safety Research and Test Project Committee has been actively participating in this entire project. The Chlorine Institute has also been involved in the task studying chlorine tank car safety.

Results of the tests conducted to date have been sent to the Office of Safety Enforcement.

7. Potential Benefits

The Chlorine Institute has petitioned the DOT to include the alternative insulation systems tested under this project in the List of Exempted Thermal Protection Systems published periodically in the Federal Register. Use of these new insulation systems will reduce the potential for hazardous materials leaks arising from corrosion caused when chlorine cars are explosed to a fire accident.

For aluminum tank cars, the new alternate insulation systems may improve tank car survivability in an accident. Results from this project may be used for an Advanced Notice of Proposed Rulemaking to provide for increased safety coverage of tank cars constructed of aluminum materials that have different properties than those found in the more usual steel tank cars.

Tank Car Thermal Protection

Chlorine Tank Car

Cost: $79,962

Schedule: 9/84-2/86

Contractor: Ballistic Research Laboratory

Aluminum Tank Car

Cost: $86,000

Schedule: 9/85-3/87

Contractor: Association of American Railroads

Tank Car Structural Integrity

1. Background

In the late 1960's, a series of tank car accidents resulted in substantial injuries, deaths, and property damage. As a result, testing was conducted on tank cars to develop measures to reduce the frequency of accidents involving tank car rupture and puncture. The resulting rulemaking, requiring insulation, head shields and shelf couplers on certain tank cars, has greatly reduced the severity of tank car accidents. Even with these improvements, tank cars can still be damaged in an accident. Cracks in the shell are not always visible because of the jacketed insulation.

Failure of a pressure vessel, such as a tank car, occurs when the wall stress reaches a critical value. Internal pressure can cause newly formed and existing flaws (cracks) to propagate. Metallurgical analysis of tank car materials has been conducted by various Government and industry sponsored groups interested in this problem of residual strength following an accident.

Recently, during retrofit, a number of tank cars have shown evidence of fatigue cracking in the shell, at the stub sill interface, at the jacket bracket, and at the pad stiffeners.

The National Transportation Safety Board has recommended that FRA analyze the causes of tank car mechanical failures and incorporate the findings in requirements for new car construction (Report No. HZM 80-1).

In a previous project, it was verified that nondestructive evaluation (NDE) with ultrasonics could be used to detect and describe flaws in a sample of 10 plates taken from tank car type steels that had been impacted and dented. In these tests the flaw pattern characteristics were found to be well correlated with the characteristics of the dent. The correlation of flaw pattern to dent characteristics could provide a relatively simple procedure for evaluating the safety condition of a damaged tank car. This procedure shows promise for use by emergency response and wreck clearing personnel in determining if a tank car is structurally unstable or sound enough for safe removal from an accident scene.

2. Current Status

Several separate efforts are ongoing for this project. One contract with the National Bureau of Standards, involves metallurgical analysis of various tank car materials and the determination of critical flaw size.

Another effort is continuing to investigate the use of nondestructive evaluation (NDE) techniques to identify flaws in uninsulated and especially in insulated tank cars. This work is being done by EG&G Idaho. To date, no reliable technique has been identified for use on insulated tank cars. A Phase 1, Small Business Innovative Research (SBIR) contract has been awarded to investigate the use of laser shearography for the location of defects in structural materials.

The problem with cracks occurring in stub sill tank cars has recently been identified. A task force of experts in metallurgy, fracture mechanics, and structural mechanics has been assembled to look at problems with the installation of non-conforming anti-shift brackets on 9,000 tank cars and with the installation of stiffener pads on certain DOT specification 111A100W tank cars.

A task has also been initiated to investigate the problem of cracks occurring in stub sill tank cars. This work by Battelle Columbus will look at the basic design of stub sill cars.

3. Related Research

The FRA has been investigating tank car structural integrity since the early 1970's. Previous efforts focused on puncture and thermal insulation. A review of the literature did not show that work was being conducted in the area of tank car critical flaw size.

New techniques for nondestructive evaluation (NDE) are continually being developed. The application of these techniques to the problem of tank car flaws has not been thoroughly investigated, especially for insulated tank cars. New techniques will be reviewed for use in detecting flaws in both insulated and uninsulated tank cars.

4. Objective

To reduce deaths, injuries, and property damage resulting from the rupture of damaged tank cars either subsequent to involvement in an accident or as a result of incipient failure through prolonged use and improper design.

5. Scope

The National Bureau of Standards (NBS) has been conducting for FRA detailed metallurgical investigations of deformed, dented, or otherwise stressed steels from tank cars involved in derailments. The NBS is drawing on this experience to study the issue of critical flaw size that may create unstable fractures in railroad tank cars. For example, fracture toughness tests have been performed on aluminum materials as this material is used in some tank car construction. This work includes determining the material's mechanical properties as a function of its loading rate and temperature. The NBS is also to investigate the potential use of thermographic techniques for detecting problem areas in insulated tank cars.

Work conducted at the Idaho National Engineering Laboratory by EG&G Idaho, for FRA concluded that ultrasonics could be used to detect and describe flaws in tank car steel. It was shown that flaw pattern characteristics correlate well with the characteristics of the visible dent in a steel plate sample. This work has been expanded to include an analysis of the stress required to cause an existing flaw to become critical. The amount of stress that can be safely applied to a damaged tank car, if it is to be moved or the lading unloaded, is to be investigated.

In the SBIR, Phase I task, the contractor will compare the shearography NDE technique with other NDE techniques such as ultrasonics, dye penetrant, x-rays, etc., to identify critical flaws. Practical and optimal approaches for implementing shearography will be developed.

A task force established at the request of FRA by the Transportation Systems Center is looking at the problems that have been identified with GATX stub sill tank cars and the practice of welding the reinforcing bar to the tank shell. The various industry welding practices and procedures used are to be investigated to determine if they are contributing to or causing the problem.

A small task has been initiated to conduct an overall engineering analysis of the design of stub sill tank cars. This work is to include a fatigue analysis and finite element modeling to determine if problems exist with the basic stub sill design.

6. Interfaces

The portion of this project dealing with critical flaw size and non-destructive inspection techniques involves the RPI/AAR Tank Car Safety Research and Test Project Committee and will also be of interest to FRA Hazardous Materials Specialists who will be informed of developments.

The tasks studying the stub sill tank car problem were initiated at the request of the Office of Safety Enforcement. This work will be of interest to that Office, the RPI/AAR Committee, as well as the individual tank car manufacturers and operating carriers.

7. Potential Benefits

If a confirmed and reliable correlation of flaw pattern to dent characteristics can be obtained, nondestructive evaluation techniques can be used, in the field, on uninsulated, damaged tank cars to assess their structural integrity. This development could help to reduce the potential hazard of having a tank car release hazardous materials during an emergency response and wreck cleanup. Guidelines for the use of this technique by emergency response personnel will also be developed.

The development of NDE techniques that can be used on insulated tank cars would be a major breakthrough in assessing the structural integrity of these cars.

Improvements in the structural integrity of stub sill tank cars that eliminate the present problems will significantly reduce the number of occurrences of leaks of hazardous materials coming from these cars. Implementation of the findings may be executed through the Association of American Railroads Manual of Standards and Recommended Practices for Tank Cars or through rulemaking.

Tank Car Structural Integrity

Critical Flaws/Metallurgical Analysis

Cost: $470,000
Schedule: 7/84--4/87
Contractor: National Bureau of Standards

Non-destructive Evaluation Techniques

Cost: $500,000
Schedule: 7/84--12/86
Contractor: Idaho National Engineering Laboratory, EG&G Idaho

Cost: $49,534
Schedule: 10/86--4/87
Contractor: Physical Optics Corporation
(Phase I, Small Business Innovative Research)

Stub Sill Tank Cars

Cost: $145,000
Schedule: Estimated 8/85--8/87
Contractor: Transportation Systems Center (Task Force)

Cost: Estimated $99,500
Schedule: 1/87--10/87
Contractor: Battelle Columbus

Testing Support

Cost: Estimated $400,000
Schedule: Estimated 1/87--1/90
Contractor: Transportation Test Center

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gallons. NTSB recommended that the FRA conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture. A review of the accident history for aluminum tank cars shows that for the last 20 years, a total of 20 aluminum tank cars have eperienced damage to the head.

As part of a public hearing on train yard accidents, a discussion was held on the puncture resistance of tank cars at low temperatures. The conclusion drawn was to expand the puncture resistance project to include the effects of cold weather on all tank cars.

2. Current Status

Puncture testing for the chlorine tank cars is being conducted at the Transportation Test Center in Pueblo, Colorado. In this testing, the DOT 105 tank car is being compared to the DOT 112 tank car with a head shield. First, the 1/5 scale model head tests were conducted using a drop tower test fixture. In this test, the heads were mounted on a small pressure vessel to simulate 50, 100, and 200 psi pressure conditions. Various head thicknesses, jacket thicknesses, and insulation thicknesses were tested. The scale model tests have been completed.

Full scale tests are being conducted to determine the puncture threshold using a tank head mounted to a pressure vessel on a rail car. An old locomotive has been modified for use as the ram car. At 13 miles per hour, the full-scale chlorine tank car scale head was dented 13.5 inches inward. Puncture occurred at 15 and 17 mph. Testing of full-scale tank car heads for the 112/114 tank car are scheduled.

The final test series is puncture tests with actual chlorine and propane tank cars. The first test with a chlorine car resulted in puncture at 15 mph.

Tests for the aluminum tank cars and for the effects of cold temperatures on puncture resistance will be conducted after the current chlorine tank car test program is completed.

A separate effort has been completed to test 1/10 and 1/5 scale model 5052 aluminum tank car heads for puncture resistance using a variety of mitigating materials and/or head shields. Based only on these scale model tests, it was concluded that a high alloy steel head shield is a good protective device. However, during the impact duration, it bends and deforms to a shape with relatively sharp edges which increases the chances to develop a puncture. A combination of an aluminum honeycomb material and thin sheets of high alloy steel proved effective and the problem with sharp edges did not occur. Since no full scale tests were conducted, these results cannot be extrapolated to full size tank car heads. Full scale tests may be conducted, depending on the results of other aluminum car puncture testing.

3. Related Research

Previous research on the DOT Specification 112/114 tank cars carrying liquified flammable gas, anhydrous ammonia and ethylene oxide has a bearing on this project. This research lead to rulemaking in 1977.

The RPI/AAR Tank Car Safety Research and Test Project has published several reports on tank car heads and switch yard impacts as well as accident histories of various classes of tank cars. These reports, along with reports prepared by the Transportation Systems Center and IIT Research Institute were reviewed. Meetings have been held with members of the RPI/AAR Tank Car Project to discuss past tests and the proposed test program. The industry conducted impact tests in June 1983 on alternate insulation systems for chlorine cars to determine if the proposed insulation provided the same amount of puncture protection as the current 4 inches of foam insulation. These test results were reviewed.

4. Objective

To assess the puncture resistance of those classes of tank cars that carry chlorine and aluminum tank cars as well as the effects of cold weather conditions on tank car puncture resistance.

