REPORT NO. FRA — OR&D—78—23

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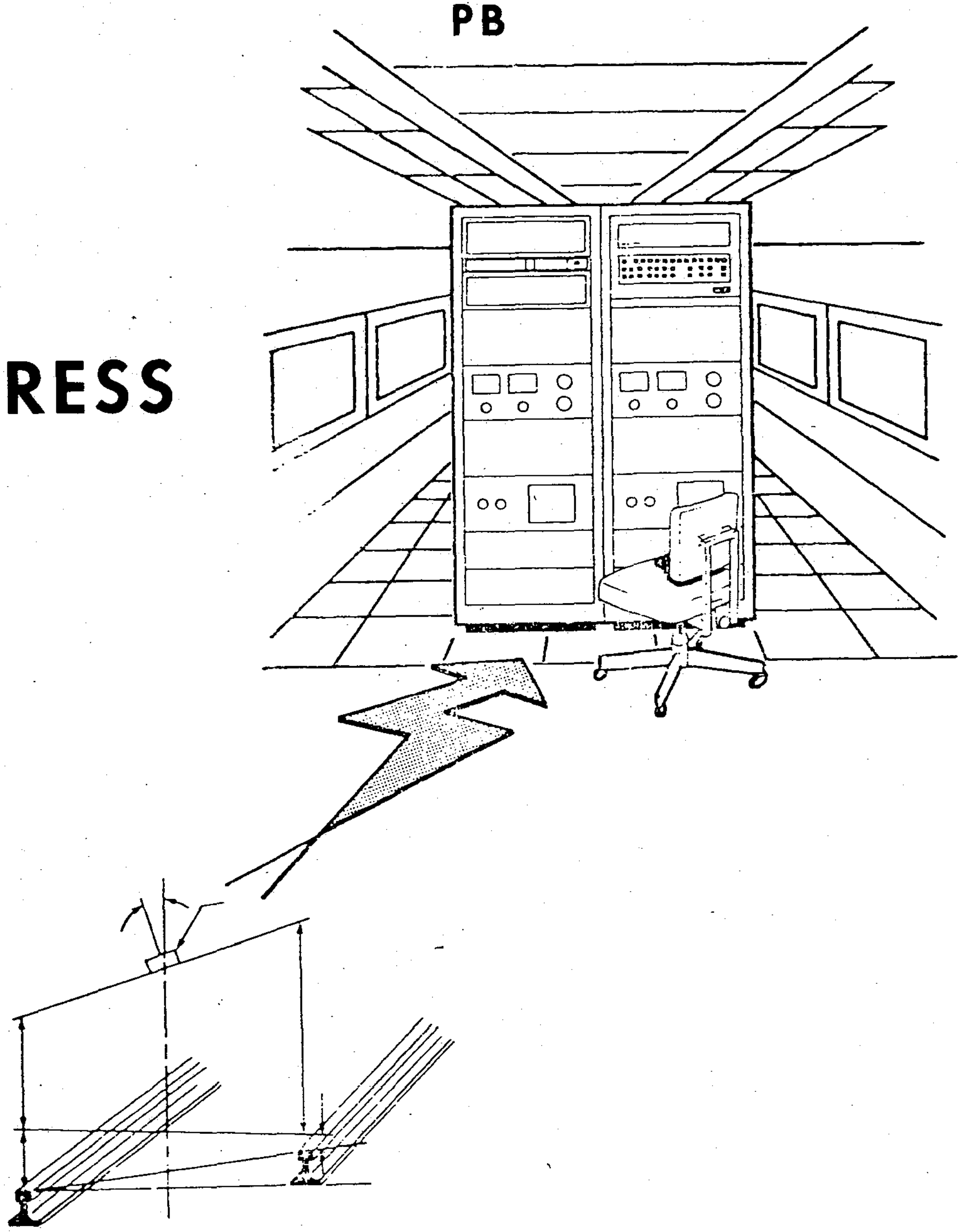
TEST TRAIN PROGRAM NINTH PROGRESS REPORT



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16. Abstract

This report describes progress on the Engineering and Test Support Services for Railroad Instrumentation, Data Acquisition, Processing and Evaluation Program from 1 July 1976 through 30 June 1977. The report covers operation of the FRA track geometry measurement and data acquisition fleet, track survey operations and vehicle dynamic tests on lightweight flat cars, DOD cars, passenger cars and locomotives. Also, the report describes test activities on the Facility for Accelerated Service Testing, aerodynamic validation, track structures, vehicle vibration and ride quality, trailer-on-a-flat-car combinations; and investigations of the automated wayside inspection station concept.

This report is intended for use by management and technical personnel concerned with accomplishments in railroad engineering.

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Track Geometry Measurement, Rail Research Data Collection, FAST, LWFC Testing, Aerodynamic Tests, Ride Quality and Locomotive Tests; Automated Wayside Inspection	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

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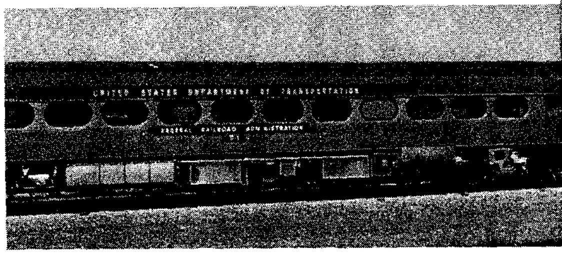
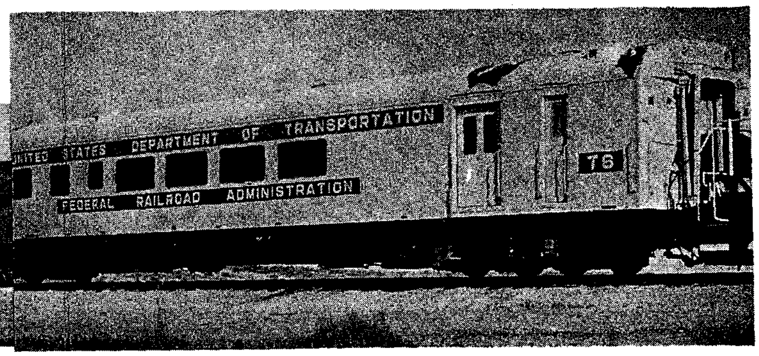
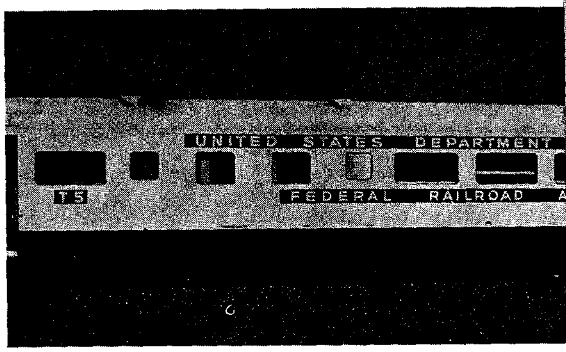
LIST OF ABBREVIATIONS

AAR	- Association of American Railroads
ALD	- Automatic Location Detector
AWIS	- Automated Wayside Inspection Station
CAS	- Compensated accelerometer system
COFC	- Container on a flat car
DODX	- Department of Defense Experimental
DOT	- Department of Transportation
EMD	- Electromotive Division of General Motors Corporation
FAST	- Facility for Accelerated Service Testing
FRA	- Federal Railroad Administration
GSI	- General Steel Industries
ISO	- International Standardization Organization
LIMV	- Linear induction motor vehicle
LRC	- Lightweight-Rapid-Comfortable train
LWFC	- Lightweight Flat Car
MDV	- Mobile Data Van
MOW	- Maintenance-of-way
NTIS	- National Technical Information Service
OFS	- Office of Freight Systems
OHSGT	- Office of High Speed Ground Transportation
OPS	- Office of Passenger Systems
ORD&D	- Office of Research, Development and Demonstrations
ORSR	- Office of Rail Safety Research
OS	- Office of Safety
OTR	- Over-the-road
PSD	- Power spectral density
RDL	- Rail Dynamics Laboratory
RFDV	- Rail Flaw Detection Vehicle
rms	- root-mean-square
RTT	- Railroad Test Truck
TOFC	- Trailer on a flat car
TSC	- Transportation Systems Center
TSD	- Track Survey Device
TTC	- Transportation Test Center
VSS	- Vertical Shaker System
W_z	- Wertungsziffer - factor used to quantify human comfort levels





TRACK GEOMETRY MEASUREMENTRACK GEOMETRY MEASUREMENT CAR T-6



DATA ACQUISITION CAI RAIL FLAW DETECTION VEHICLE

1.0 INTRODUCTION

This report describes progress on and results of the Engineering and Test Support Services for Railroad Instrumentation, Data Acquisition, Processing and Evaluation Programs from 1 July 1976 to 30 June 1977. The program is sponsored jointly by the Offices of Rail Safety Research, Safety, Freight Systems, and Passenger Systems of the Federal Railroad Administration (FRA). As a prime contractor to FRA, ENSCO operates and maintains a fleet of seven FRA test and data acquisition vehicles, collects and analyzes track geometry and vehicle dynamic data, develops improved track measurement techniques and performs special studies and tests to solve operating problems involving vehicle-rail interaction, car and truck design, catenary-pantograph interaction, locomotive derailments, and to advance the state-of-the-art in railroad engineering.

During FY 77, ENSCO conducted 42 tests which required the use of the test vehicles. Of these tests, 24 were track geometry surveys which covered 18,568 miles over 13 different railroads and the Transportation Test Center. Nineteen of the track geometry surveys, covering 15,638 miles, were in support of the Rail Inspection Program sponsored by the Office of Safety. The remaining 18 tests, covering 19,232 miles, were conducted in support of 11 special tests and 7 instrumentation checkouts.

The special tests involved evaluation of Metroliner truck improvements, lightweight flat cars, trailer-on-a-flat car combinations, DODX railcar stability, and ride quality of the Rohr Turboliner and the lightweight-rapid-comfortable train. Also included were extensive tests of the French ALSTHOM and the SDP-40F locomotives.

There were many improvements and innovations in software and data processing. The improvements (described in detail in Section 3.0) increased the usability of output material, improved efficiency and reduced cost.

2.0 OVERVIEW OF PROGRAM

2.1 HISTORY OF PROGRAM TO START OF CONTRACT YEAR 1977

The Test Train Program was inaugurated in March, 1966 by the United States Department of Transportation, Federal Railroad Administration, Office of Research and Development with MELPAR Incorporated as prime contractor. The program was named the Test Car Program at that time and remained at MELPAR until July 1969.

In July 1970, ENSCO Incorporated was named prime contractor and the program was renamed the Test Train Program.

The history of the program and the technical achievements resulting from studies and tests authorized and funded thereunder in the period March 1966 through June 1976 are detailed in a series of eight progress reports. These reports are listed for reference in Table 2-1 along with a brief description of work accomplished in the periods reported.