5. Scope

Testing for the chlorine tank cars includes 1/5 scale model, full scale, and actual tank car puncture tests of specification 105 tank cars and, for comparison, specification 112/114 LPG cars with head shields. A final report will be prepared describing the test results.

Parameters that affect puncture resistance will be evaluated. These include jacket thickness, insulation material and thickness, internal pressure, head shield thickness and impact location. In each test series, the dependent parameter will be a measure of the extent of dent and/or puncture of the tank head after impact. For the scale model tests, a coupler shaped weight will be used. In the full scale tests and actual tank car tests, a coupler will be attached to the ram car.

This same approach will be used for the tests on aluminum tank car heads. For the cold temperature impact tests, only 1/5 scale model tests are planned.

6. Interfaces

This project has involved the participation of the RPI/AAR Tank Car Safety Research and Test Committee, the Chlorine Institute, tank car manufacturers and chemical companies that ship hazardous materials. The Office of Enforcement has been informed of this project.

The project on Tank Car Structural Integrity is related to this project because of the work in critical flaw sizes in tank cars and the use of nondestructive evaluation techniques to detect flaws.

7. Potential Benefits

The results of this project will indicate if there is a need to add head shields to tank cars carrying chlorine and to aluminum tank cars to provide the same protection against head punctures as provided for DOT Specification 112/114 tank cars with head shields. An Advanced Notice of Proposed Rulemaking may result from this project. A cost benefit study would be required if a rulemaking is proposed. Also, the previous policy of excluding tank cars less than 18,500 gallon capacity will require review.

Based on meetings with industry representatives, there is concern with the safety of chlorine tank cars and there has been cooperative assistance in formulating this project.

Tank Car Puncture Resistance

Chlorine Car Testing

Cost: $1,127,623

Schedule: 9/84--6/87

Contractor: Association of American Railroads

Aluminum Car Testing

Cost: Estimated $898,800

Schedule: 1/87--1/89

Contractor: Association of American Railroads

Cold Temperature Car Testing

Cost: Estimated $209,650

Schedule: 1/87--1/89

Contractor: Association of American Railroads

Technical Support

Cost: $250,000

Schedule: 1/84--1/89

Contractor: Transportation Systems Center

Tank Car Frangible Disks

1. Background

Over the past several years, many undesired releases of hazardous materials, occasionally resulting in injuries, have occurred due to the failure of frangible or rupture disks under conditions other than when failure is intended. These disks are used in nonpressure cars in place of the more common pressure relief valve found in pressurized cars. The disks are commonly used in cars designed to carry acids or other corrosive materials and are intended to fail only when the internal pressure of the tank reaches the rated burst pressure; typically this is between 60 and 100 psi. They may be made of any material, however, lead is often chosen for economic reasons.

The history of disk failures suggests that the disks may not be adequately designed for their normal operating environment. The actual failure mode(s) are not known, however, the disks are required to fail only at the designed burst pressure. Whether the disks experience an actual overpressure or are simply corroded and/or thinned due to creep or metal flow must be determined from the study of actual premature failed disks. The adequacy of qualification requirements for frangible disks should therefore be reviewed.

Several studies have been conducted in the past by the industry, resulting in numerous recommendations relating to frangible disks. One change that has been implemented was to increase the required outage to 2 percent from 1 percent in domeless acid type cars. Another change that has been implemented was to increase the vent pressure to 100 percent (from 75 percent) of the tank test pressure.

The Association of American Railroads Tank Car Committte conducted tests of frangible disks to develop improvements in the requirements contained in Appendix A of the Specification for Tank Cars. The AAR published the performance criteria for frangible disks on tank cars in May 1984, however, the AAR does not approve designs or materials for frangible disks. Lead disks are generally unable to pass the qualification testing and were exempted by the AAR from these requirements.

This project was initiated at the request of the Office of Safety Enforcement because of the number of reports of premature disk failure received from the field.

2. Current Status

A study has been initiated to identify the failure mechanism of the frangible disk. The AAR Project Director, Tank Car Research, has provided background reports on the previous testing conducted by the AAR.

3. Related Research

The research and testing conducted under the sponsorship of the AAR Tank Car Committee will be useful in determining the additional testing to be undertaken in this study.

A review of the accident reports received indicates there is still a problem with injuries to railroad employees resulting from inadvertent spills due to failed frangible disks.

4. Objective

To develop an understanding of the failure mechanism of frangible disks and design recommended qualification testing procedures to insure adequacy of initial disk design. Also, to reduce railroad employee injuries due to spills resulting from failed disks.

5. Scope

This study will evaluate the various failure modes reported to have occurred with frangible disks including corrosion and pressure surge. A test program is to be developed to test several disk designs and also test the disks under cyclical pressure and in a corrosive environment.

6. Interfaces

This project is of interest to the Office of Safety Enforcement. Contact will be made with the AAR Tank Car Committee early in the study in order to obtain its support, cooperation, and previous experience.

7. Potential Benefits

Based upon the study findings, a recommended testing procedure for frangible disk qualification that includes corrosion testing will be offered for voluntary use in the AAR standards. If the investigation indicates that substantial problems exist with the lead disks, a proposed rulemaking may be required.

Tank Car Frangible Disks

Technical Support

Cost: $100,000
Schedule: 10/85--10/87
Contractor: Transportation Systems Center

Testing

Cost: Estimated $100,000
Schedule: To be determined
Contractor: Association of American Railroads

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Intermodal Hazardous Materials Transportation

1. Background

The Office of Safety, FRA, has been receiving requests for waivers to transport hazardous materials in trailer-on-flatcar (TOFC) and container-on-flatcar (COFC) configurations. The shipment of regulated commodities by TOFC in interchange service is prohibited by AAR regulations, but individual railroads may choose to provide this service if FRA approval is obtained. Recently, both the number and scope of the requests for approval of tank TOFC/COFC service have been expanding. The most important concern from a safety standpoint is what happens to the MC 307/312 cargo tanks (highway trailer) and the IM portable tanks (container) if there is a derailment or collision involving the flatcars carrying these tank containers. A major question with MC and IM tanks is whether or not they will become disengaged from the flat car during a derailment and, if they do, what happens to them. There are no existing standards for approving the waiver requests.

Tank cars used to transport hazardous materials have thicker shells than either the MC 307/312 or the IM101 or 102 tanks. Also, some tank cars are required to have thermal protection systems and/or head shield, depending on the hazardous material being transported. Because of the size and weight of the cargo tanks and portable tanks, it is not cost effective to install protective devices, such as head shields. Some cargo tanks and portable tanks have insulation covered by a jacket.

An Advanced Notice of Proposed Rulemaking, Docket HM-197, was released in April 1985. Multimodal freight containers are currently used to transport both hazardous and non-hazardous materials by rail. In the Notice it was stated that a more complete safety criteria for TOFC and COFC service of tanks transporting hazardous material needed to be established. A public hearing was held on June 11, 1985.

The Office of Safety requested that the Office of Research and Development initiate a program to determine the safety issues involved in the shipment of hazardous materials in tanks in TOFC and COFC service.

While waivers have been granted for shipment by rail of hazardous materials in IM portable tanks in COFC service, the relative safety of these shipments has never been fully investigated. The waivers granted have been only for COFC use of IM portable tanks and only if on a flatcar equipped with end-of-car cushioning.

2. Current Status

In order to address some of the safety issues, a test program was initiated at the Transportation Test Center. Specific areas addressed in the test program are:

Modal response of the flat car and tank trailer or container;
Lift/drop tests on the tank trailer;
Impact testing of the loaded flatcar;
Curve negotiation;
Track tests; and
Simulated derailment tests.

The equipment included 6,900-gallon capacity highway tank trailers (MC) and several different 20-foot intermodal (IM) tank containers. Some IM's were loaded onto a 20-foot highway trailer chassis and tested in the TOFC configuration. The flatcar used was a general purpose 89-foot Trailer Train car, equipped with conventional end-of-car cushioning devices. Water was used as the lading.

Tests were conducted using the Vibration Test Unit (VTU) to determine resonant frequencies and responses to simulated track conditions. The critical speed for the roll mode was 13-16 miles per hour for the car body, 29-32 mph for the trailer, and 24-27 mph for the 20-foot chassis.

The track tests and curving tests produced no unusual results. The hunting threshold of 65-70 mph was the same as the flatcar with non-liquid lading.

Impact testing at 4, 6, 8, and 10 mph into loaded buffer cars was conducted to simulate the forces encountered in rail yards. There was no indication of any damage to the structural integrity of the tank trailers or to the tank containers.

Six simulated derailment tests have been conducted with a variety of MC tank trailers and IM tank container configurations. In all of the tests, the trailers and containers have disengaged from the flat cars during derailment. The trailers and containers sustained damage but no leaks occurred except from the dome area and vents. Test speeds were 23.4, 19.0, 42.0, 40.0, 64.5, and 60.0 mph The tank trailer was used in three of the tests and several of the tank containers were in multiple tests.

An accordian derailment was conducted on November 19, 1986. The test consist included a lead buffer car, a flatcar with an MC312 and an IM102 on chassis, a flatcar with an IM101 on a chassis, and an IM102 in COFC, a flatcar with an IM101 in COFC and an MC312, and a trailing buffer car. The MC312's had holes in them but no catastrophic failures occurred. A final test report will be prepared.

An analysis of the use of portable tanks on double stack flatcars, with end-of-car cushioning, has been planned.

3. Related Research

Research on tank car protection has a bearing on this project. The tank car safety regulations were developed in response to serious railroad accidents. There is no history of problems resulting from the shipment of hazardous materials in TOFC or COFC service, mainly because it has not been allowed for TOFC. Most of the exemptions granted for IM portable tanks have been for less dangerous commodities and the total volume of such shipments remains low.

4. Objective

To determine the safety issues associated with the transportation of hazardous materials in MC cargo tanks and IM portable tanks in trailer-on-flatcar and container-on-flatcar service.

5. Scope

Since no data existed on the shipment of hazardous materials in tanks in TOFC or COFC service, a test plan was developed to identify potential safety concerns. A review of current AAR regulations was also conducted.

A test program was developed to test the flatcar and various TOFC/COFC configurations. The first test series was conducted on the Vibration Test Unit to determine modal responses to a variety of track geometries and to obtain information on resonant frequencies of the flatcar, MC cargo tanks, and IM portable tanks. Lift/drop tests in accordance with AAR M-931, Section 6.4, were conducted on the MC 307 cargo tanks.

Impact tests were conducted following the guidelines of AAR specifications M-928 and M-952 at speeds of 4, 6, 8, and 10 mph in both directions. Additional impact tests were performed in accordance with the requirements of AAR.600-15d where a loaded hopper car impacts a freestanding flat car, and the two cars couple into backup cars.

Track tests were conducted to investigate the conditions of curve negotiation and truck hunting, neither of which can be simulated on the VTU. The effects of liquid slosh are of interest in curve entry. To evaluate this condition, tests were performed at, below, and above balance speeds, with and without shimmed track perturbations.