2.2 ACCOMPLISHMENTS DURING CONTRACT YEAR 1977

During the past year, the program has made significant contributions in supporting FRA contract objectives, i.e., "providing information on vehicles, track structures and other railroad equipment for a wide variety of FRA programs including improved freight and passenger vehicle design, improved track and track structures and various safety projects". On 11 June 1976, the project was manned by 65 people working on 16 different tasks. The fleet of vehicles assigned to the project included track survey consist T-1/T-3, a general purpose data acquisition vehicle T-5, and a special Track Survey Device.

During the year, 11 new tasks and 25 people were added to the project. Project growth is illustrated in Figures 2-1 and 2-2. The fleet of track survey consists is in the process of expanding to three with the addition of consists T-2/T-4 and T-6. The general purpose data acquisition fleet now includes T-7.

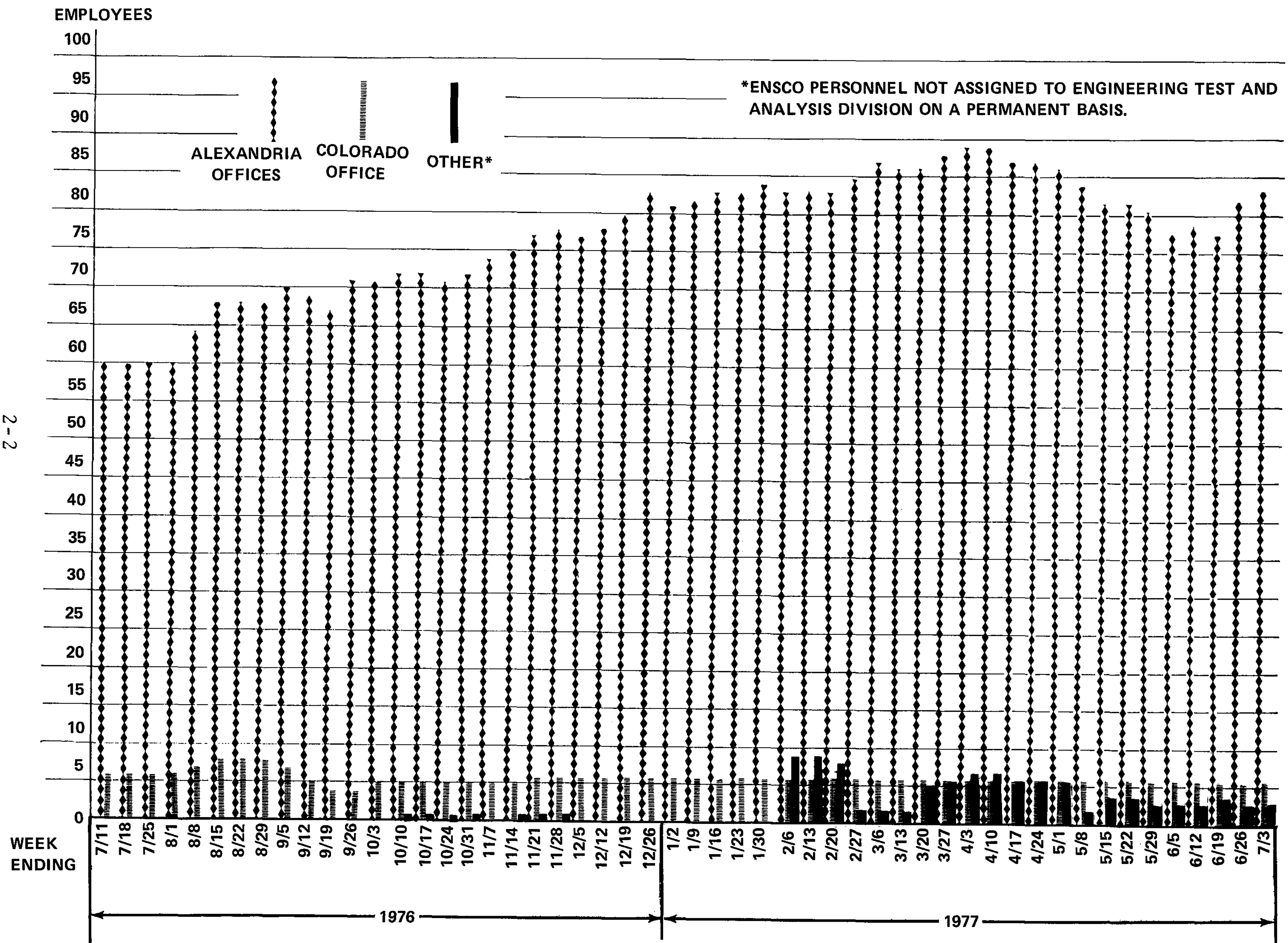


Figure 2-1. Manpower Assigned to Contract DOT-FR-64113 (July 76 - June 77)

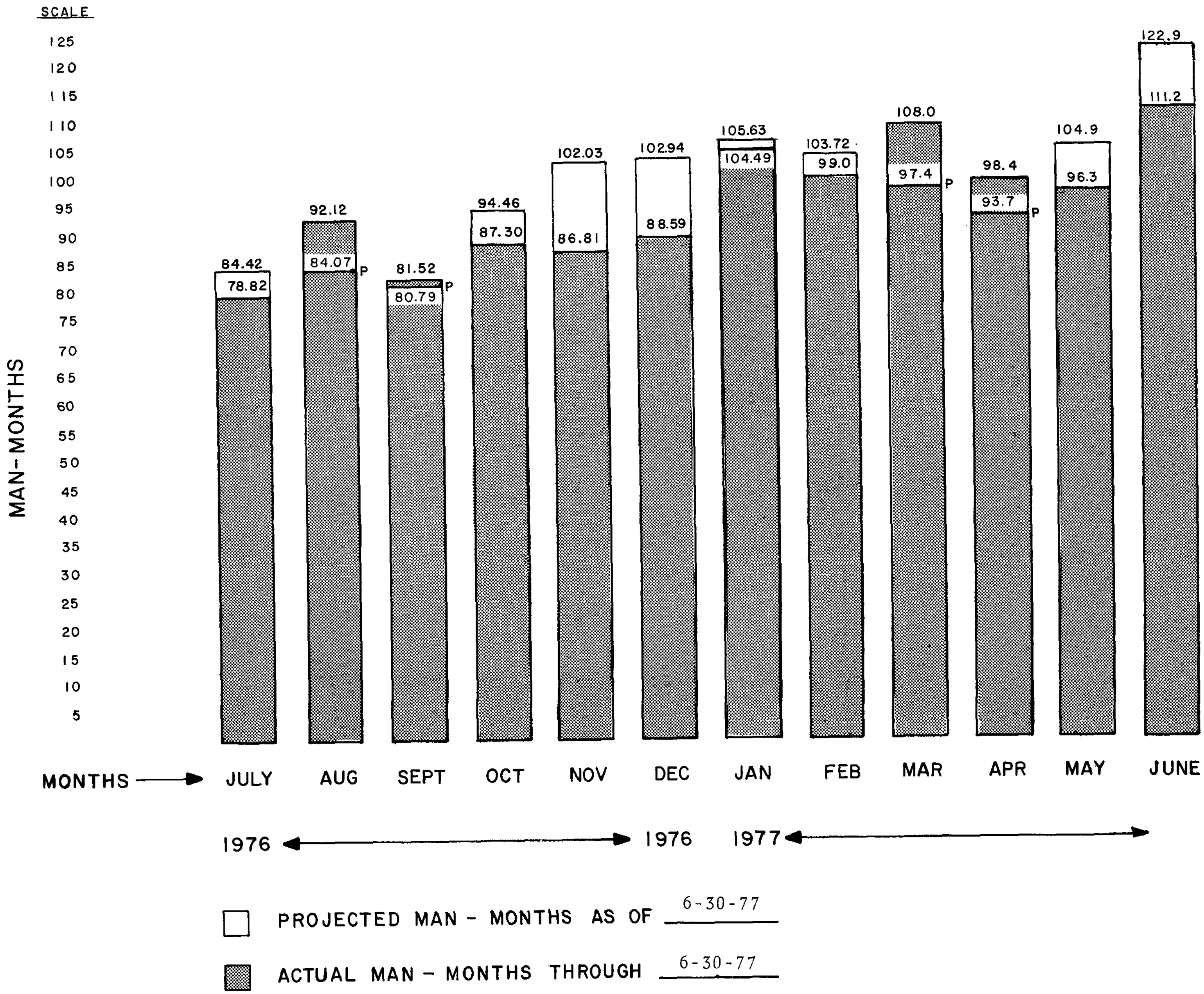


Figure 2-2. Man-Months (Expanded vs. Actual) Contract DOT-FR-64113
July 1976 - June 1977 (Monthly)

TABLE 2-1

LISTING OF PROGRESS REPORTS - TEST TRAIN PROGRAM

PERIOD COVERED	REPORT NUMBER	TITLE	CONTRACT	SPONSOR-ING AGENCY	PRIME CON-TRACTOR	ABBREVIATED DESCRIPTION OF WORK ACCOMPLISHED
3 March 1966 through 30 Nov 1968	Unknown	Test Car Program First Progress Report (May be obtained from NTIS as Document No. PB 182470	C-111-66	DOT OHSGT	MELPAR	Development of an operational system for high-speed non-contact measurement of track geometry characteristics in support of the Metroliner Demonstration Program.
1 Dec 1968 through 31 July 1969	FRA-RT-71-48	Test Car Program Second Progress Report (May be obtained from NTIS as Document No. PB 195400)	C-111-66	DOT OHSGT	MELPAR	Improvement and refinement of existing systems. Development of a signal conditioner for gage sensors, a magnetic pulser for improved speed and distance measurement and new sensor configurations to improve accuracy and reliability of track measurements. System performance was improved by special purpose calibration devices, modified electronics, more extensive filtering and improved accelerometers. Data processing techniques and data displays were improved. Track geometry runs were made using the DOT test cars.
July 1970 through June 1971	DOT-FR-71-2	Test Train Program Third Progress Report (May be obtained from NTIS as Document No. PB 209762)	DOT-FR-00015	DOT OHSGT	ENSCO	Upgrading of test cars to full operational status. Improvements included a digital-tape, error-checker circuit and indicator panel, an analog gage linearizer, a track grade computer, an analog data monitor and a modified communications system. The test cars were operated on 12 tests covering 13,000 miles after new operating procedures were evolved and formalized. Data processing support was improved and advanced rail technology studies were made on LIMV track construction, design of a wheel/rail dynamics test facility, and development of instrumentation to measure wheel/rail forces.
July 1971 through June 1972	DOT-FR-72-09	Test Train Program Fourth Progress Report (May be obtained from NTIS as Document No. PB 226048)	DOT-FR-00015 and DOT-FR-20032	DOT ORD&D	ENSCO	Increasing operational test capability and effectiveness of the FRA test cars and advancing the state-of-the-art in the measurement of truck characteristics and vehicle response. Development of an algorithm and instrumentation to measure track curvature, and investigation of truck dynamic performance. Testing and accuracy validation of track survey device as well as development of software for same. Development of a Power Spectral Density Program to compute power spectral densiry of various track geometry parameters, a computer program for the Digital Data Acquisition System to permit loading of system programs from magnetic tape rather than from punched paper tape and a Brush chart reproduce program to permit multi-channel, pen-chart recordings after converting previously recorded digital data. Major refinements were developed for the profile and crosslevel programs. The test cars were operated on 12 tests covering 4601 miles.
July 1972 through June 1973	FRA-ORD&D-75-19	Test Train Program Fifth Progress Report (May be obtained from NTIS as Document No. PB 241419	DOT-FR 20032	DOT ORD&D Rail Systems Division	ENSCO	The test cars were used on nine track geometry surveys covering approximately 6,000 miles. Baseline track quality indicators based on track geometry were developed for modeling studies. Long range planning procedures for track maintenance were developed. Design of and materials used for track structures were investigated. The effectiveness of automatic track geometry inspection was demonstrated. The test cars and the TSD were used to determine initial characteristics of the Kansas Test Track before it was opened to traffic, and to obtain