A series of simulated derailment tests have been conducted. In all, six broken rail derailments were performed at speeds of 20, 40, and 60 mph, two at each speed. In these tests, a test flat car was coupled to three buffer cars and the cars were pulled up to the desired speed by a locomotive. Once the consist was at speed, the locomotive uncoupled from the consist and accelerated away from the test area. A switch was set up to simulate a broken rail occuring as the consist passed over it.

In the accordian derailment test, three flat cars loaded with MC312's, IM101's, and IM102's (one of each on a chassis) were tested. The switch arrangement was used to guide some trucks into a turnout, then thrown back so other trucks would continue on the tangent track.

Based on the test data analysis, additional model simulations and/or testing may be required.

6. Interfaces

The Office of Safety Enforcement, the Office of Chief Counsel, and the Office of Hazardous Materials Transportation, RSPA, have been involved in this project. The Bureau of Motor Carrier Safety, FHWA, has been informed of the project and some of the video tapes of the tests involving cargo tanks have been viewed by its personnel.

The Canadian Transport Commission (CTC) expressed interest in this program. A representative from CTC has observed several of the derailment tests. Video tapes and still photographs of the tests have been sent to CTC.

The test video tapes have also been shown to various AAR committees, Track Train Dynamics Committee, technical groups, and emergency response groups.

7. Potential Benefits

Data for use in rulemaking to provide for safe transportation of hazardous materials in intermodal service. This data may lead to performance specifications for MC cargo tanks and IM portable tanks used in TOFC and COFC service.

Intermodal Hazardous Materials Transportation

Testing

Cost: $1,803,713
Schedule: 9/84--3/87
Contractor: Association of American Railroads

Follow on testing

Cost: Estimated $285,000
Schedule: To be determined
Contractor: Association of American Railroads

Technical Support

Cost: $830,300
Schedule: 6/84--12/87
Contractor: The MITRE Corporation

Cost: $100,000
Schedule: To be determined
Contractor: To be determined

Spent Nuclear Fuel
Cask Accident Analysis

1. Background

Shipment of spent nuclear fuel in railroad casks is expected to increase substantially in the 1990's. At that time, repositories and/or interim storage facilities will be operational. The Department of Energy (DOE), under the Nuclear Waste Policy Act of 1982, has the responsibility for developing the repositories as well as developing the transportation capability necessary to support the repository system. The DOE will take title to the spent fuel at the reactor and use Nuclear Regulatory Commission (NRC) certified casks to transport the spent fuel to the repository.

The FRA has been concerned for a number of years with the survivability of spent fuel casks should they be involved in a rail accident, especially one where fire is involved. One option to reduce the exposure of the cask to a rail fire accident is to require special train handling. In 1975, the AAR recommended that radioactive materials be shipped in special trains with speed restrictions and other operational requirements. After extensive hearings, the Interstate Commerce Commission (ICC) and the courts determined that there was insufficient evidence that the benefits (if any) of the proposed special train service justified the additional cost of that service.

The FRA and other government agencies have sponsored research to evaluate the behavior of spent nuclear fuel casks in simulated railroad accidents. In controlled crash testing of the casks, there has been no release of radioactive materials into the environment. The issue of cask survivability in a rail fire environment has not been resolved.

The FRA has identified, confirmed, and established in regulatory standards (49 CFR Part 179-105.4) an accident environment which is unique to the railroad mode of transport. Technical specifications for tests to verify the required level of thermal protection have been applied to tank cars carrying flammable gases and ethylene oxide. The fire environment is based on two accident scenarios. One is a fully engulfing pool fire at 1600°F for 100 minutes. The other is a torch fire at 2200°F for 30 minutes.

The NRC uses the International Atomic Energy Agency (IAEA) fire environment for cask certification which requires exposure of the cask for not less than 30 minutes to a heat flux, not less than that of a radiation environment of 800°C (1475°F) with an emissivity coefficient of at least 0.9 and an absorbtivity of at least 0.8. Cask compliance can be demonstrated by test or calculation using thermal computer codes. The DOE and the FRA have questioned the use of these thermal codes since they have not been benchmarked for actual fire tests nor have fully engulfing pool fires been conducted to validate these codes.

In 1978, the FRA initiated a program to study the fire environment of a fully engulfing pool fire. An obsolete cask was modified to include impact limiters and a neutron water jacket. Three calorimeter tests were conducted using a cask size calorimeter to determine pool fire repeatability. Because of the effect of varying wind speed and direction, no determination was possible on repeatability. The actual cask was not tested. Instead the boundary conditions from the calorimeter tests were used as the basis for one of the thermal codes developed to predict if the lead shield would melt during a 30 minute test. The preliminary analysis indicates some lead melt would occur in the 30 minute test. No calculations were made for a 100 minute test.

The draft report for the calorimeter tests states that the thermal input from the engulfing open pool fires exceeded that specified in 10 CFR 71, the NRC regulation. Also, the internal temperatures of the calorimeters routinely exceeded 1,475^{o}F (the boundary temperature specified in 10 CFR 71).

Meetings have been held with both DOE and NRC in an attempt to resolve the issue of the rail thermal accident environment. At the last meeting on September 23, 1986, the NRC requested FRA to evaluate the differences between the FRA requirements for tank cars (established to prevent violent explosion of a full tank car) and the NRC fire accident and be prepared to explain any differences, if they exist.

2. Current Status

A cooperative program has been established with DOE to benchmark the thermal codes and to compare data between an 800^{o}C 30 minute radiation exposure and an 870^{o}C 100 minute radiation exposure. The DOE has contracted with Sandia National Laboratory to conduct an extensive analysis of the thermal codes used to demonstrate compliance with the NRC requirements. The FRA has added to this effort to include an analysis of a typical rail fire environment of 100 minutes at 870^{o}C. The DOE agreed to fund $50,000 of this $250,000 added effort. The analysis work has been initiated and a test plan has been developed for the thermal code benchmarking.

Another task is being initiated with the Transportation Systems Center (TSC) to review the previous work on cask fire response and to conduct a risk assessment of the two thermal fire environments.

3. Related Research

Numerous reports on the transportation of spent nuclear fuel have been reviewed to determine if full scale or actual testing of a cask in a pool fire had been conducted. Only one test (Yankee Rowe cask) was ever conducted and there was evidence of lead melt after 100 minutes. No work was done to benchmark the thermal codes used to show compliance with the NRC regulations.

The NRC has been conducting a study of the response of casks to severe highway and railroad accident conditions. To date, no report has been issued on this effort. When the report is released it will be used in the risk assessment task.

Another effort being completed is an analysis of the IF-300 cask and its neutron shielding during a pool fire.

The previous work by FRA on defining the rail accident thermal environment is relevant. The FRA also conducted testing on an obsolete cask using the simulated torch test facility.

4. Objective

To benchmark the thermal codes used for certification of spent nuclear fuel casks, and to provide a comparison between the (NRC) thermal radiation environment and the FRA engulfing pool fire environment.

5. Scope

The thermal codes analysis will be run with a set of conditions and the results will be compared to actual test results. Once the thermal codes are validated and benchmarked, the analysis can be completed to compare the thermal radiation environment (800°C for 30 minutes) with the engulfing pool fire environment (875°C for 100 minutes). Based on previous analyses from other FRA sponsored work, the difference in temperature is not as significant as the duration of the fire. This theory will be part of the analysis.

A review of the FRA fire environment will be performed to determine the relationship of the simulated pool and torch fire tests for tank cars with the NRC thermal environment for spent nuclear fuel casks. Based on this review and analysis, a risk assessment will be conducted to identify the similarities and differences between the two accident environments.

6. Interfaces

Meetings have been held with the DOE and the NRC to discuss the various programs involving spent nuclear fuel casks. The Office of Hazardous Materials Transportation, RSPA, and the Office of Safety Enforcement have been involved in some of these meetings. Several meetings have been held with the AAR.

7. Potential Benefits

A better understanding of the FRA and NRC thermal accident environments will lead to a decision, if needed, should there be any significant differences that would require a change in DOT regulations. The NRC is very sensitive to the work FRA is doing and has challenged FRA to defend its position if more stringent thermal standards than the NRC requires are recommended. This controversy has been going on since the late 1970's. One potential solution would be a change in operating rules for trains containing spent nuclear fuel casks.

Reports will be prepared for the current work and copies will be sent to DOE and NRC. Based on the findings, additional meetings may be necessary to resolve any new issues that are identified.

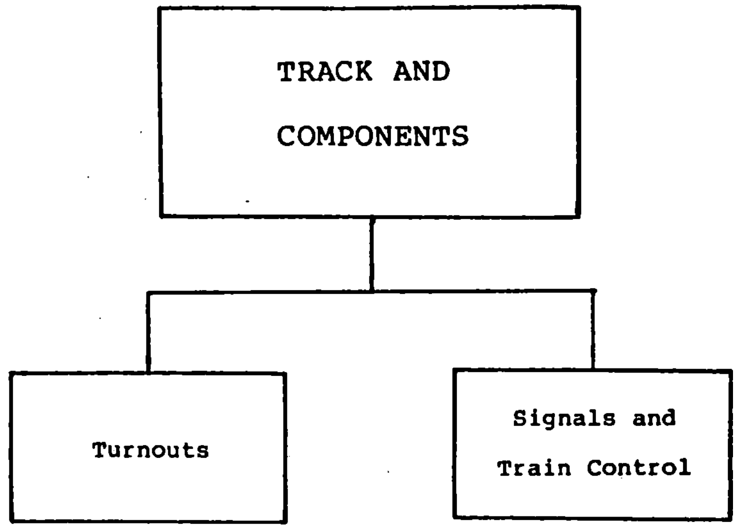
Spent Nuclear Fuel
Cask Accident Analysis

Cost: $265,000
Schedule: 12/86--9/87
Contractor: Transportation Systems Center

Cost: $200,000
Schedule: 9/86--12/87
Contractor: Department of Energy

Additional work in FY 88

Cost: $300,000 estimated
Schedule: To be determined
Contractor: To be determined


TRACK AND COMPONENTS
Turnouts
Signals and Train Control

F1

Turnouts

1. Background

In 1985, 376 of 1,280 track caused accidents were attributed to "frogs, switches, and track appliances." This represents nearly 30 percent of all track-related accidents (up from 20 percent ten years ago).

Turnouts, in addition to being a source of accidents for a variety of reasons, are a source of considerable maintenance of way expense for the railroads. To a large degree, derailments at turnouts are the result of the difficult task of maintaining a large and complex mechanism. As a result, the railroads are investigating the use of a variety of new turnout designs to alleviate the large amount of maintenance required. New innovations include, movable wing rail or movable point frogs, concrete ties, and special fastening systems. A variety of other components are being modified to accommodate heavier traffic at higher speeds. These changes include larger flared guard rails, special alloy rails for switch points, and higher speed (#30 for example) turnouts.

2. Current Status

This work is a new initiative. The FRA has not, with the exception of a few basic experiments at Facility for Accelerated Service Testing - High Tonnage Loop (FAST-HTL), done any research on turnouts. This effort is currently in the planning stages. The AAR is planning an effort to investigate vehicle performance through turnouts and has indicated a willingness to discuss a cooperative program. The industry has offered to donate two turnouts for FAST-HTL if they are needed for testing. This offer is very soft, however, and may not reflect the needs of the FRA research project.

3. Related Research

Much work has been done in Europe by the Office for Research and Experiments (ORE), the central research institution of the European railroads, and British Rail. There will be a thorough review of all relevant research prior to any work being done.

4. Objectives

Testing and evaluation of the performance of new and innovative turnouts (particularly the turnout components) on Amtrak Northeast Corridor (NEC) and on the FAST-HTL loop.

5. Scope

This project will probably include testing and evaluation of two turnouts on the NEC and testing and evaluation of several turnouts on the FAST-HTL loop during the 125-ton car test.

There are several safety-related component performance evaluations that will be made. The new fastening systems' capability to restrain the stock rail and frog wing rails will be evaluated. The structural support for the long switch points used on high speed turnouts will be evaluated. And the capability of different frog designs to reduce large lateral forces in the turnout will be evaluated.

6. Interfaces

The principal external points of contact are:

- Mr. A. J. Reinschmidt
  Director, Track Research
  Association of American Railroads
  3140 South Federal Street
  Chicago, Illinois 60616

- Gene Ellis
  Chief Engineer
  Amtrak
  1617 John F. Kennedy Boulevard
  Philadelphia, Pennsylvania 19103

The principal Office of Safety Enforcement contact is:

Mr. E. R. English
Chief, Maintenance Programs Division, RRS-13
Office of Safety
Federal Railroad Administration
400 Seventh Street, SW
Washington, D.C. 20590

7. Potential Benefits

The initial study on Amtrak will be used to verify that the installed turnouts are performing to the design requirements. The results will be useful in determining short and long term safe performance. Further testing on FAST-HTL will help determine the component performance and maintenance requirements for new turnout designs.

Prepared by: ______________________
Contracting Officer's Technical Representative — Date

Concurrence: ______________________
Director, Office of Safety Enforcement — Date

Approval: ______________________
Division Chief — Date

Concurrence: ______________________
Director, Office of Safety Analysis — Date

Concurrence: ______________________
OR&D Program Coordinator — Date

Approval: ______________________
Associate Administrator for Safety — Date

Approval: ______________________
Director, Office of Research and Development — Date

Turnouts

Cost: $221,927 FY 87

Schedule: Start August 1987 - June 1988

Contractor: TBD

G 1

Signals and Train Control

1. Background

Several new concepts are now being used or proposed for use to communicate with trains or exert control over train movements. Central train control (CTC), and other automated or software dependent and satellite-based train control systems are replacing existing signal and communications methodologies. One industry project, Advanced Train Control Systems (ATCS), is actively pursuing innovations in railroad control system "packages." These packages, now in various stages of engineering and testing, have resulted from basic rethinking of the way train movements are controlled, both in the United States and Canada. Railroads are expected to implement such systems rapidly as the cost of available technology is entering favorable benefit/cost relationships for nearly all levels of traffic density. New systems are usually independently designed and installed with minimal uniform safety performance overview. Safety reviews may be limited to areas of conflict with FRA regulations or current industry rules leaving wide areas of system safety performance remaining which are discretionary to the designer of the system. Further, conditions may be created upon installation of the new component, device or system, or replacement of an existing system with a new system, which sacrifice or denigrate the previous level of safety. Adequate knowledge and test methods are not currently available to provide assurance that all components, interactions of components or system functions, or all operational characteristics of a new installation provide an adequate level of safety. In addition, greater understanding is needed concerning the situations which may be generated by implanting a new system with an existing system or a new system with other new systems.

2. Current Status

The initiation of an ongoing program is being contemplated, by comprehensive review of the signal and train control systems, components and devices in the market place. FRA will direct research to principal problem areas, components, or systems for which the safety level cannot be readily determined. A systematic approach to establishing safe performance criteria, methods of measurement and evaluation and obtaining knowledge of system or component operating characteristics is to be established. Industry presentations, product review, trade information and railroad system information is being sought and reviewed.

3. Related Research

The fundamentals of some portions of new railroad systems and devices may be similar to those of communications and operating systems in other transportation modes or industries. Coordination with Federal Aviation Administration, U.S. Coast Guard, Department of Defense, and other

Government agencies and their associated industries is anticipated to assure the most complete and rapid accomplishment of program needs and to assure full use of previously performed research. Also, cooperation is anticipated with AAR and their associated researchers as the American/Canadian ATCS project continues. This project is closely related to the Train Dispatching Practices project dealing with the human factors element.

4. Objective

The program will encompass the study of a broad range of communication, signal, and train control systems available; however, testing and research will be limited to those components, devices or system elements for which safety performance is immediately determined to be questionable or for which insufficient knowledge is available to accurately determine the safety expections of the device, component or system.

5. Scope

The project envisions analysis and tests of both new and existing signal and train control systems and individual components to provide information concerning failure modes and failure frequencies. Such information is useful in establishing requirements for system design to limit the possibility of accident-causing system malfunction and to prescribe the frequency and level of system or component inspection to avoid undetected failure.

The research will involve contacts with system and component designers, manufacturers, railroads and other Government agencies such as the Federal Aviation Administration, U.S. Coast Guard, and Department of Defense. The industry research relationship available at the Transportation Systems Center will be utilized. Test activities will be centralized at the Transportation Test Center. However, the nature of the candidate components or device may necessitate activities to be located at the supplier or a railroad location.

6. Interfaces

A broad range of industry, supplier, and Government interfaces is anticipated. Contacts known to have knowledge or to be interested in the program are listed below:

- Railroad Safety Division
  Transportation Systems Center - Cambridge, Massachusetts

- Advanced Railroad Electronic Systems Division
  Burlington Northern Railroad - Overland Park, Kansas

- Collins Air Transport Division
  Rockwell International Corporation - Cedar Rapids, Iowa

- Association of American Railroads - Washington, DC

- Office of Safety Enforcement, FRA

7. Potential Benefits

Methodology will be available for understanding the safe performance capabilities of railroads operating with newly introduced signal and train control systems, devices, components, or communications. Inspection criteria and frequencies, effective "fail safe" techniques, and limits of safe performance will be understood and method will be in place to further evaluate other new systems introduced into service. These understandings will permit FRA to encourage safety improvements in control systems or operating practices or to study the need for potential safety regulations in critical areas.

Prepared by: ______________________
Contracting Officer's Technical Representative — Date

Concurrence: ______________________
Director, Office of Safety Enforcement — Date

Approval: ______________________
Division Chief — Date

Concurrence: ______________________
Director, Office of Safety Analysis — Date

Concurrence: ______________________
OR&D Program Coordinator — Date

Approval: ______________________
Associate Administrator for Safety — Date

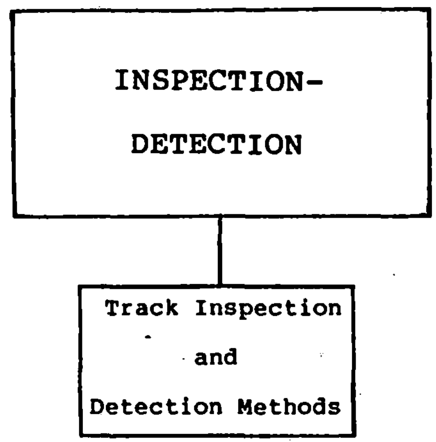
Approval: ______________________
Director, Office of Research and Development — Date

Signals and Train Control

Cost: To Be Determined

Schedule: 11/87--9/92

Contractor: To Be Determined


INSPECTION-
DETECTION
Track Inspection
and
Detection Methods

H 1

Track Inspection and Detection Methods

1. Background

Track defects caused 1,280 accidents in 1985, with resulting reported damage of $59,720,068. This project is to reduce accidents by providing improved methods of track inspection and improved detection of track hazards. This includes the development of improved inspection equipment as well as consideration of inspection methods, procedures, and scheduling issues.

The use of automated inspection systems, such as track geometry measurement and rail flaw detection cars, has become widespread in the industry. They provide the capability for highly accurate determination of track conditions to pinpoint track hazards immediately, while simultaneously recording objective, quantified information about track quality.

Efforts under this project are targeted at the evaluation of inspection system performance and improvement of the capabilities of such systems. The work underway is being coordinated with the Track Measurement Systems Committee of the American Railway Engineering Association (AREA), with the Committee on Rail Testing, and with ad hoc industry technical panels established to assist on individual task elements within the project.

2. Current Status

This is an ongoing research project being conducted with the support of the Track Measurement Systems Committee of the American Railway Engineering Association (AREA), the Association of American Railroads (AAR), individual railroads, and the Sperry Rail Service.

3. Related Research

Earlier efforts conducted under this project led to the development of railbound and highway-rail track inspection vehicles. The inspection systems used in the Automated Track Inspection Program (ATIP) were developed as part of this project, as were the measurement systems used on FRA Highway-Rail cars R-1, R-2, and R-3.

Other projects in the Track Safety Research Program also participate in the development of specialized inspection devices to support particular requirements of the Program. These have included the Harmonic Cross-level Measuring System and the Gauge Restraint Measuring System. These devices were developed to support the research and initial implementation phases of proposed new track safety standards, and to validate new concepts of criteria for establishing track safety. After concept validation, further development of these systems for field deployment will be conducted under this inspection project.

4. Objective

The objective of this project is to improve track inspection and detection capabilities in the railroad industry by sponsoring the development of new inspection devices and improved inspection methods and procedures.

5. Scope

Current tasks underway in this project include the development of improved ultrasonic transducers for rail flaw inspection, comparison of the track loading characteristics of geometry measurement systems, the development of systems capable of measuring the longitudinal force in rails in track, and the development of a statement of acceptable detection capability for rail flaw detection systems.

The development of electromagnetic acoustic transducers (EMAT's) for rail flaw detection is being conducted by Magnasonics, Inc., under contract to the Federal Railroad Administration with the Assistance and support of the Santa Fe Railway, the AAR, and the Sperry Rail Service. The AAR provided cost sharing funding and the other participants have provided equipment and technical assistance.

The feasibility of EMAT transducers has been demonstrated. They appear to have unique new capabilities which will improve rail flaw detection. A prototype fieldworthy system is now being constructed for testing on the Facility for Accelerated Service Testing (FAST) track at the Transportation Test Center (TTC). This test will determine and demonstrate the comparison between the new EMAT's and conventional ultrasonic flaw detection systems.

The comparison of the characteristics of track geometry measurement systems is being conducted with the assistance of several railroads and industry suppliers who participate in the AREA Track Measurement Systems Committee. This assistance has included providing geometry cars, track access, and test support including use of locomotives, crews, and engineering services at no cost to the FRA. Ensco, inc., is providing data collection and analysis support under contract to FRA. A direct comparison test of five geometry systems over instrumented track has been conducted. Planning is underway for further tests to clarify several key aspects of geometry car design.