TABLE 2-1

LISTING OF PROGRESS REPORTS - TEST TRAIN PROGRAM

PERIOD COVERED	REPORT NUMBER	TITLE	CONTRACT	SPONSORING AGENCY	PRIME CONTRACTOR	ABBREVIATED DESCRIPTION OF WORK ACCOMPLISHED
						samples of representative track sections to support construction of a simulator at the Wheel/Rail Test Facility and to serve as input for mathematical models of rail vehicles. Nine other track geometry-related tests were performed to evaluate improved track measurement instrumentation. A catenary test was carried out to test the performance of two different pantographs. A study was conducted over 5,000 miles of track to evaluate stresses occurring in a box car during revenue service. The Mechanical Ballast Consolidator was evaluated and a general purpose digital data collection system was developed.
July 1973 through June 1974	FRA-ORD&D-75-25	Test Train Program Sixth Progress Report (May be obtained from NTIS as Document No. PB 247084	DOT-FR-20032	DOT ORD&D Rail Systems Division	ENSCO	The test cars were used in 38 tests on 15 different railroads covering 10,441 miles. The tests included 13 track geometry surveys, 13 instrumentation and demonstration tests and 12 dynamic tests requiring test car support. The dynamic tests included the Unit Steel Coil Train Test, the High-Speed Locomotive Test, AAR Truck Model Validation, the New Haven Catenary Survey and Instrumented Wheelset Testing. Instrumentation development included an inertial profilometer, a compensated accelerometer system, all-weather gage instrumentation, an instrumented wheel and a Portable Ride Quality System. Improvements were made in data processing and the GEOPLOT, COMPARE, INTEGRATE and CHANGER programs were developed. Special studies were made on test car instrumentation validation, long range maintenance planning, track degradation, ride quality, statistical characteristics of track and wheel/rail dynamics.
July 1974 through June 1975	FRA-OR&D-76-140	Test Train Program Seventh Progress Report (May be obtained from NTIS as Document No. PB 251186	DOT-FR-54174	DOT ORSR	ENSCO	The test cars were used on 47 operational tests covering 16,930 miles. This includes 28 track geometry surveys covering 14,037 miles on 9 different railroads and the Transportation Test Center, and 19 special tests and demonstrations covering 2,893 miles. The special tests included lateral/vertical force tests in support of the FRA/AAR track/train dynamics program, truck laterial stability tests for AAR, tank car coupler impact tests to verify a vertical-plane, train-impact-simulation model, DODX rail car stability tests, a ride quality test of the Lightweight-Rapid-Comfortable Train, an evaluation of a rail flaw detector, locomotive ride quality tests to obtain basic data on high frequency, high-energy vibrations generated at the wheel/rail interface, and a Metroliner-shell ride quality test. A servo-magnetic gage system, an improved profilometer sensor system and a redesigned compensated accelerometer system were developed. An Integrated Standards program was developed to analyze track geometry data for exceptions to FRA Standards and a ride quality software analysis package was designed to permit determination of ride quality as compared with international standards (ISO 2631).

TABLE 2-1

LISTING OF PROGRESS REPORTS - TEST TRAIN PROGRAM

PERIOD COVERED	REPORT NUMBER	TITLE	CONTRACT	SPONSORING AGENCY	PRIME CONTRACTOR	ABBREVIATED DESCRIPTION OF WORK ACCOMPLISHED
July 1975 through June 1976	FRA-OR&D-77-25	Test Train Program Eighth Progress Report	DOT-FR-54174 and DOT-FR-64113	DOT ORSR	ENSCO	The test cars were used on 56 operational tests covering 24,904 miles. This includes 34 track geometry surveys covering 23,667 miles on 19 different railroads and the Transportation Test Center, and 22 special tests and checkouts covering 1,237 miles. During this period, primary emphasis was on track surveys of heavily used mainline track as opposed to the research and development associated track surveys of previous years. The special tests included a feasibility study for converting an ambulance car to a general purpose data acquisition vehicle, a study of the stability of DOD rail cars used to transport nuclear materials, ride quality testing of a tracked air-cushion vehicle, testing acceleration levels inside the cab of an E-60 locomotive, track stiffness analysis, ride quality testing of a Metroliner, acceleration testing of the P-30 locomotive and the Rohr Turbotrain. A portable ride quality meter and vibration isolators for servo-accelerometers were developed. Both the servo-magnetic gage system and the portable ride quality package were improved. The Office of Safety track survey data processing programs were converted to improve efficiency and reduce costs. These programs included tape summary, PAKSTN, milepost generation, curve analysis and integrated standards.

In addition, a Rail Flaw Detection Vehicle has been added. As of 30 June 1977, the contract was supported by 90 people who were working on or have completed the following:

- For Office of Freight Systems
  - Eleven tasks which encompassed all categories of program management and administration, equipment maintenance and calibration, special testing, test car operation, computer programming and data processing.
  - Provided engineering support for the FAST program which included test and repair of existing instrumentation, design and fabrication of new instrumentation, design of mounting hardware, fabrication of signal conditioning electronics, test and wiring of strain gages, design of system cabling and layout, conduct of tests and design of the data reduction format.
  - Provided engineering support for the LWFC special tests which included design and installation of instrumentation, performing tests, collection of data, programming, data reduction and mathematical analysis to define vibrations encountered during TOFC and COFC operations.
  - Design, fabrication and installation of instrumentation, design of data reduction software and performance of tests to determine aerodynamic effects on a TOFC configuration.
  - Provided engineering and technical support for maintenance and operation of the Rail Flaw Detection Device.

- For Office of Rail Safety Research
  - Twelve tasks which encompassed all categories of program management and administration, equipment maintenance and calibration, special testing, test car operation, computer programming and data processing.
  - Support for a major FRA test program on the SDP-40F locomotive.
  - Initiation of a system design for an automated Wayside Inspection Station (AWIS).
  - Performance of extensive track survey measurements and the data collection, processing and interpretation associated therewith.
  - Programming, data processing and analysis of track stiffness data. Summarized these in a report along with detailed description of track stiffness test techniques and use of track stiffness test equipment. Recommended further development of track stiffness algorithms including track/roadbed signature modeling and operational use of track stiffness data.
  - Converted the MOWS and MOWP Programs to run on the Raytheon RDS-500 computer. The conversion also included the Integrated Exception and the GEOPLOT Programs.
  - Digitized, analyzed and processed vehicle vibration data collected on a P30 locomotive.
  - Provided analysis and documentation of the operation, maintenance and utilization of the Rail Flaw Detection Vehicle.

- For Office of Safety
  - Eight tasks which encompassed all categories of program management and administration, equipment maintenance and calibration, special testing, test car operation, computer programming and data processing.
  - Planned, implemented, and provided data processing service and reported the results of 19 track surveys in accordance with FRA(OS) requirements through June 1977. These surveys covered 15,638 miles of revenue track in the USA.
  - Trained FRA Rail Inspectors in the use of the RFDV and completed an operations plan for the RFDV hyrail vehicle.
- For the Office of Passenger Systems
  - Seven tasks which encompassed all categories of program management and administration, special testing, test car operation, computer programming and data processing.
  - Provided engineering support on the GSI Metroliner truck improvement program, a locomotive test plan, a flammability test, ride-quality-software maintenance, T-7 computer system operation, Rohr Turboliner analysis, SDP-40F derailment study, track perturbation definition, maintenance of ride quality hardware, LRC testing, development of triaxial accelerometers and development of the W_z method for evaluating ride performance.
  - Provided operational support for the T-7 Test Car.

- Supported identification and selection of strain gage instrumentation for locomotive wheelsets.
- Designed, fabricated, installed and tested the data acquisition system for the T-7 Test Car.

Efforts to develop new multi-consist maintenance concepts and to identify design improvements in the instrumentation installed on test vehicles continue. The ultimate goals of these efforts are to minimize down time, to provide automatic calibration and to improve quality control to the point where nominal operation approaches the zero-defects condition.

In cooperation with FRA, ENSCO personnel studied statistics on and past history of car inspection by maintenance personnel, as opposed to automated inspection by strategically placed wayside inspection stations. This study has been focused on degree and sophistication of testing from the technical and quality control standpoints, need for particular tests from practical and economic considerations, and cost trade-offs to justify the costs involved in installation, operation and maintenance of wayside inspection stations. Effort has also been expended to identify cost savings that would be produced in the areas of personal injury together with repair and down time of equipment by means of preventive maintenance triggered by frequent and detailed inspection before an accident occurs.

Additional evaluation was made of the concept of using maintenance support teams on track survey vehicles. Meetings were held with operational and maintenance personnel to clearly delineate vehicle maintenance and operational crew responsibilities. In addition, preliminary estimates were made concerning the amount of additional survey time that could be realized due to increased up-time resulting from the use of track-survey-vehicle maintenance teams.

2.3 WORK IN PROGRESS AND BEING CARRIED FORWARD INTO CONTRACT YEAR 1978

The following projects are in progress and being carried forward into Contract Year 1978:

- Maintenance and calibration of the test and data acquisition vehicles and the instrumentation installed therein. This includes improving test instrumentation and software, implementing better maintenance procedures, and more efficient use of maintenance manpower.
- Track survey operations for ORSR, OS and special tests and data processing associated therewith.
- Special tests of lightweight flat cars.
- Full scale aerodynamic validation tests of trailer-on-a-flat-car (second series).
- Rail flaw detection systems support.
- Metroliner truck improvement.
- Firestone Air Bag testing.
- Ride quality testing and associated software processing.
- Evaluation of candidate locomotives for near-term use on the Northeast Corridor.
- Testing of eddy current brakes.
- Studying "lessons learned" in the introduction of new equipment into revenue service.
- Refurbishing and return to service of test consist T-2/T-4.
- Development of a functional specification detailing a bypass instrumentation layout and design of software for an Automated Wayside Inspection Station at TTC.
- Development of a detailed performance specification for a self-propelled Mobile Automated Wayside Inspection Station.

- Support for the data analysis phase of the SDP-40F/E-8 dynamic locomotive tests.
- Track stiffness system evaluation testing.
- Track survey operations in support of the Iowa Department of Transportation.

3.0 TRACK SAFETY STANDARDS SURVEY OPERATIONS

3.1 INTRODUCTION

During the period 1 July 1976 through 30 June 1977, ENSCO conducted 42 tests in support of the Federal Railroad Administration's program to improve and update United States railroad operations. Of these tests, 24 were track geometry surveys, 19 of which involved surveys for the Office of Safety over revenue producing track.

Table 3-1 is a summary of the test statistics by category. Included with each category are the number of tests, the number of days during which testing took place, a listing of the test numbers, and the total mileage tested. Each category is discussed in detail later in this section. Table 3-2 provides detailed information on the purpose and results of each test.

3.2 IMPLEMENTATION

3.2.1 TRACK SURVEYS

Track geometry surveys using the FRA test cars accounted for approximately 57 percent of the total testing effort and resulted in 18,568 miles of surveyed track (Table 3-1). Track geometry surveys can be identified in Table 3-2 by those test numbers which are preceded by the letters RG.

These surveys were conducted on 13 railroads and at the Transportation Test Center near Pueblo, CO. Railroads on which testing was accomplished were:

AMTRAK
Atchison, Topeka and Santa Fe
Bessemer and Lake Erie
Chessie System (B&O/C&O)
Chicago and Northwestern
Chicago Rock Island and Pacific

TABLE 3-1. SUMMARY OF TEST STATISTICS*

TEST CATEGORY	NO. OF TESTS	NO. OF DAYS TESTED	NO. OF MILES TESTED	TEST NUMBERS
Office of Safety Measurement Surveys	19	84	15,638	RG-169, RG-196, RG-200, RG-201, RG-203, RG-205.1, RG-208.1, RG-209.1, RG-212.2, RG-215, RG-216.1, RG-218, RG-220 RG-221, RG-224, RG-225, RG-236/248, RG-237, RG-238
Annual/Semi-Annual Maintenance Planning Surveys	3	15	2,253	RG-213, RG-219, RG-253
Track Geometry Surveys in Support of SDP-40 Testing	1	3	676	LV-255
Special Track Surveys	1	1	1	RG-204
Track Survey Test Sub-Total	24	103	18,568	See Above
Special Tests	11	181	16,309	CV-128.2, CV-128.4, CV-192, SV-206, SV-210, RR-211, RR-214, MM-223, LG-249, RR-251, RR-254
Instrumentation Checkout Tests	7	82	2,925	RI-177.6, RI-177.7, RI-177.8, RI-199.3, RI-226.1, RI-226.2, RI-226.3
TOTAL	42	366	37,800	

* Test number codes can be identified using the list of test codes contained in Appendix A.

TABLE 3-2. FRA RAIL RESEARCH PROGRAM TESTS DURING FY77

TEST NUMBER	TEST TITLE	LOCATION	DATE	RAILROAD	DISTANCE TESTED (MILES)	NO. OF TEST DAYS
CV-128.2	LWFC Mode Shape Tests	LaJunta, CO area	17 Aug - 23 Sep 1976	Atchison, Topeka & Santa Fe	28	11
CV-128.4	LWFC Over-the-Road Tests	Los Angeles, CA to Kansas City, KS	12 Dec - 18 Feb 1977	Atchison, Topeka & Santa Fe	12,257	24
RG-169	Track Survey	Chicago, IL to Pittsburg, PA	15-16 Jul 1976	CONRAIL	445	2
RI-177.6	Maintenance & Inspection	Denver, CO	10 Oct 1976	Denver & Rio Grande Western	30	1
RI-177.7	Maintenance & Inspection	Alexandria, VA to Charlottesville, VA	30 Nov - 9 Dec 1976	Southern	275	5
RI-177.8	Maintenance & Inspection	Alexandria, VA to Richmond, VA and Washington, DC to Baltimore, MD	31 Jan - 12 Feb 1977	Richmond, Fredericksburg & Potomac and AMTRAK	588	8
CV-192.1	TOFC Test	Pueblo, CO	12 Aug - 21 Nov 1976	Transportation Test Center	588	9
RG-196	Track Survey	Newton, KS to Houston, TX	8-15 Sep 1976	Atchison, Topeka & Santa Fe	856	6
RI-199.3	T-2/T-4 Acceptance	Kansas City, KS to Topeka, KS	10-18 Aug 1976	Atchison, Topeka & Santa Fe	150	3
RG-200	Track Survey	Chicago, IL to Rock Island, IL to Peoria, IL	13-14 Jul 1976	Chicago, Rock Island & Pacific	392	2
RG-201	Track Survey	Kansas City, KS to Emporia, KS	7 Sep 1976	Atchison, Topeka and Santa Fe	128	1
RG-203	Track Survey	Chicago, IL to Harmon, NY	28 Jun - 9 Jul 1976	CONRAIL	1,658	7
RG-204	Track Survey	Chicago, IL	12 Jul 1976	Chicago and North Western	1	1
RG-205.1	Track Survey	Kansas City, MO to Beaumont, TX	19-30 Jul 1976	Kansas City Southern	1,248	7
SV-206	DODX Railcar Stability Test	Pueblo, CO	13, 27 Jul 1976	Transportation Test Center	N/A	2
RG-208.1	Track Survey	Ft. Worth, TX to Quad Cities (Silvis)	23 Aug - 3 Sep 1977	Chicago, Rock Island & Pacific	760	6
RG-209.1	Track Survey	Topeka, KS to Colorado Springs, CO	4-7 Oct 1976	Chicago, Rock Island & Pacific	520	4
SV-210	FAST Support	Pueblo, CO	Oct-Nov 1976 & Feb 1977	Transportation Test Center	90	6
RR-211	T-7 Ride Quality	Washington, DC to Wilmington, DE	Sep 1976	AMTRAK	9	1
RG-212.2	Track Survey	Newton, KS to Albuquerque, NM	16-24 Sep 1976	Atchison, Topeka & Santa Fe	769	4
RG-213	Track Survey	Denver, CO to Ogden, UT	8-17 Oct 1976	Denver & Rio Grande Western	1,362	7
RR-214	Rohr Turboliner: Northeast Corridor Ride Quality	Washington, DC to Newark, NJ	29 Sep 1976	AMTRAK/CONRAIL	400	1

TABLE 3-2. FRA RAIL RESEARCH PROGRAM TESTS DURING FY77 (Cont'd)

TEST NUMBER	TEST TITLE	LOCATION	DATE	RAILROAD	DISTANCE TESTED (MILES)	NO. OF TEST DAYS
RG-215	Track Survey	Pueblo, CO	20 Sep 1976	Transportation Test Center	5	1
RG-216.1	Track Survey	Amarillo, TX to Topeka, KS	28 Sep - 1 Oct 1976	Chicago, Rock Island and Pacific	663	4
RG-218	Track Survey	Chicago, IL to New Orleans, LA	3-20 May 1977	Illinois Central Gulf	1,876	9
RG-219	Track Survey	North Bessemer, PA to Conneaut, OH	1-5 Nov 1976	Bessemer and Lake Erie	470	4
RG-220	Track Survey	Washington, DC to Boston, MA	15 Feb - 4 Mar 1977	AMTRAK/CONRAIL	1,758	11
RG-221	Track Survey	Omaha, NE to Silvis, IL	19-21 Oct 1976	Chicago, Rock Island and Pacific	342	2
MM-223	RFDV Support of FAST	Pueblo, CO	17 Sep - 30 Jun 1977	Transportation Test Center	575	108
RG-224	Track Survey	Jamestown, NJ to Marion, IN	3-4 Nov 1976	CONRAIL	435	2
RG-225	Track Survey	Chicago, IL to Council Bluff, IA	12-15 Apr 1977	Chicago and North Western	990	4
RI-226.1	T-6 Checkout	Alexandria area	Dec 1976 - Mar 1977	Southern	1,800	40
RI-226.2	T-6 Repeatability Testing	Alexandria, VA to Wilmington, DE	7-16 Apr 1977	Southern/AMTRAK	60	5
RI-226.3	T-6 Functional Checkout	Pueblo, CO	May - Jun 1977	Transportation Test Center	20	20
RG-236/248	Track Survey	Washington, DC to St. Louis, MO and Cincinnati, OH to Charlottesville, VA	16-23 Mar 1977	Chessie System (B&O/C&O)	1,848	7
RG-237	Track Survey	Kansas City, MO to Memphis, TN	21-22 Apr 1977	St. Louis - San Francisco	490	2
RG-238	Track Survey	Memphis, TN to New Orleans, LA	26-28 Apr 1977	Illinois Central Gulf	455	3
LG-249	French Locomotive Testing	Washington, DC to New Haven, CT	24-25 Mar 1977	CONRAIL	20	2
RR-251	LRC Quality Test	East Lyme, CT & Princeton Junction, NJ	17-30 Mar 1977	CONRAIL	62	4
RG-253	Track Survey	North Bressemer, PA to Conneaut, OH	4-7 Apr 1977	Bessemer and Lake Erie	421	4
RR-254	Metroliner Track Improvement Testing	Wilmington, DE to Baltimore, MD	5-30 Jun 1977	CONRAIL	2,280	13
LV-255	Support SDP-40 Test	Huntington, WV to Charlottesville, VA and return	8-10 Jun 1977	Chessie System (B&O/C&O)	676	3

Consolidated Rail Corporation (CONRAIL)
Denver and Rio Grande Western
Illinois Central Gulf
Kansas City Southern
Richmond, Fredericksburg and Potomac
St. Louis and San Francisco
Southern
Transportation Test Center (TTC)

For convenience of discussion, the track surveys are subdivided into four areas: (1) Office of Safety surveys; (2) annual/semi-annual maintenance planning surveys; (3) special surveys; and (4) track geometry survey in support of SDP-40F testing.

3.2.1.1 Office of Safety Surveys

During FY77, 19 track measurement surveys were completed for the Office of Safety. These surveys involved 84 days of testing covering 15,638 miles of track. Test numbers of these surveys are listed in Table 3-1.

3.2.1.2 Annual/Semi-annual Maintenance Planning Surveys

Two railroads, the Bessemer and Lake Erie (B&LE) and the Denver and Rio Grande Western (D&RGW), are cooperating with the FRA in a long range track maintenance planning study. The FRA track inspection cars are used to perform surveys on these railroads at regular intervals to determine patterns of track deterioration. This information is combined with railroad data on traffic loads, and the amount and type of maintenance performed between track surveys to determine future maintenance actions. Anticipated benefits of this program for the railroad industry and the Government include:

- Improved information for long range maintenance planning.
- Improved control of maintenance-of-way budget allocations.

- Establishment of parameters for quality control of track maintenance.
- Improved track safety through the application of continuous, automated, track geometry inspection.
- Development of data processing programs to process the data collected and to display the results in user-oriented formats tailored for different management levels.