The development of rail force measurement systems is being conducted by Magnasonics, Inc., under the Small Business Innovation Research (SBIR) Program and is receiving assistance from the Santa Fe Railway. Concept feasibility was demonstrated in Phase I of the SBIR contract, and efforts toward a field demonstration are now underway.

The development of a statement of acceptable performance for rail flaw detection systems is being conducted as an activity of the AREA Track Measurement Systems Committee, Subcommittee on Rail Flaw Inspection, in which FRA is a participant. This subcommittee effort is a direct technical assignment to the subcommittee from the AREA Board of

Direction. The assignment included not only producing the minimum acceptable performance statement, but also defining the means by which performance will be tested. The results of this effort are intended to be included as a voluntary recommended practice in the AREA Manual of Standards and Recommended Practices.

This project also provides general test and technical support to other projects within the Track Safety Program. Such support includes the operation and maintenance of the FRA Research Track Geometry Measurement Car T-6 and the inventory of specialized railroad test equipment owned by FRA. These support efforts are provided by Ensco, Inc., on a continuing basis under contract to FRA.

6. Interfaces

This project is conducted cooperatively with the Track Measurement Systems Committee of the AREA, with the AAR, and with individual participating railroads and industry suppliers as discussed above.

7. Potential Benefits

This project will result in a reduction in the number of track-caused accidents by providing improved detection of track hazards. This can occur through more accurate inspections, which will allow the detection and correction of greater numbers of critical defects than are now located. It can also occur through more efficient inspection systems or strategies, which allow more frequent inspections for the available inspection resources.

The development of a statement of acceptable performance for rail flaw detection systems is expected to lead to an industry recommended practice to be implemented through voluntary action.

The development of practical means to measure longitudinal force in rails in track would contribute to the development of a track safety standard to limit track buckling, as well as voluntary industry recommended practices.

Track Inspection and Detection Methods

Development of EMAT Rail Flaw Transducers

Cost: Prior year funding only, no FY 1987 funds.

Schedule: 9/87

Contractor: Magnasonics, Inc.

Comparison of Track Geometry Car Characteristics

Cost: $275,000 FY 1987

Schedule: 6/88

Contractor: Ensco, Inc.

Longitudinal Rail Force Measurement System

Cost: Prior year funding only, no FY 1987 funds.

Schedule: 10/88

Contractor: Magnasonics, Inc.

Statement of Acceptable Rail Flaw Detection Performance

Cost: No contract funds used

Schedule: 4/88

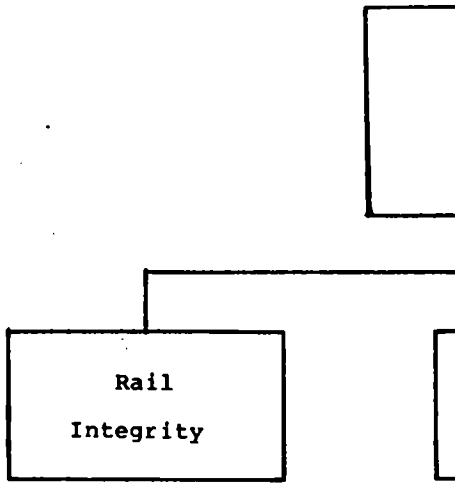
Contractor: In-house effort supported by AREA Committee 2

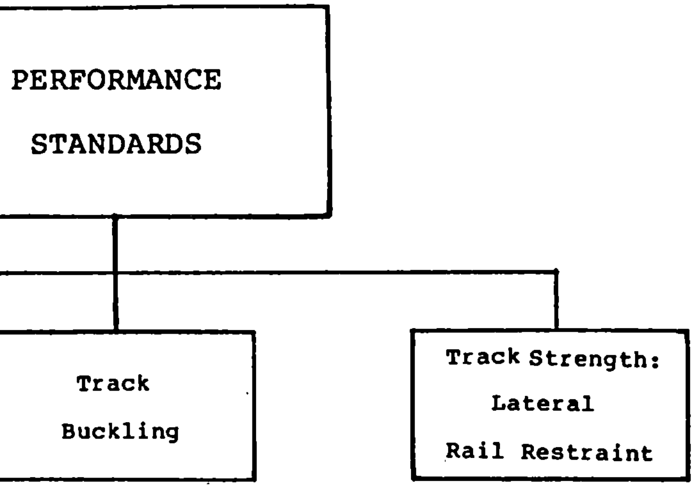
General Technical Support

Cost: $400,000 FY 1987

Schedule: 9/89

Contractor: Ensco, Inc.


Rail
Integrity


PERFORMANCE STANDARDS
Track Buckling
Track Strength: Lateral Rail Restraint

1

Rail Integrity

1. Background

The Rail Integrity project addresses one of the major causes of track related train accidents, the fracture of rails under wheel loads due to internal rail defects. In 1985, there were 282 accidents resulting in nearly $24,000,000 of damage. In recent years with the increased installation of continuous welded rail and perhaps the increased use of 100-ton cars, derailments caused by detail fractures have increased.

Rail flaws develop with traffic due to a variety of reasons including material properties (i.e., strength and cleanliness) and residual stress patterns. Defects generally occur internally and often grow internally to a critical size before failing. Current ultrasonic rail flaw detection techniques and the rail break detection inherent in railroad signals systems provide significant detection for rail failures but undetected failures do occur often with costly results.

Through the Federal Railroad Safety Act of 1970, the FRA is authorized to conduct research in railroad safety. This research on rail integrity is a result of that authorization legislation. In addition, the National Transportation Safety Board (NTSB) has often recommended research in rail integrity to improve the detection capability and the timely removal of rail flaws. For instance, the NTSB report (dated February 14, 1985), on the Marshall, Texas, accident made specific recommendations for FRA research.

2. Current Status

There are existing research programs at the Transportation Systems Center (TSC) through Project Plan Agreement (PPA) and at the Transportation Test Center (TTC) under contract to the Association of American Railroads (AAR) that support this activity. The TSC work currently addresses flaw occurrence and growth of detail fractures, bolt hole cracks, vertical split heads and horizontal web cracks. The latter work evolved from the Marshall, Texas derailment. TSC work will result in a track performance standard to determine optimum rail inspection frequencies. To support this effort crack growth rates were evaluated on rail flaws on the Facility for Accelerated Service Testing - High Tonnage Loop (FAST-HTL) track at the TTC. To date three tests have been conducted, two on detail fractures and one on bolt hole cracks. Current tests on FAST-HTL evaluate the rate of occurrence of rail flaws in a variety of rails and the rate of growth of those naturally occurring flaws. Technical evaluations, modeling and performance standard development is supported at the TSC through a variety of contracts with universities and research organizations such as Battelle, and A. D. Little. In addition, new work at the Oregon Graduate Center (OGC) is proposed to support the rail integrity project.

There is wide industry and Association of American Railroads (AAR) support for this project which ranges from supplying test rails and equipment at FAST-HTL to joint sponsorship by the AAR of some of the work at the OGC.

3. Related Research

Work done by a variety of organizations including the AAR, U.S. Railroads, the Office for Research and Experiments (ORE), International Union of Railways (UIC),and rail manufacturers both domestic and foreign is reviewed constantly so that our work can benefit from their results and avoid duplication.

In particular, very close cooperation is maintained with the AAR Technical Center. Of course, the FAST-HTL testing is a cooperative test which by its nature results in industry, AAR and FRA coordination.

4. Objective

The primary objective is to reduce the number of railroad accidents caused by rail failures. This will be achieved by providing a rigorous technical specification on the rate of inspection required for detecting rail flaws before breakout.

5. Scope

The project scope encompasses evaluation of about 90 percent of rail defect types which cause track accidents. All research sponsored by the FRA and other organizations which are relevant are used to develop a track performance specification for rail testing.

6. Interfaces

The American Railway Engineering Association (AREA) Ad Hoc Committee for Track Performance Standards, composed of railroad chief engineering officers is the primary interface with the industry for this work. The principal point of contact for that committee is Louis T. Cerney, Executive Director of the AREA. Other important points of contact are A. J. Reinschmidt, Manager of Track Research and R. K. Steele, Assistant Manager of Metallurgy of the Research and Test Department of the AAR.

The principal point of contact in the Office of Safety Enforcement is E. R. English, Chief of the Maintenance Programs Division.

7. Potential Benefits

The primary benefit from this program is improved railroad safety resulting from a reduction in the number of rail defect-caused accidents. To do this effectively a standard must be reasonable so that the industry is inclined to implement the requirement without further

Government regulation. The work will also provide a constant capability to keep the industry and FRA informed of technical progress so they can react to changes in industry practice which could affect safety, such as flaw development and growth with heavy axle loads.

Rail Integrity
(03/82 - 05/91)

Defect Occurrence & Growth Testing

Cost: $500,000 FY 87

Schedule: 10/82 - 07/87 given consistent FAST-HTL operation

Contractor: Association of American Railroads
(82-C-00282, Task Order #1)

Facility for Accelerated Service Testing - High Tonnage Loop

Cost: A portion of $2,170,000 for FAST-HTL Operations (FY 87)

Schedule: 10/82 - 10/92

Contractor: Association of American Railroads
(82-C-00282, Task Order #1)

Rail Integrity Analysis and Support

Cost: Portion of $2,000,000 PPA FY 87

Schedule: 10/88

Contractor: Transportation Systems Center (PPA 719)

Oregon Graduate Center

Cost: $306,204

Schedule: 1/87 - 1/89

Contractor: Oregon Graduate Center

J 1

Track Buckling

1. Background

The Track Buckling project addresses one the major causes of track related accidents, the dynamic lateral buckling or misalignment of track. In 1985, sixty derailments were reported costing $8,095,597. The increased use of continuous welded rail (CWR) in railroads has increased the opportunity for track buckling events caused by thermal and vehicle loads.

Track buckling is one of the most difficult and complex technical problems facing the railroad industry. Buckling can occur with extreme thermal stress abetted by mechanically induced stress under a variety of track lateral strength conditions and track misalignments. Theoretically track buckling cannot occur on perfectly straight track because there is no lateral force component. Practically speaking, however, there is no perfectly straight track. The lateral force component can be applied from compressive stresses acting on curved track or a misalignment, or the lateral force can be generated dynamically. Track resistance is provided primarily by the ballast section which can vary considerably. Ballast section resistance or lateral track resistance is affected by the ballast type, section and degree of consolidation.

The technical approach taken by most railroad people is to determine the safe rail neutral temperature (RNT) for a given track. RNT is defined as the temperature where there is no thermal stress in the rail. Ideally, this is the rail laying temperature. The selection of an appropriate RNT is usually done empirically and in spite of much experience to date, is not always suitable for all track conditions.