Historical data over a period of six years exists for the tracks of these railroads. The B&LE is surveyed twice yearly (in the spring and in the fall) and the D&RGW is surveyed once a year (in the fall). Both railroads utilize the data in scheduling long range maintenance efforts.

During FY77, three surveys were conducted under this cooperative program: (1) fall semi-annual survey (RG-219) for the B&LE; (2) annual survey (RG-213) for the D&RGW; and (3) spring semi-annual survey (RG-253) for the B&LE.

3.2.1.3 Special Surveys

Track survey RG-204.1 was conducted in support of a special test to obtain track measurement data on Chicago and Northwestern test track near Chicago. The purpose of the test was to collect track geometry data over a one-mile test section of track containing eight different groups of tie configurations.

3.2.1.4 Track Geometry Survey in Support of Locomotive Testing (SDP-40F/E-8)

The purpose of the track geometry survey was to provide track measurement data for use in site selection. The consists were operated from Huntington, WV to Charlottesville, VA and back to Huntington. Track measurement data was recorded over the entire route.

3.2.1.5 Special Tests

Special testing was conducted throughout the report period. Track geometry measurements performed as part of these tests are discussed in Sections 4.0 through 11.0.

3.3 INSTRUMENTATION

3.3.1 CHECKOUTS

Instrumentation checkouts were performed either to verify the operation of existing equipment or to validate the performance of new equipment. The following paragraphs provide a brief summary of these tests.

3.3.2 MAINTENANCE AND INSPECTION

The purpose of operational survey RI-177 was to evaluate the reliability of the instrumentation on FRA Test Cars T-1/T-3 and T-2/T-4 during operational over-the-road surveys, and to validate different crosslevel systems. Four experimental crosslevel systems were tested and evaluated; this resulted in the upgrading of all Compensated Accelerometer Systems. The test runs resulted in the acquisition of accurate, repeatable data and, therefore, the cars were considered fully operational.

3.3.3 T-2/T-4 ACCEPTANCE

The purpose of test RI-199 was to conduct validation and acceptance testing of Test Cars T-2/T-4. The test was conducted in accordance with the requirements of the acceptance and validation task of Contract DOT-FR-54190 and the T-2/T-4 Acceptance Test Plans approved by FRA on 6 March 1976. As an added verification of the T-2/T-4 system, ENSCO engineering used advanced CAS technology available on T-1/T-3 and compared it to the T-2/T-4 CAS systems. During all tests, instrumentation verifications were conducted on T-2 and T-3 instrumentation to insure that all data was accurate and comparable.

3.3.4 T-6 FUNCTIONAL CHECKOUT

The purpose of test RI-226 was to conduct repeatability tests on and functional checkout of the total Rail Flaw and Data Acquisition systems on the T-6 vehicle. Class 2 and Class 6 repeatability tests have been completed. Rail Flaw and Data Acquisition systems functional checkouts are continuing.

3.4 SOFTWARE AND ANALYSIS

Software has been designed and used for many different tests; however, only use in Office of Safety and Office of Rail Safety Research surveys is described here. Software designed for special tests will be described under each individual special test.

3.4.1 OFFICE OF SAFETY TRACK SURVEY SOFTWARE

The software for the Office of Safety track surveys has gone through a continuous evolution in response to the needs of the contract.

Over the year, data was processed for 23 different Office of Safety surveys. This data covered 33 weeks of survey operations. All data for these surveys was brought to ENSCO, examined, processed, validated, prepared and delivered to FRA. During the year, turnaround time was reduced from approximately 2 weeks to the current figure of 3-5 working days per survey week by improving both computer and manpower operating efficiency.

3.4.1.1 Train-borne Geometry System

The GEOMETRY program is the real-time system that controls the collection of track geometry data on survey consist T-1/T-3. Early in the contract period, data was being collected and digitized with 8 bits of accuracy per channel. Therefore, in a ±10-volt channel, the smallest unit of significance had a value of 0.078125 volts. While this appears to be a rather small unit of significance, it did not provide the desired level of resolution. To improve resolution, a change was made to the

GEOMETRY program to allow the digitizing of data at 12 bits of accuracy per channel; this produced a value of 0.00488281 volts as the smallest unit of significance in a ±10-volt signal. This modification required a similar modification to the PACK program to accomodate the increased resolution. The value of this increase in resolution is that it provided more accurate measurement and analysis of track geometry parameters.

3.4.1.2 PACK Program

The purpose of the PACK program is to take the raw magnetic data tapes containing unprocessed signals and combine and convert them in order to produce an output tape with the desired parameters expressed in engineering units. Once the tape is in this form, it may be used as input to any of a variety of programs for data analysis and reduction.

During the period, many modifications were made to the PACK program in order to accomodate hardware changes and customer desires as well as to improve the quality of the output data and the speed with which it could be produced.

There are, in actuality, two different PACK programs: one is PAKSTN, used in the processing of data collected on survey consist T-1/T-3; the second is called PKST24 and manipulates data collected on survey cars T-2/T-4.

3.4.1.2.1 PKST24 Program - The T-2/T-4 PACK program did not exist at the beginning of this period. When T-2/T-4 became operational under this contract, processing track geometry data collected by this consist became necessary. Investigation revealed that T-2/T-4 computations and tape formats differed from those used on T-1/T-3 to such a degree that the existing PAKSTN program could not be used. It was determined that the most efficient way to use the data from T-2/T-4 for Office of Safety survey work was to create a tape that could be used as an input tape to a STANDARDS program and that would be in the same format as T-1/T-3 PACK data tapes. A tape from either consist could then be used as input for the STANDARDS program and identical processing steps could be followed for both consists. This reduced programming time since downstream preparation programs already existed, and with minor modifications could be used for T-2/T-4 data. This also saved a great deal of training time because currently existing techniques could be used rather than a new processing sequence.

This program was designed and written using techniques parallel to those used in the PAKSTN program. The APOLLO (Array Transfer Processor) was used in order to reduce processing time. In less than a month and a half, the PKST24 program was written, checked, and ready for use.

3.4.1.2.2 Multi-Volume Capability - Because of multiple failures of the tape drives on the RDS-500 system, it was often necessary to use the 7-track tape drive during the running of the PACK program. Because the same amount of data produces a longer record on a 7-track drive than on a 9-track drive, it was necessary to have the capability for producing a multi-volume output tape from a single input tape. A change was made to both PACK programs to add this capability. This change permits use of the full storage volume of the raw data tapes and provides an acceptable back-up in case of the failure of one of the tape units.

3.4.1.2.3 Substitution Option - The survey cars have two systems for measuring gage: capacitive and magnetic. The magnetic gage system provides greater accuracy and is not prone to malfunctions caused by rain. Thus, it is used most often during survey run processing.

The magnetic gage has one serious drawback in that the sensors must be raised while going through switches and road crossings. It is in these areas that important data often occurs. In order to make full use of both systems, an option was added to the PACK program. When this option is enabled, it automatically substitutes the capacitive gage values for the magnetic gage output whenever the magnetic gage sensors are raised. This option reduces the amount of data lost during magnetic sensor up-cycles and permits full utilization of both systems.

During implementation of this option, changes were made to the PACK program to increase efficiency; this resulted in a five percent reduction in the computer time required for analyzing the data.

3.4.1.2.4 ALD Analysis - Exceptions (defects) found in survey data are designated in the Standards Report by milepost number and footage. This method of designation often makes the determination of defect location difficult. For instance, if an exception is located at milepost 58 + 4200 feet, it is often difficult to accurately pace off the 4200 feet from the milepost. In addition the milepost itself is only accurate to within about 20 feet.

In an attempt to reference exceptions more accurately to actual track structures, a modification was made to print out the location of all switches and road crossings. This involved the analysis of the ALD (Automatic Location Detector) trace for representative signatures of these structures. A modification was made to the PACK program to set an indicator bit when one of these events occurs. These bits can then be examined by the various data reduction programs to produce an output locating these events.

3.4.1.2.5 Accomodation of 12 Bits of Digitized Sensor Data - As discussed previously, a change was made to the GEOMETRY data collection system to permit 12 rather than 8 bits of sensor data to be digitized. This change caused a restructuring in the format of the output tape. Thus, changes were required in the PACK program to make full use of these extra bits of digitized data. These program changes were determined, accomplished and the results verified before they were used to process actual survey data.

3.4.1.3 STANDARDS PROGRAM

The Standards program takes the data tape created by the PACK program and, with a table of class and speed information, produces the Standards Report. This report lists all track geometry deviations from FRA Safety Standards and produces summaries of the exception information by milepost. This output, in an edited form, is the final product of survey runs and is delivered to the FRA, the railroads, and other interested agencies.

Since this is the most visible output from the surveys, it is under constant modification. These modifications include accomodation of new equipment, changes to existing hardware, format changes requested by the Office of Safety and internal changes to improve efficiency of processing techniques.

As mentioned previously, the addition of survey consist T-2/T-4 has required many software changes and additions. Of particular concern to the STANDARDS program was the fact that this new consist has a one-foot sample length while consist T-1/T-3 has a 2.4-foot sample length. While this provides an improvement in resolution of exceptions, it creates some problems in terms of program operation. Many algorithms, especially those dealing with curve detection, require looking ahead in the data for distances often exceeding 200 feet. When using a 2.4-foot sample length, 200 feet of data requires 80 sample points whereas this same distance, using a one-foot sample length, requires 200 data sample points stored in core. In order to accomodate the one-foot sample on T-2/T-4, it was necessary to expand the size of the arrays within the program. At the same time, improvements were made in end-of-file, parity and sequence error accounting. These changes improved program efficiency but did not completely eliminate the effect that larger numbers of data points had on program run time. Thus, any amount of track miles surveyed by consist T-2/T-4 takes longer to process than the same number of track miles surveyed by consist T-1/T-3. There are 2.4 times as many data points per mile to examine with T-2/T-4 data then with T-1/T-3 data.

Office of Safety representatives requested certain format changes which did not affect the information presented in the report but did remove some redundant and outmoded portions of the output. The net effect was a clearer, less cluttered report that is easier for field personnel to use.

In the past, much of the data was divided into ten-mile sections called locations. These locations were started at an identifiable physical structure (i.e., a switch or road crossing). All exceptions were listed as a distance from this structure; this was cumbersome since a particular defect could be 9 miles and 4000 feet from a particular structure and finding such a point was too difficult. A more accurate method of designating mileposts was developed and exceptions are listed by milepost plus footage. This makes location of exceptions much easier. Location distances were initially kept in the report as a backup (Figures 3-1 and 3-2).

FRA requested the deletion of these location distances and their designation was removed from the formal output. This affected the detailed report and the class-change-summary sections of the Standards Report (Figures 3-3 and 3-4).

When consist T-2/T-4 became operational, it was necessary to determine which consist was used to collect the data. To provide this information, an indicator bit was placed in the record header of each packed data tape. By interrogating this bit, the programmer could determine which sample length to use and the consist name was printed at the top of each page of the Standards Report and the summaries (Figures 3-3 through 3-6).

The Class Summary portion of the Standards Report initially contained certain information relating to curve-limiting speeds (Figure 3-7). With the addition of the Curve Summary to the Standards Report, such information became redundant and was sometimes misleading. In order to provide a less cluttered and more useful format, this curve limiting information was removed from the Class Summary (Figure 3-6).

```
INTEGRATED TRACK GEOMETRY SAFETY STANDARD REPORT-MOD G   ACQUISITION  61017      PROCESSED  11/08/76          PAGE.  1
  LOC X93                       (MP93.2-86.1)

  LOCATION : 93                TRACK NUMBER :  1                CLASS  4 TRACK
                      PROFILE                       GAGE          XLEVEL         WARP       SPEED      FACT
THRESHOLDS (IN.)---- (2.000)                       (57.25)        (1.250)        (1.250)     (MPH)
                                              CURVE-(57.50) SPIRAL-(1.000) SPIRAL-(1.000)
                   N   RAIL         S   RAIL          MAX    O/A      MAX    O/A     MAX                              LOCATION
 MP   DIST       MAX  O/A         MAX  O/A            EXC    DIST     EXC    DIST    EXC  LENGTH                      MILE DIST


  93 -3987                                       --SENSORS DOWN--                                                     0  220


* 92 -4186                                       --SENSORS UP--                                                       1  423
* 92 -4488                                       --SENSORS DOWN--                                                     1  725

* 91 -4550                                                    1.95 R   73                          62        T        2  685

* 90  -807                                                   -1.64 R   14                          59        T.       2 2205
* 90 -2475                                       --SENSORS UP--                                                       2 3872
* 90 -2786                                       --SENSORS DOWN--                                                     2 4184
* 89  -539   CHANGE TO CLASS   2 TRACK                                                                                3 1930
                      PROFILE                       GAGE          XLEVEL         WARP
THRESHOLDS (IN.)---- (2.750)                       (57.50)        (2.000)        (2.000)
                                              CURVE-(57.75) SPIRAL-(1.500) SPIRAL-(1.750)

* 89 -1252                                        57.98     7                                      19        S 0      3 2643
* 87 -3163   CHANGE TO CLASS   3 TRACK                                                                                5 4586
                      PROFILE                       GAGE          XLEVEL         WARP
THRESHOLDS (IN.)---- (2.250)                       (57.50)        (1.750)        (1.750)
                                              CURVE-(57.75) SPIRAL-(1.250) SPIRAL-(1.250)

* 87 -3478                                       --SENSORS UP--                                                       5 4901
```

Figure 3-1. Old Standard Detailed Report

SUMMARY OF CLASS CHANGES

MP	FEET	TRK/LOC		MILE	FEET	NEW CLASS	PAGE
93	0	1	93	0	0	4	1
89	-539	1	93	3	1930	2	1
87	-3163	1	93	5	4586	3	1
86	0	1	92	0	1034	4	2
83	-4200	1	92	3	5224	3	2
80	-3176	1	92	6	4145	4	3
75	-4754	1	91	0	1863	3	3
67	0	1	90	0	483	4	4
66	-2637	1	90	1	3111	3	5
66	-3690	1	90	1	4164	4	5
63	-4304	1	90	4	4639	3	6
50	-1056	1	88	8	1560	2	7
48	0	1	88	10	442	3	8
42	-2296	1	85	0	2	2	9
41	-4200	1	85	1	1912	3	9
38	-2632	1	85	4	345	2	9
18	0	1	82	0	2610	3	10
18	-4744	1	82	1	2074	4	10

Figure 3-2. Old Standards Class Change Report

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INTEGRATED TRACK GEOMETRY SAFETY STANDARD REPORT-MOD 12  T3/T1  ACQUISITION  70804      PROCESSED  08/09/77     PAGE   3
   LOC X01                              MP192.0-314.6)TK1          CROSSLEVEL  : + = S RAIL HIGH      - = N RAIL HIGH

   LOCATION :  1                     TRACK NUMBER :  1                   CLASS  3 TRACK

                          PROFILE                               GAGE          XLEVEL           WARP       SPEED      FACT
THRESHOLDS (IN.)---- (2.250)                                   (57.50)        (1.750)         (1.750)     (MPH)
                                                          CURVE-(57.75) SPIRAL-(1.250) SPIRAL-(1.250)
                      S  RAIL         N  RAIL                MAX     O/A      MAX     O/A      MAX
  MP   DIST         MAX  O/A        MAX  O/A                 EXC     DIST     EXC     DIST     EXC  LENGTH


* 236   1063   CHANGE TO CLASS    4 TRACK

                          PROFILE                               GAGE          XLEVEL           WARP
THRESHOLDS (IN.)---- (2.000)                                   (57.25)        (1.250)         (1.250)
                                                          CURVE-(57.50) SPIRAL-(1.000) SPIRAL-(1.000)

* 241   1378                                                57.44      5                                        49       T3
* 241   3224                                                                -1.68 R   63                        48       T3