Track buckling incidents are not frequent occurrences. However, the cost (i.e., the severity of potential damage) is higher than for most other track-caused accidents. For instance, in 1985 the cost per reported accident for rail and joint bar defects is $85,000 versus $134,000 per accident for track buckling. In addition, the increased use of CWR and the much higher traffic densities on CWR will increase the exposure to this type of accident. The NTSB has singled out high cost accidents such as track buckling as topics that should have intensive applied research to resolve. (Ref. NTSB comments to NPRM Docket No. RST-3, March 1982)

2. Current Status

There are research programs at the Transportation Systems Center (TSC) through a Project Plan Agreement (PPA), and at the Transportation Test Center (TTC) using the Facility for Accelerated Service Testing-High Tonnage Loop (FAST-HTL), Task Order #1 with the Association of American Railroads (AAR). This work supports the development of a track buckling performance standard as a part of the track safety peformance standards program.

Work to date has developed static track buckling analysis and track resistance characterizations. Static and dynamic track buckling tests at the TTC have been conducted and analysis is currently being done at the TSC.

Through the FAST program, evaluations of RNT are conducted. Future plans include more intensive track buckling tests than previously conducted at the TTC and RNT tests at various locations on the CSX and on the FAST-HTL. The work on the FAST-HTL and elsewhere at the TTC has the support of the railroad industry through donations of equipment and track components.

3. Related Research

Track buckling is a concern of every railroad that uses CWR. FRA research has used data from U.S. railroads and from European railroads extensively to help develop the track buckling performance standard. There is no active AAR research project in this area. Earlier efforts in support of the FRA work were conducted on the Southern Railway in 1981 and 1983.

Careful evaluation of research results from British Rail and others is always done to avoid unnecessary duplication of effort.

4. Objectives

The objective of this program is to reduce the number of accidents caused by track buckling. This will be accomplished by application of technical results to determine appropriate inspection strategies and remedial actions for preventing track buckling.

5. Scope

The track buckling work includes work in rail neutral temperature variation, track lateral strength through the single tie push test, and dynamic track buckling tests. All research sponsored by the FRA and results from other organizations where relevant are used to develop a track performance specification for track buckling.

6. Interfaces

The American Railway Engineering Association (AREA) Ad Hoc Committee for Track Performance Standards composed of railroad chief engineering officers is the primary interface within the industry for this work. The principal point of contact is Louis T. Cerney, Executive Director of the AREA. Another important point of contact is A. J. Reinschmidt, Manager of Track Research of the Research and Test Department of the AAR.

The principal point of contact in the Office of Safety Enforcement is E. R. English, Chief of the Maintenance Programs Division.

7. Potential Benefits

The primary benefit from this program is improved railroad safety resulting from a reduction in the number of track buckling incidents causing train accidents. To do this effectively, a standard must be reasonable so that the industry is inclined to implement the requirement without further government regulation.

Track Buckling

Track Buckling Testing

Cost: $500,000 FY 87

Schedule: 6/83 - 10/88

Contractor: Association of American Railroads (82-C-00282, Task Order #1)

Track Buckling Analysis and Technical Support

Cost: Portion of $2,000,000 PPA (FY 87)

Schedule: 10/88

Contractor: Transportation System Center (PPA 719)

Facility for Accelerated Service Testing - High Tonnage Loop

Cost: A portion of $2,170,000 for FAST-HTL Operations (FY 87)

Schedule: 10/82 - 9/88

Contractor: Association of American Railroads
(82-C-00282, Task Order #1)

K 1

Track Strength: Lateral Rail Restraint

1. Background

Lateral rail restraint refers to the ability of the track structure to prevent the rails from moving outward under the loads of passing trains. Lateral rail restraint capacity is provided by the crossties, tie plates, and rail fasteners.

Deteriorated track with inadequate lateral rail restraint can allow a wide gage condition to occur and leads to derailment if sufficiently wide gage allows a wheelset to drop from the rails to the track structure. In 1985, 22 percent of track-caused accidents were attributed to inadequate rail restraint.

New track construction methods and new track components are selected to assure adequate lateral restraint with substantial margins of safety against all but very extreme lateral dynamic loads. However, accumulated service loadings and aging phenomena progressively weaken the track components, and the lateral restraint capacity of the track structure is progressively reduced. Wood crosstie track, in particular, is subject to deterioration which reduces rail restraint capacity, as cut spikes become loosened, as tie plates cut into the body of the ties, and as the wood decays, splits, or suffers mechanical damage.

The structural capacity of wood crosstie track is difficult to assess manually or visually. Ties which have suffered splitting or mechanical damage may appear to offer little lateral restraint capacity but may in fact provide adequate restraint for the dynamic loads actually imposed. Ties which appear completely sound may, in fact, be hollowed out by decay and provide little or no lateral restraint capacity.

Present means of manual inspection rely on visual estimates of tie condition, since means are not readily available to field inspectors to apply known loads to the track structure and measure the resulting track geometry conditions. The dynamic gauge conditions during the passage of trains are almost impossible to observe or accurately quantify.

These difficulties cause several related problems for the railroad industry. At present, the industry does not have a practical, readily available method to measure the lateral rail restraint capacity of track. As a result, railroads wishing to take a conservative approach to safety, and can afford to do so, replace many more crossties and other track components prior to an actual need to do so in order to maintain a more than adequate margin of safety for operations.

On the other hand, carriers that are unable to afford a conservative approach may leave inadequate components in track, often resulting in accidents since no clear measure of the adequacy of ties is available. The lack of a quantifiable measure of tie suitability can cause confusion and/or disagreements between railroad company and Government inspectors since each must rely on subjective judgment of the ability of the track to perform.

The Lateral Rail Restraint project addresses these concerns by (1) determining the minimum acceptable levels of rail restraint that will assure safe train operations, and (2) providing practical methods to measure the lateral restraint capacity of track in an objective, quantified manner.

2. Current Status

This project is one of the major tasks in the effort to develop performance-based track safety standards. The project was begun in 1978 and is a continuing effort. Several carriers have offered to participate in the project by providing field test support including track access and locomotives and crews. The efforts in the project are being coordinated with the AREA Ad Hoc Committee on Performance Standards.

3. Related Research

The "Decarotor" test car operated by the Association of Amercian Railroads was intended to measure the lateral restraint capacity of track. The Decarotor was operated over very limited track segments and provided useful information, but suffered from fundamental mechanical problems which prevented widespread use.

A new Controlled Track Loading Vehicle (CTLV) is being built by the AAR under the Track Train Dynamics Program. The CTLV will provide further research information on lateral restraint, as well as new information concerning wheel climb derailment tendencies and wheel-rail angle-of-attack information which are addressed under the Vehicle-Track Interaction Project.

4. Objective

The objective of this project is to reduce or eliminate derailments caused by inadequate lateral rail restraint. This will be accomplished by providing a practical means to measure the actual restraint capacity of track so that no ambiguity exists as a result of differing opinions. The project is developing a Gage Restraint Index (GRI) which will quantify the lateral restraint safety margin available in track based on measurements made with a Lightweight Track Loading Fixture (LTLF) or Gauge Reserve Measurement System (GRMS) system.

5. Scope

This project includes both an assessment of the required lateral rail restraint to assure safe operations and the development of measurement systems and methods to assure that lateral rail restraint capacity can be objectively measured and quantified in the field.

Under this project, the Transportation Systems Center (TSC) has completed the assessment of required lateral restraint capability for track under low speed operations, and has developed two systems for the practical measurement of lateral rail restraint capability in the field: the GRMS or "Split Axle" and the LTLF.

The GRMS is an instrumented railcar that will allow continuous measurement of rail restraint capacity under known vertical and substantial applied lateral loads. A major ongoing effort in the project is to validate the GRMS system and to conduct a limited survey of revenue service track. These tasks will be directed by TSC with technical support from Ensco, Inc., with participation and support from the FRA Office of Safety field staff and member railroads of the AREA Ad Hoc Committee on Track Performance Standards. The research will include a direct comparison of GRMS data with conventional track geometry measurements from the FRA Research Track Geometry Measurement Car T-6. It will clearly establish the benefits which may be obtained if track geometry surveys were augmented with the use of a GRMS or similar system.

The LTLF is intended to provide a man-portable means of determining rail restraint capacity. TSC is directing the development and field deployment trials of the LTLF with participation of the FRA Office of Safety field staff and railroads participating in the AREA Ad Hoc Committee on Track Performance Standards. The LTLF has undergone several limited field trials indicating several design improvements are needed prior to widespread use of the device. One aspect of the field testing will be to compare readings obtained with the LTLF that does not provide vertical loading with the GRMS that does provide loads representative of revenue service vehicles.

6. Interfaces

The AREA Ad Hoc Committee on Track Performance Safety Standards is substantially involved in the completion of the project. The Ad Hoc Committee provides technical guidance to assure that the project will result in products useful to the industry and will be continually informed of efforts underway. The Committee interface has provided a method of obtaining industry contributions to reduce total project cost, including access to revenue track and the services of locomotives with crews.

The FRA Office of Safety field staff has provided assistance to the project by field-testing the LTLF and furnishing recommendations for the deployment of the GRMS. Field staff members will accompany the GRMS to assess its operability, its ability to detect track hazards, and its ability to quantify track lateral restraint capacity.

7. Potential Benefits

The successful completion of this project will provide a substantial improvement in the safety of operations in the railroad industry by directly reducing the number of accidents caused by inadequate lateral rail restraint. This will be accomplished by defining adequate restraint in practical terms and by providing a practical means of measuring lateral restraint capacity of large segments of track.

Additional benefits will accrue because railroads will be able to reduce the number of ties replaced and to assure that truly defective track components are removed.

The project will improve safety regulations by reducing the need to take regulatory action based solely on the nonquantifiable opinion of an inspector, sometimes subject to controversy. The information produced by this project will provide the basis for a Lateral Restraint Track Safety Standard that will serve as a railroad-elected alternative to present Track Safety Standard requirements. This effort is also expected to contribute to voluntary recommended practices implemented by the AREA.