* 242   1346                                                57.38      5                                        50       T3
* 242   2219                                                57.37      5                                        50       T3
* 242   3806                                                57.41      7                                        50       T3
* 245   4000   CHANGE TO CLASS    2 TRACK
                          PROFILE                               GAGE          XLEVEL           WARP
THRESHOLDS (IN.)---- (2.750)                                   (57.50)        (2.000)         (2.000)
                                                          CURVE-(57.75) SPIRAL-(1.500) SPIRAL-(1.750)
  247   4200   CHANGE TO CLASS    4 TRACK
                          PROFILE                               GAGE          XLEVEL           WARP
THRESHOLDS (IN.)---- (2.000)                                   (57.25)        (1.250)         (1.250)
                                                          CURVE-(57.50) SPIRAL-(1.000) SPIRAL-(1.000)
```

Figure 3-3. Current Standards Detailed Report

SUMMARY OF CLASS CHANGES

MP	FEET	TRK/LOC		NEW CLASS	PAGE
192	0	1	1	2	1
195	4249	1	1	4	1
235	4024	1	1	3	3
236	1063	1	1	4	3
245	4000	1	1	2	3
247	4200	1	1	4	3
310	4708	1	1	2	5

Figure 3-4. Current Standards Class Change Report

ONE MILE SUMMARY EXCEPTION REPORT-MOD 12 T3/T1 ACQUISITION 70804 PROCESSED 08/09/77 PAGE 1

TRACK NUMBER : 1

	MILEPOST			PROFILE				GAGE		X LEVEL		WARP	
				S RAIL		N RAIL							
	START	END	DIST	OPCL	CL1	OPCL	CL1	OPCL	CL1	OPCL	CL1	OPCL	CL1
	192	193	5230										
*	193	194	5203										
*	194	195	5343										
*	195	196	5312										
	196	197	5312										
*	197	198	5191					4					
*	198	199	5314										
*	199	200	5235										
*	200	201	5256										
*	201	202	5215										
*	202	203	5251										
*	203	204	5387					2	2				
*	204	205	5261										
*	205	206	5177					7					
*	206	207	5370							14			
*	207	208	5261					2					
*	208	209	5305										
*	209	210	5222										
*	210	211	5561										
*	211	212	5198					8		38			

Figure 3-5. Standards One Mile Summary Exception Report

ONE MILE CLASS SUMMARY REPORT-MOD 12 T3/T1 ACQUISITION 70804 PROCESSED 08/09/77 PAGE 6

TRACK NUMBER : 1

	MILEPOST START	MILEPOST END	DIST	PROFILE CLASS	GAGE CLASS	XLEVEL CLASS	WARP CLASS	O/A TRK CLASS	POSTED CLASS	TRACK SPEED
*	293	294	5201	4	4	4	4	4	4	50
*	294	295	5302	4	4	4	4	4	4	50
*	295	296	5309	4	4	4	4	4	4	50
*	296	297	5244	4	4	4	4	4	4	50
*	297	298	5019	4	4	4	4	4	4	50
*	298	299	5566	4	4	4	4	4	4	50
*	299	300	5271	4	4	4	4	4	4	50
*	300	301	5193	4	4	4	4	4	4	50
*	301	302	5249	4	4	4	4	4	4	50
*	302	303	5251	4	4	4	4	4	4	50
*	303	304	5365	4	4	4	4	4	4	50
*	304	305	5317	4	4	4	4	4	4	50
*	305	306	5145	4	4	4	4	4	4	50
*	306	307	5416	4	4	4	4	4	4	50
*	307	308	5706	4	4	4	4	4	4	50
*	308	309	4640	4	4	4	4	4	4	50
*	309	310	5235	4	4	3	3	3	4	50
*	310	311	5235	2	2	2	2	2	2	20
*	311	312	5268	2	2	2	2	2	2	20
*	312	313	5297	2	2	2	2	2	2	20

Figure 3-6. Old Standards One Mile Class Summary Report

ONE MILE CLASS SUMMARY REPORT-MOD 6 ACQUISITION 61017 PROCESSED 11/08/76 PAGE 1

TRACK NUMBER : 1

	MILEPOST START	MILEPOST END	MILEPOST DIST	PROFILE CLASS	GAGE CLASS	XLEVEL CLASS	WARP CLASS	O/A TRK CLASS	POSTED CLASS	CURVE TRACK SPEED	CURVE LIMITING SPEED	CURVE POINT OF LIMIT
	93	92	1518	4	4	4	4	4	4	60	60	
*	92	91	5167	4	4	4	4	4	4	60	58	3096
*	91	90	5273	4	4	4	4	4	4	60	59	1895
*	90	89	5273	4	4	4	4	4	4	60	60	
*	89	88	5387	2	0	2	2	0	2	20	20	
*	88	87	5206	2	2	2	2	2	2	20	20	
*	87	86	5278	2	2	2	2	2	2	20	20	
	86	85	5278	4	4	4	3	3	4	60	57	2567
*	85	84	5198	4	4	4	3	3	4	60	60	
*	84	83	5353	4	4	4	4	4	4	55	55	
*	83	82	5251	3	3	3	3	3	3	40	40	
*	82	81	5278	3	3	3	3	3	3	40	40	
*	81	80	5256	3	3	3	3	3	3	40	40	
*	80	79	5293	3	3	3	3	3	3	40	40	
*	79	78	5290	4	4	4	4	4	4	60	60	
*	78	77	5278	4	4	4	4	4	4	60	60	
*	77	76	5278	4	4	4	4	4	4	60	60	
*	76	75	5264	4	4	4	4	4	4	60	60	
*	75	74	5283	3	3	3	3	3	3	40	40	
*	74	73	5261	3	3	3	3	3	3	40	36	3045
*	73	72	5295	3	3	3	3	3	3	30	30	

Figure 3-7. Old Standards One Mile Class Summary Report

Prior to last year, the detailed report listed the particular class of an exception only if it exceeded Class Ø or Class 1 safety standards (Figure 3-1). At the request of FRA, modifications were made which permitted the program to print out the class of any exception (Figure 3-3). To make them more apparent, Class Ø and Class 1 exceptions are offset.

The FRA standards do not normally permit spiral runoff to occur on non-curve track. However, this situation does occur frequently on track where speed has been increased by additional elevation without any physical change in location of the roadbed. This situation caused a large number of tangent-crosslevel exceptions to be indicated in this runoff area. To help alleviate this situation, a 100-foot window was permitted in the Standards Report on either side of a curve. Exceptions occurring in this window were printed with an "R" next to them to indicate that they occurred in the runoff area. At the request of the Office of Safety, the size of this window has been reduced from 100 feet to 62 feet.

As mentioned earlier, a method for locating exceptions more accurately was required. A change in the PACK program to analyze the ALD trace for detection of switches and road crossings was made and modifications were made to the Standards Report to produce an ALD Events Report listing the location of these events (Figure 3-8).

3.4.1.4 TAPESUM On Board T-2/T-4 Consist

In order to speed up production of the final report, it was determined that some preprocessing of data on board the survey cars would be desirable. A tape summary program was developed in a form that could be run on board the T-2/T-4 consist (Figure 3-9).

The tape summary program produces a listing of all mileposts, locations, messages and other events on a data tape. This information is listed with the data record and scan number where it occurred on the tape. Any selection of processing areas requires this listing.

ALD EVENT REPORT PAGE 1

		MP	FEET	EVENT
LOC X01				(MP192.0-314.6)TK1
		192	-39	SWITCH
		192	-261	ROAD XING
		192	-307	ROAD XING
		192	-1063	ROAD XING
		192	-1138	SWITCH
		192	-3746	SWITCH
		192	-3847	ROAD XING
		192	-4531	ROAD XING
	*	193	420	ROAD XING
	*	193	1109	SWITCH
	*	193	1781	SWITCH
	*	193	2828	ROAD XING
	*	193	4227	SWITCH
	*	193	4319	SWITCH
	*	193	4425	SWITCH
	*	194	1298	ROAD XING
	*	194	1600	ROAD XING
	*	194	1754	SWITCH
	*	194	2153	ROAD XING
	*	194	2284	SWITCH
	*	194	2704	ROAD XING
	*	194	3509	ROAD XING
	*	194	4215	SWITCH
	*	194	4314	ROAD XING
	*	194	4374	SWITCH
	*	194	5276	SWITCH
	*	195	3603	ROAD XING
	*	195	3908	SWITCH
	*	195	4014	SWITCH
	*	195	4162	SWITCH
	*	195	5005	ROAD XING
		196	4727	ROAD XING
	*	197	44	ROAD XING
	*	197	534	SWITCH
	*	197	1658	ROAD XING
	*	197	1875	ROAD XING
	*	197	2753	SWITCH
	*	197	3308	ROAD XING
	*	197	3627	ROAD XING
	*	197	4048	ROAD XING
	*	197	4959	ROAD XING
	*	198	5239	ROAD XING
	*	199	2052	ROAD XING
	*	199	4534	SWITCH
	*	200	4628	ROAD XING
	*	201	338	ROAD XING
	*	201	1071	ROAD XING
	*	201	4510	ROAD XING

Figure 3-8. Standards ALD Events Report

GEOMETRY NEWTAPE REPORT

LOC	REC	SCAN	SEQ	PREVIOUS MP	CURRENT MP	DIST FROM LAST MP	COMMENTS
	1993	25	10		100	5106	
	2021	39	6		101	5447	
	2048	15	1		102	5162	
	2075	34	12		103	5265	
	2102	11	7		104	5164	
	2130	33	3		105	5466	
	2158	51	15		106	5456	
	2183	53	8		107	4838	
	2211	34	4		108	5367	
	2238	22	15		109	5191	
	2266	53	11		110	5488	
	2292	80	5		111	5091	
	2319	74	0		112	5205	
	2346	75	11		113	5222	
	2374	67	7		114	5394	
	2401	57	2		115	5195	
	2429	25	14		116	5336	
	2456	78	9		117	5348	
	2482	65	3		118	4995	
888	2496	25	1	118		2609	LOCATION
	2509	69	14		119	5229	
	2536	49	9		120	5171	
	2565	35	6		121	5572	
	2592	27	1		122	5200	
	2645	31	6		124	10256	
	2673	27	2		125	5403	
	2699	41	12		126	5060	
	2726	79	7		127	5311	
	2754	6	3		128	5236	
	2781	65	14		129	5362	
	2809	8	10		130	5275	
	2835	75	4		131	5188	
	2863	71	0		132	5403	
	2890	59	11		133	5191	
	2920	38	9		134	5749	
555	2970	15	11	134		9611	LOCATION
	2971	1	12		134	9770	TRACK CHANGE/TRACK 1 TO TRACK 5
	2981	75	6				OSCILLATOR ON

Figure 3-9. Tape Summary Reports

Previously, this program had to be run in-house before any manual selection of processing areas could be accomplished. With the advent of on-board production of this report, some of the manual selection of processing areas could be accomplished by the computer operator in the field. This in turn reduced the amount of time required for processing the data in-house by approximately one-half day. Investigation is underway as to the feasibility of producing a similar on-board TAPESUM report for consist T-1/T-3.

3.4.1.5 MAXAS-LOCAL Program

In order to examine data for conformance with FRA Safety Standards, it is necessary to know the designated class and track speed for a given section of track. This information is manually prepared in the field by the FRA Track Safety Inspectors. Two weeks before a survey run, this information is delivered to ENSCO. Using the standard form provided by the inspectors, this information is punched onto computer cards which are used as input for two newly developed programs.

The first new program is the MAXAS program (Figure 3-10). This produces a listing of class and speed information for each track to be surveyed. This output is prepared before the run so that the on-board data specialist can have the track inspector examine it and make any desired changes or corrections.

When the data is returned from the field, it is necessary to prepare a table providing the track number, class and speed for each data tape. This is done with the new LOCAL program which uses the same input cards as are used by the MAXAS program. These cards and instructions as to what tracks are covered on a particular tape are combined with a table of milepost numbers and lengths created by the TAPESUM program. The program produces a table listing each milepost number, its length, class and/or changes, speed and the track number (Figure 3-11). The information on this table is stored on a temporary disc file for use in running the STNRAY program.

RAILROAD :
DATE :
COMMENTS :

P = PASSENGER
F = FREIGHT

MILEPOSTS START	END	TRACK NO. 1 SPEED P	F	CLASS P	F	TRACK NO. 2 SPEED P	F	CLASS P	F	TRACK NO. 3 SPEED P	F	CLASS P	F	TRACK NO. 4 SPEED P	F	CLASS P	F
596.2 –	595.8	60	55	3	4	60	55	3	4								
595.8 –	587.2	70	55	4	4												
587.2 –	586.9	60	55	3	4	60	50	3	4								
586.9 –	572.5	70	55	4	4	70	55	4	4								
572.5 –	571.5	30	30	2	3	30	30	2	3								
571.5 –	562.5	70	55	4	4	70	55	4	4								
562.5 –	562.1	65	55	4	4	65	55	4	4								
562.1 –	549.0	70	55	4	4	70	55	4	4								
549.0 –	548.0	45	45	3	4	45	45	3	4								
548.0 –	542.9	70	55	4	4	70	55	4	4								
542.9 –	539.3	70	55	4	4	70	55	4	4		55		4				
539.3 –	532.7	70	55	4	4	70	55	4	4								
532.7 –	531.7	45	30	3	3	45	30	3	3								
531.7 –	527.7		55		4	70	55	4	4	70	55	4	4				
527.7 –	524.0		20		2	55	55	3	4								
524.0 –	520.5		40		3	40	40	3	3	40	40	3	3				
520.5 –	516.7		40		3	40	40	3	3								
516.7 –	516.0		40		3	40	40	3	3	15	10	1	1				
516.0 –	514.2		40		3	40	40	3	3	40	40	3	3				
514.2 –	9999.0	60	50	3	4	35	35	3	3								

Figure 3-10. MAXAS Report

LOCAL 244

INDEX	MP	LENGTH	DIST	CLASS	TRACK	SPEED
1	11	5280	0	2	1	20
2	12	5280	0	2	1	20
3	13	5280	4224	4	1	20
4	14	5287	0	4	1	50
5	15	5398	0	4	1	50
6	16	5272	0	4	1	50
7	17	5272	0	4	1	50
8	18	5272	0	4	1	50
9	19	5272	0	4	1	50
10	20	5272	0	4	1	50
11	21	5297	0	4	1	50
12	22	5297	0	4	1	50
13	23	5217	0	4	1	50
14	24	5269	0	4	1	50
15	25	5269	0	4	1	50
16	26	5369	0	4	1	50
17	27	5212	0	4	1	50
18	28	5425	0	4	1	50
19	29	5157	0	4	1	50
20	30	5355	0	4	1	50
21	31	5338	0	4	1	50
22	32	5307	0	4	1	50
23	33	5232	0	4	1	50
24	34	5249	0	4	1	50
25	35	5369	0	4	1	50
26	36	5287	0	4	1	50
27	37	5241	0	4	1	50
28	38	5280	0	4	1	50
29	39	5290	0	4	1	50
30	40	5316	0	4	1	50
31	41	5241	0	4	1	50
32	42	5246	0	4	1	50
33	43	5391	0	4	1	50
34	44	5077	0	4	1	50
35	45	5381	0	4	1	50
36	46	5294	0	4	1	50
37	47	5236	0	4	1	50
38	48	5381	0	4	1	50
39	49	5212	0	4	1	50
40	50	5466	0	4	1	50
41	51	5597	0	4	1	50
42	52	5862	0	4	1	50
43	53	5297	0	4	1	50
44	54	5297	0	4	1	50
45	55	5268	0	4	1	50
46	56	5319	0	4	1	50
47	57	5210	0	4	1	50
48	58	5311	0	4	1	50
49	59	5290	0	4	1	50
50	60	5328	0	4	1	50
51	61	5298	0	4	1	50
52	62	5298	0	4	1	50
53	63	5203	0	4	1	50
54	64	5253	0	3	1	35
55	65	5253	0	3	1	35
56	66	5258	0	4	1	50

Figure 3-11. Local Program Output

Previously this information was prepared manually making it necessary to punch a card for each table entry; this was time consuming since up to 1000 miles of data had to be processed. The development of these two programs represents a great improvement in both the accuracy and time of preparation of this information.

3.4.1.6 Microfilm Record Keeping

In order to investigate alternate means for data storage, the feasibility of microfilming some of the Office of Safety output was examined. This examination indicated that for minimal additional cost, data could be stored on microfilm and three major advantages over current methods of storage would be realized.

First, storage space and costs would be reduced. Second, organization of the data would be improved which would increase recall speed. Data is presently stored in several locations with information from a given test being in five possible locations. Storing information for a single test on one roll of microfilm would make recall easier and quicker. Third, greater assurance of the integrity of the data would be afforded. With information on microfilm, copies can be made of desired information while keeping the total data intact.

A proposal to provide this service to the Office of Safety has been prepared and submitted for approval.

3.4.2 OFFICE OF RAIL SAFETY RESEARCH (MOW) SOFTWARE AND ANALYSIS

The major accomplishment in this area was the conversion of the MOW software from a CDC (terminal) configuration to our in-house RDS-500 computer configuration. This conversion resulted in a major cost reduction and subsequent savings to the Government.

Prior to this conversion, the six different programs required to process MOW surveys were: INGRATE, PROFILE, GAGE, CURVATURE, GEOPLOT and INDEX. Computer cost to run these programs on a time-sharing terminal system were $19.74 per mile of data processed. After conversion to three programs, computer costs were reduced to $1.50 per mile on the in-house RDS-500 computer. These programs increased efficiency, reduced costs and time of production, and provided improved formats and additional information not previously available.

Conversion efforts included representatives from two cooperating railroads who were consulted concerning improvement of output usefulness. Mr. Keith Bradley of the Denver and Rio Grande Western Railroad and Mr. Bud Price of the Bessemer and Lake Erie Railroad were most helpful in the design of the desired output as well as in obtaining approval of and suggesting changes to the formats during finalization.

3.4.2.1 Maintenance-of-Way Standards (MOWS) Program

Information previously produced by programs INGRATE, PROFILE, GAGE and CURVATURE were combined to produce the MOWS program. This program resembles the STANDARDS program in that it examines several different parameters for exceptions. It also produces both mile summaries of this information and a detailed point-by-point listing of exceptions (Figures 3-12 through 3-18). However, the MOWS program differs from the STANDARDS program in two major ways.

First, the MOWS program allows the user (i.e., the railroad) to select its own exception thresholds for each parameter and class. The STANDARDS program only accepts the Office of Safety Standards threshold. MOWS indicates where FRA and railroad thresholds are exceeded.

Second, MOWS provides exception information for track geometry parameters not mentioned and/or handled differently in the

MAINTENANCE OF WAY STANDARDS REPORT

REPORT THRESHOLDS

TRACK CLASS----			1	2	3	4	5	6
PROFILE (IN.)		EXC	2.000	1.750	1.500	1.250	1.000	0.500
		*SEV	3.000	2.750	2.250	2.000	1.250	0.500
GAGE (IN.)	TANGENT	EXC	57.500	57.500	57.250	57.250	57.000	56.750
		*SEV	57.750	57.500	57.500	57.250	57.000	56.750
	CURVES(BODY-SPIRAL)	EXC	57.500	57.500	57.500	57.500	57.500	57.000
		*SEV	57.750	57.750	57.750	57.500	57.500	57.000
TIGHT GAGE (IN.)		*EXC	56.000	56.000	56.000	56.000	56.000	56.000
CURVATURE (DEG.)	TANGENT	EXC	3.000	2.000	1.500	1.000	0.750	0.500
		SEV	5.000	3.000	1.750	1.500	0.750	0.500
	CURVES(BODY-SPIRAL)	EXC	2.500	2.000	1.500	1.000	0.625	0.375
		SEV	5.000	3.000	1.750	1.500	0.625	0.375
CROSSLEVEL (IN.)	TANGENT-CURVE BODY	EXC	2.000	1.500	1.500	1.000	1.000	0.500
		*SEV	3.000	2.000	1.750	1.250	1.000	0.500
	SPIRAL	EXC	1.500	1.250	1.000	1.000	0.750	0.500
		*SEV	1.750	1.500	1.250	1.000	0.750	0.500
WARP (IN.)	TANGENT-CURVE BODY	EXC	2.000	1.500	1.250	1.000	0.750	0.625
		*SEV	3.000	2.000	1.750	1.250	1.000	0.625
	SPIRAL	EXC	1.750	1.500	1.250	1.000	0.750	0.500
		*SEV	2.000	1.750	1.250	1.000	0.750	0.500
ROCK AND ROLL (IN.)		EXC	1.000	1.000	1.000	1.000	1.000	1.000
		SEV	1.500	1.500	1.500	1.500	1.500	1.500
MAXIMUM ALLOWABLE SPEED (MPH) ----								
		PASSENGER	15	30	60	80	90	110
		FREIGHT	10	25	40	60	80	110

* - FRA STANDARDS

Figure 3-12. MOWS Threshold Listing

NOTES

EXPLANTION OF SYMBOLS USED IN THIS REPOST

* – NEXT TO MILEPOST NUMBER ON LEFT MARGIN OF REPORT. THIS INDICATES THAT THE MILEPOST APPEARS ON THE BRUSH CHART.

R – NEXT TO CROSSLEVEL AND WARP EXCEPTIONS IN DETAILED REPORT. THIS APPEARS WHEN SUPERELEVATION IS MEASURED BEFORE A CURVE WAS DETECTED. THESE EXCEPTIONS DO NOT AFFECT AFFECT ONE MILE CLASS AND EXCEPTION SUMMARY REPORTS.

L – NEXT TO CROSSLEVEL AND CURVATURE IN DETAILED REPORT. WHEN LIMITING SPEED EXCEPTIONS ARE PRINTED THE CROSSLEVEL AND CURVATURE VALUES AT THAT POINT ARE ALSO INCLUDED. ALL THESE VALUES ARE PRINTED ON THE SAME LINE.

* – NEXT TO PROFILE, GAGE, CURVATURE, CROSSLEVEL, WARP AND ROCK AND ROLL EXCEPTIONS IN THE DETAILED REPORT. THIS ONLY APPEARS WHEN EXCEPTION INDICATED EXCEEDS SEVERE THRESHOLDS.

T, S, OR C – IN FACT COLUMN. THESE INDICATE TYPE OF TRACK AS DEFINED BY CURVATURE. T=TANGENT, S=SPIRAL, C=CURVE BODY

0, 1, 2, 3, 4, OR 5 – IN FACT COLUMN. 0=EXCEPTION DOES NOT MEET CLASS 1 THRESHOLDS, 1, 2, 3, 4 OR 5=EXCEPTION LOWERS TRACK TO SPECIFIED CLASS (THESE ONLY APPEAR WHEN SEVERE THRESHOLDS ARE FRA STANDARDS)

IN CURVE SUMMARY REPORT SIGN CONVENTION IS AS FOLLOWS:
1) CROSSLEVEL
   + = EAST RAIL HIGH
   – = WEST RAIL HIGH
2) CURVATURE
   + = CURVE TO WEST
   – = CURVE TO EAST

--SENSORS UP-- MESSAGE INDICATES LOSS OF GAGE ONLY
PA ERR. – 193 FT. NOT ANALYZED
-OR-
SE ERR. – 193 FT. NOT ANALYZED – MESSAGES INDICATES MAGNETIC TAPE ERROR AND LOSS OF 193FT. OF DATA TO ANALYZE

Figure 3-13. MOWS Program Notes