Track Strength: Lateral Rail Restraint

Validate Gauge Reserve Measurement System (GRMS)

Cost: Portion of $2,000,000 PPA FY 1987

Schedule: 7/87

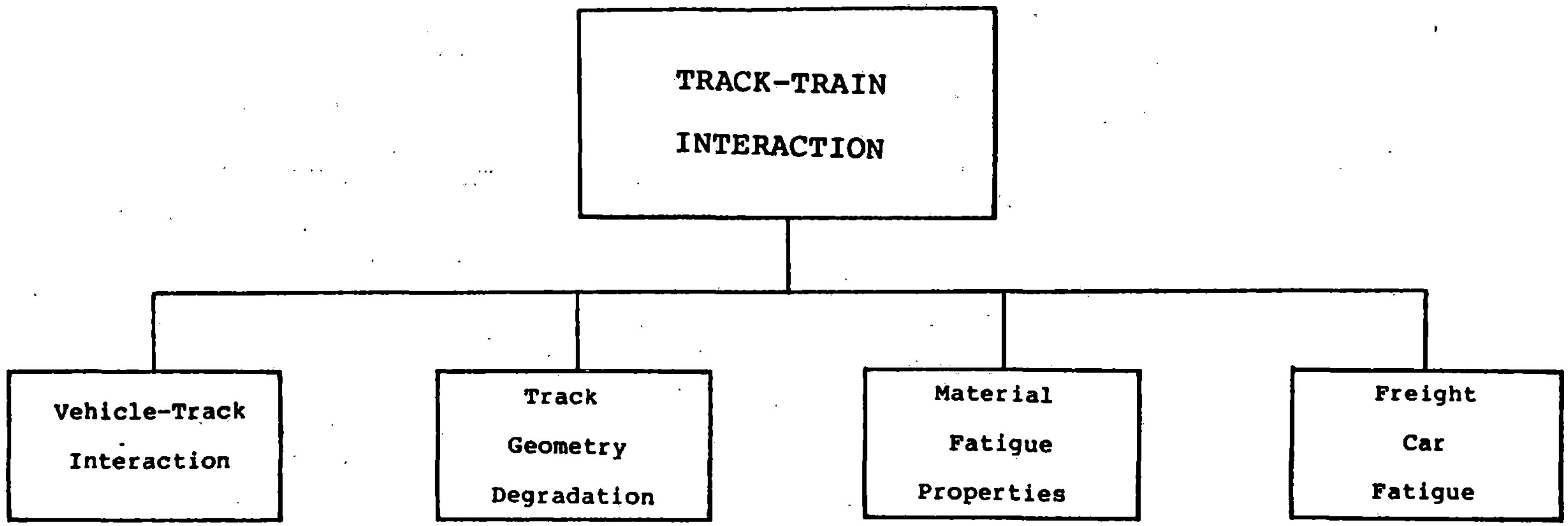
Contractor: Transportation Systems Center with support from Ensco, Inc. and participating railroads

Improve Fieldability of Lightweight Track Loading Fixture (LTLF)

Cost: Portion of $2,000,000 PPA FY 1987

Schedule: 10/87

Performer: Transportation Systems Center


TRACK-TRAIN INTERACTION
Vehicle-Track Interaction
Track Geometry Degradation
Material Fatigue Properties
Freight Car Fatigue

L 1

Vehicle-Track Interaction

1. Background

The Vehicle-Track Interaction project addresses one of the major causes of train accidents; derailments due to car response to track geometry defects. In 1985, there were over 100 accidents with damage in excess of $4,000,000 directly attributable to car response to track geometry defects.

Considerable research was conducted in the past few years on vehicle response to track geometry defects. For example, field tests at Starr, Ohio, on the CSX and on the Boston and Maine System (B&M) helped to establish and evaluate an index (called the "Cross Level Index" or CLI) for vehicle response to periodic crosslevel errors associated with staggered jointed track.

Other studies evaluated the car response to known track conditions. In particular, there were evaluations of high center of gravity cars at the Transportation Test Center (TTC) and elsewhere. There is a current effort at the TTC to evaluate a new articulated covered hopper car to determine if the prototype car response is within acceptable limits.

The average freight car capacity for Class 1 railroads is reported by industry to have advanced to 84.3 tons per car in 1985. It is necessary to assure that existing limits of track geometry are adequate for the high track loadings possible with large car capacities and that vehicle-track interactions under all loading and operating conditions are understood. Also, it is necessary that safe track geometry limits and track performance are appropriately represented by inspection and analytical critieria and techniques currently in use or proposed by the railroad industry. Refinement of analytical tools is needed and alternative methods for evaluation of train responses to track inputs is required for load and speed variations. Studies at the Transportation Systems Center (TSC) to set forth and evaluate analysis and measurement tools such as the "Cross Level Index," and the "Track Analyzer" are underway to characterize track conditions and predict vehicle response to those conditions.

In the decade of the 1980's, deregulation has caused considerable change in the railroad industry. To cope with new competitive challenges, the industry is rapidly expanding its use of new systems such as low tare weight cars, slackless unit trains, and articulated cars. The Association of American Railroads (AAR) has initiated a cooperative High Productivity Integral Train (HPIT) program to develop a radically new unit train system that will incorporate a host of new concepts. Nine firms have submitted proposed design concepts and the designs and prototypes are in various stages of development, construction or evaluation. These firms are motivated by the competitive economic forces now at work in the marketplace. It is necessary for the Federal Railroad Administration to be aware of new technology and test techniques associated with these new train systems and concepts, and to encourage a high level of safety performance prior to their introduction into service. Development of a uniform safety testing procedure is needed to permit evaluation of these prototypes as well as others that may follow. Limits of performance in safety-critical regimes of track-train interaction, braking, and train handling are required. By cooperating with the AAR on its Vehicle-Track Systems program (the directorate of the HPIT program) in a timely manner, along with designers and industry evaluators, FRA will gain this knowledge at a minimum cost.

2. Current Status

Involvement in the covered hopper car testing is nearing completion. The laboratory test of a prototype covered hopper car is to be complete in early 1987 and final results of the vehicle testing will be available in mid-1987. The testing of new HPIT train consists is now beginning and the analysis of test results for prototype train systems or consists will be completed in 1989. The derailment analysis studies of wheel/rail profile and interface conditions are to begin upon construction by the industry of a test device (the Controlled Track Loading Vehicle) which is expected to be completed in mid-1987. Evaluation of safety test capabilities, demonstration, and track testing will be accomplished by fall of 1989. The analysis techniques associated with the "Cross Level Index" and the "Track Analyzer" have been presented to industry for review and evaluation.

The activities being conducted in association with the AAR Vehicle-Track Systems program (follow-on to the Track Train Dynamics Program) are conducted under a cost-sharing contract with significant benefit to FRA. Work being conducted for the Track Safety Research Division and the Equipment and Operating Practices Research Division is expected to yield research efforts equivalent to approximately ten times the cost of the contract to FRA.

A contract to provide Track Train Research Support is in the late stages of the procurement process. The contractor will provide expert technical support to this project and to other FRA research areas.

3. Related Research

Several existing and previous projects such as the "NUCARS" analysis project at Massachusetts Institute of Technology and Canadian steerable-axle truck project are related to this research. Portions of those projects have been drawn upon as foundations for this research and have aided in establishing needed dynamic relationships. Nearly all previously performed testing has provided some insight into understanding track-train interaction. Earlier portions of the covered hopper car tests have shown characteristics that will lead to understanding vehicle accident rates associated with high center of gravity cars. The testing of covered hopper cars on perturbed track to generate vehicle reactions will be drawn upon to establish criteria for the testing of HPIT train system prototypes. That earlier testing is to aid in evaluation of the limiting track geometry and resulting wheel-rail loads of train systems. Similarly, derailment analyses activities are to be based on previous research outputs such as the AAR moving vehicle track measurements, the Gage Reserve Measuring System, and the derailment coefficient studies at Princeton University. Knowledge gained from many other research outputs, both national and international are used in study of the forces affecting the wheel-rail interface and contributing to derailment causes in that region.

4. Objectives

The principal objective of this project is to reduce the number of accidents caused by adverse vehicle response to track geometry conditions. To accomplish this principal objective evaluations will be made of vehicle reactions to known geometry conditions through analyses conducted and models developed, appropriate recommendations will be made for suggested changes to vehicle design and limitations on acceptable track geometry conditions.

5. Scope

The research will cover nearly all aspects of vehicle response including rock and roll, dynamic curving, bounce, and hunting. To accomplish this, detailed evaluation will be made of car and truck characteristics, wheel-rail vertical and lateral forces, steering (creep) forces, wheel angle of attack, braking forces, and buff and draft forces under a variety of track conditions.

6. Interfaces

The analysis of vehicle and component characteristics as well as complete train systems will be aligned with the needs of other elements of the Office of Safety. The contract with the AAR in conjunction with the HPIT program places FRA in close contact with research outputs from many industry sources, including the railroads, suppliers, and universities. Outputs of the project are expected to become inputs to industry standards and operating practices. Coordination with TSC, TTC and other research organizations is provided.

- Association of American Railroads

  S. B. Harvey - Senior Assistant Vice President
  G. Way - Vice President, Research and Test Department
  R. A. Allen - Executive Director, Chicago Technical Center
  J. A. Elkins - Transportation Test Center
  A. J. Reinschmidt - Research and Test Department

- Vehicle-Track Systems Program Steering Committee

  Various railroad and supplier corporations and Government executives

- Transportation Systems Center

  R. J. Madigan - Chief, Railway Safety Division
  P. Tong - Chief, Structures and Dynamics Division

- Mitre Corporation

L. E. Diebel - Associate Department Head, Systems Planning and Engineering

G. Kachadourian - Transportation Engineering

- Track Train Research Support

Contractor to be determined.

7. Potential Benefits

The primary benefit of this work is an improvement in railroad safety resulting from a reduction of track geometry-related derailments.

Reduction of derailments through improved performance of covered hopper cars and new train consists is expected. Design of new equipment introduced into service will reflect safety knowledge gained. Safety performance will be evaluated prior to widespread distribution of new car or train consists into the marketplace. Capability for testing of new equipment will be assured. Derailment tendencies caused by undesirable conditions at the wheel-rail interface will be understood and reduced. Information will be developed leading to track performance standards for vehicle-track interaction for voluntary use by the industry and as input for possible changes to the FRA track safety standards.

Vehicle-Track Interaction

New Designs & Train Consists:

Cost: FRA $848,000
AAR $1,832,000*
Total $2,680,000

Schedule: 9/86--9/89

Contractor: Association of American Railroads, Chicago Technical Center

Derailment Analysis:

Cost: FRA $566,000
AAR $17,313,000
Total $17,899,000

Schedule: 1/87--9/89

Contractor: Association of American Railroads, Chicago Technical Center

Articulated Prototype Covered Hopper Car Test:

Cost: $350,000

Schedule: 9/86--9/87

Contractor: Association of American Railroads, TTC

Track Train Research Support:

Cost: $89,000

Schedule: 12/86--6/87

Contractor: The Mitre Corporation

Track Train Research Support:

Cost: $687,000

Schedule: 1/87--1/90

Contractor: TBD, Competetive Award

Track Train Research Support:

Cost: $ Part of $2,000,000 PPA

Schedule: 10/86--9/87

Contractor: Transportation Systems Center, PPA-RR-719

* Includes Test Device

Track Geometry Degradation

1. Background

Track geometry degradation refers to the long-term deterioration in track geometry which occurs as a result of wear and fatigue due to usage and also as a result of factors such as weathering. Track degradation is a major contributor to track-caused accidents. In 1985, defects related to track geometry degradation caused 466 accidents that resulted in $13,117,145 in direct damages.

This project is to determine rates at which track geometry degrades and the factors which increase or reduce degradation. A major direct use of this information is to assist in setting inspection intervals to assure that hazards are detected prior to causing accidents. In addition, the knowledge of causes of degradation is useful in understanding track performance characteristics, so that improved track structures can be designed and installed, further enhancing the safety of operations.

2. Current Status

This is an ongoing research project which is being conducted in cooperation with Conrail, the Boston and Maine Railroad (B&M), other participating railroads, and technical committees of the American Railway Engineering Association (AREA).

3. Related Research

The information on geometry degradation rates and influencing factors is furnished to other elements of the Track Safety Research Program. It is used to assist in determining realistic inspection strategies for the implementation of proposed track safety standards and for the insight it provides into the behavior of the track structure under actual service.

4. Objective

The objective of this project is to determine and document the degradation rate of track geometry and the factors, such as usage, weather, and maintenance activities, that are major influences on track quality changes.

5. Scope

Current tasks underway in this project include joint monitoring of short stretches of Conrail and B&M track which show unusually high degradation rates, and a controlled study of degradation rates on the Facility for Accelerated Service Testing (FAST) track at the Transportation Test Center. An effort is being planned to monitor lateral restraint degradation using the Gage Restraint Measuring System ("Split Axle").

The Conrail study is being conducted under a joint Memorandum of Understanding between the Federal Railroad Administration and Conrail. Data collection and analysis support is being provided by Ensco, Inc., under contract to the FRA. The study utilizes data from routine Conrail track geometry car runs and a specially designed data acquisition system to obtain highly detailed crosslevel and gage information about selected test zones which historically have shown unusually high degradation rates. These particular zones are most likely to become areas of hazard if extraordinary maintenance procedures are not followed.

The maintenance efforts expended on each of the test zones will be recorded. Examinations will be made to determine the factors which cause these short segments to degrade so rapidly in comparison with adjacent track. The track condition will be monitored over the course of two years, so that the relative hazard level of each site can be determined, and the likely hazard level predicted if maintenance were not performed.

The B&M study utilizes the gyroscope-based Crosslevel Measurement System and is specifically targeted at determining degradation in crosslevel index (CLI). This study is being conducted with support from the B&M, the Transportation Systems Center (TSC), and Arthur D. Little. Measurements will be taken prior to surfacing selected jointed-rail sections of the B&M where exceptions to acceptable levels of CLI are likely to exist.

Measurements will also be taken during and immediately after the railroad's normal surfacing operation is performed in order to document the effect of routine maintenance practice on CLI. Subsequent measurements are planned over the course of a one-year period to observe the crosslevel degradation rate under tonnage, weather, and other influences.

The FAST study was performed by the Transportation Test Center and involved simulated revenue service track under heavy traffic conditions and was focused on degradation in crosslevel and gage at bolted joints. This effort is presently suspended due to damage from a non-test related derailment in the track test section. The FAST study may resume when the future operating plans for FAST are finalized.

A study to determine the degradation rate of rail lateral restraint, which governs the dynamic gage of track under load, is now being planned. TSC will provide analysis support and direction to the study and will be technically supported by Ensco, Inc. Several railroads are expected to assist this effort by providing track access and locomotives and crews, as well as technical guidance.

This effort will make use of the Gage Restraint Measuring System (GRMS) which is expected to provide previously unavailable information about the condition of ties and fasteners. The GRMS will be operated over selected segments of track on a periodic basis to determine the changes in restraint capacity of the track under heavy revenue service.

6. Interfaces

This project has the cooperation of Conrail and the B&M. They are providing access to revenue service test sites. The AREA Ad Hoc Committee on Track Performance Standards is advised of project results, to assist with consideration of proposed performance-based track safety standards. The AREA Track Measurement Systems Committee provides assistance in obtaining track geometry information from members' routine geometry surveys of participating railroads.

7. Potential Benefits

The determination of normal and abnormal track geometry degradation rates can allow improved inspection strategies since inspections can then be made when needed, but only when needed. The detailed observation of degradation rates also provides an improved fundamental understanding of the behavior of the track structure. This information is essential for the formulation of safety standards or voluntary industry recommended practices which may specify inspection frequencies.

Track Geometry Degradation

Conrail Study

Cost: $125,000 Fiscal Year 1987

Schedule: 3/89

Contractor: Ensco, Inc., with support from Conrail

Boston & Maine Railroad Study

Cost: Prior year funding only

Schedule: 10/87

Contractor: Transportation Systems Center
Arthur D. Little
B&M

Rail Lateral Restraint Study

Cost: $325,000 Fiscal Year 1987

Schedule: 7/88

Contractor: Transportation Systems Center
Ensco, Inc.
Support from railroads participating in the AREA Ad Hoc Committee on Track Performance Standards

Material Fatigue Properties

1. Background

Several prototype cars have been introduced by the car building industry using aluminum or other non-ferrous materials to lower tare weight to reduce car costs. Information for prediction of fatigue failure for these materials is nonexistent for many typical shapes, sizes, and weldments used in railcar construction, particularly at the vibration frequencies found in the railroad environment. It is necessary that this information be available to accurately predict the performance, or evaluate the failure of shapes and weldments critical to the safe operation of the vehicle when subjected to fatigue conditions in service. Fatigue data developed by automotive, aircraft, and ship building industries have been found to be of limited use for fabrication methods in freight car construction.

A series of car construction shapes and weldments has been developed representing those critical to safe car construction, and the principle failure modes of structural members have been assessed. An evaluation has been made to determine the materials most likely to be used in future car construction in conjunction with the Association of American Railroads Car Construction Committee. Adequate fatigue data for those materials is not available. A search of literature is needed to show the material types for which fatigue failure prediction data is most needed, and fatigue data developed for those materials. Experience indicates those materials may be within the 5000 series, 6000 series, or 7000 series of aluminum alloys.

2. Current Status

This project is new and is a part of the cooperative industry/Government Track Train Dynamics Program. The contract was signed September 30, 1986, and work has just begun. Complementary funding for this program is $130,000.

3. Related Research

Work of a similar nature is currently being performed at the University of Illinois on A-441 steel. Various welded structural shapes and connections, typical of those used on freight cars, are undergoing fatigue testing in its laboratory. A report on this work is in preparation. The work and methods followed for the fatigue properties data development for this project will parallel that for the previous project using A-441 steel. Also related is "Materials Substitution in Railroad Freight Cars," Association of American Railroads, 1983.

4. Objective

The objective of this project is to provide reliable data for one type of non-ferrous material selected from many being introduced into the industry, to be used as a point of reference for the prediction of fatigue failures of critical components in rail car construction, and to make that information available to industry groups or persons to prevent premature failure due to fatigue.

5. Scope

This task will review existing material fatigue properties data from available bodies of literature that are applicable to freight car structures to establish the most urgent data needs. One type of material will be selected for fatigue data development testing. The selection will be made on the basis of its use, or potential future use in construction of safe-critical freight car components. A test program will be conducted to establish fatigue performance characteristics of a series of shapes and weldments for that one material type. The data tables and fatigue failure prediction criteria will be published in AAR technical literature and disseminated in the industry as a reliable point of reference for prediction of safe fatigue life of structural components and for evaluation of existing car component characteristics. Laboratory materials testing will be accomplished mainly by subcontract (probably to a university) with guidance from the AAR staff.

6. Interfaces

AAR Technical Center - Program manager, engineer and technical personnel.

FRA - R&D Program Manager and staff, Office of Safety Maintenance Programs Division.

Consultants - As required
Industry

Car Builders - Chief Engineers, designers

Suppliers - Aluminum Industry - Chief Engineers and technical personnel

Railroads - General Managers, engineers

7. Potential Benefit

The fatigue properties of the material tested will be documented and will provide the basis for predictions to prevent premature failures due to fatigue. Developed data will be recommended for inclusion in AAR fatigue design specifications.

A report will be prepared presenting the criteria for selecting the material for fatigue testing and summarizing the materials for which fatigue data are available or not available. Finally, a standardized test plan will be developed and used in conducting laboratory tests to determine fatigue characteristics of the material selected.

Material Fatigue Properties

Cost:

FRA	$183,000
AAR	$130,000
Total	$313,000

Schedule: 9/86--10/89

Contractor: Association of American Railroads

0 1

Freight Car Fatigue

1. Background

New rail cars developed to reduce tare weight and otherwise improve operating efficiency are continually being placed in service. The expected safe operating life of many critical components of these new cars has not clearly been established and their reaction to strain and acceleration in the railroad environment is not yet known. Uniform procedures to accurately predict car and component fatigue failures are necessary. Historically, the failure of a component due to fatigue was compensated for by over design or otherwise liberally increasing safety margins based on failure experience. That approach has not proven to be successful and its extension to newly designed rail cars experiencing increased utilization and loading is expected to potentially lead to even more severe failure situations. Attempts to alter that approach have been hampered in the past by lack of reliable whole-car response data. The ability to obtain reliable data needed to predict premature fatigue failure of components was elevated to a new plateau by the installation of the "Simuloader" vibration test unit at the Transportation Test Center. This unit is designed to test the whole car through the application of controlled forces directly to the carbody, thereby providing the first opportunity to simulate known force and acceleration inputs that might not otherwise be experienced except over extended time periods in revenue service.

2. Current Status

A candidate test vehicle of a car type that is known to have experienced fatigue damage has been identified and possible candidate components of that car are being reviewed to determine the most reasonable tests to perform. Upon approval of the Task Order, negotiation for use of the vehicle in testing will begin and specific test plans provided. Preliminary discussions with the AAR Fatigue Task Force regarding test conduct and appropriate data requirements have been held.

This project is a part of the Track Train Dynamics program. FRA contribution to this cost sharing project is $227,000.

3. Related Research

Fatigue failures and prediction of fatigue life of materials and railroad equipment has been progressively studied in the Track Train Dynamics Program. Empirical data was developed recently for reference in calculating fatigue parameters for one ferrous metal used in car sills, side frames, coupler supports, center plates, etc. That report is expected early in 1987.

The Simuloader test unit is being utilized for short run fatigue tests under the New Trucks and Lightweight Car project. The AAR has been engaged in ongoing research to establish a relationship of failure from fatigue due to mileage exposure.

4. Objectives

To develop a means for realistic estimation of fatigue life of freight car components through test of a whole car by simulating failure of a freight car specimen of a type known to have experienced fatigue failure. The capabilities of the Simuloader will be utilized and verified by comparative analysis.

5. Scope

This project will evaluate fatigue failure of car components by comparison with track data, Vibration Test Unit data and Simuloader data taken from the same candidate vehicle. The project will cover a range of train speeds and track classes and will provide measurements of vibration amplitudes, frequencies, and failure cycles which contribute to railroad accidents. The candidate vehicle will be of a car type known to have experienced fatigue failures.

6. Interfaces

This program interfaces with industry sources such as rail car manufacturers and users. Input and guidance is obtained from the AAR Fatigue Task Force, the AAR Car Construction Committee, and interested participants in the AAR Vehicle Track Systems Program.

7. Potential Benefits

A realistic approach to predicting fatigue failure of rail car components will be developed. The capabilities of the Simuloader test unit in performing safety testing will be verified by comparative data from track and VTU tests. Information leading to reduction of accidents due to fatigue failures will be obtained. The data will be made available to railroads and car owners to improve car component inspection schedules and maintenance to reduce accident frequencies due to component failure.

Freight Car Fatigue

Cost:

FRA	$227,000
AAR	345,000
Total	$572,000

Schedule: 3/87--1/89

Contractor: Association of American Railroads

SAFETY

TESTING

P 1