```
***************** SUMMARY OF CLASS CHANGES *****************
*                                                 PAGE  1  *
*                                                          *
*     CE TO KO JCT TRK 1 N. DIV                            *
*                                                          *
*     MILEPOST  DISTANCE     TRACK     NEW CLASS  PAGE     *
*                                                          *
*                                                          *
*       126       3404         1           4         1     *
************************************************************
```

Figure 3-14. MOWS Class Change Summary Report

MAINTENANCE OF WAY STANDARDS - CURVE SUMMARY REPORT ACQUISITION 11/ 3/76 PROCESSED 02/04/77 PAGE 1

TRACK NUMBER : 1

F = SPIRAL OUT OF CURVE NOT DETECTED

START MP	START DIST	END MP	END DIST	CURVE LENGTH	AVERAGE CURVATURE DEG/MIN	AVERAGE ELEV. INCHES	AVERAGE SPEED MPH	EQU. SPEED MPH	POSTED SPEED MPH	LIMITING SPEED: MAX ALW SPEED MPH	LIMITING SPEED: POINT LIMIT MP/FT	LIMITING SPEED: CURVATURE DEG/MIN	LIMITING SPEED: ELEVATION INCHES	LIMITING SPEED: TOTAL EXCEPT. FEET
126	4819	126	5174	355	-4/13	.62	35	14	45	34	126/ 5003	-4/13	.54	5
* 125	-1233	125	-1672	440	-3/42	1.25	40	21	45	40	125/-1438	-3/40	1.25	5
* 125	-2704	125	-3200	495	-4/43	1.27	35	19	45	33	125/-3043	-5/ 9	1.17	203
* 125	-3200	125	-3412	46	-5/ 7	1.26	34	18	45	33	125/-3371	-5/23	1.25	46
* 125	-3412	125	-3852	341	-4/49	1.12	34	18	45	32	125/-3581	-5/ 4	.86	106
* 124	-1259	124	-2332	1073	3/54	-.04	33	4	45	29	124/-1880	5/51	.62	128
* 124	-2721	124	-3333	611	-4/57	1.82	37	22	45	36	124/-3031	-4/45	1.56	14
* 124	-3342	124	-3579 F	234	-3/44	-.29	35	10	45	27	124/-3502	-5/56	.23	56
* 124	-4722	123	-87	643	0/57	1.11	78	40	45					
* 123	-360	123	-1262	901	-2/48	3.06	55	39	45					
* 123	-2144	123	-2992	848	3/36	-3.26	49	35	45					
* 122	-363	122	-1595	1233	2/ 4	-1.50	55	32	45	41	122/-1281	3/59	-1.87	22
* 122	-2182	122	-2501	319	-2/21	2.60	58	39	45					
* 122	-2501	122	-2876 F	133	0/20	1.01	130	65	45					
* 122	-4524	122	-5251	727	-2/41	1.24	47	25	45	43	122/-4969	-2/58	1.01	14
* 121	-411	121	-1428	1017	4/15	-5.13	52	41	45					
* 121	-1914	121	-2327	413	2/53	-2.10	50	32	45					
* 121	-2813	121	-3746	933	2/21	-2.12	55	35	45					
* 120	-17	120	-892	875	2/28	-2.59	56	38	45					
* 120	-3997	120	-4394	396	2/17	-1.19	51	27	45					
* 119	-551	119	-872	321	0/30	.74	101	45	45					
* 119	-2161	119	-2318	157	3/16	-1.89	46	28	45					
* 119	-2318	119	-2692	259	2/ 4	-1.71	56	34	45					
* 119	-3521	119	-4024	503	3/24	-1.60	43	25	45	43	119/-3772	3/21	-1.40	14

Figure 3-15. MOWS Curve Summary Report

MAINTENANCE OF WAY STANDARDS - ONE MILE CLASS SUMMARY REPORT ACQUISITION 11/ 3/76 PROCESSED 02/04/77 PAGE 1

MILEPOST START	END	DIST	TRK	CURVATURE CLASS (RR)	ROCK+ROLL CLASS (RR)	PROFILE CLASS (RR/FRA)	GAGE CLASS (RR/FRA)	XLEVEL CLASS (RR/FRA)	WARP CLASS (RR/FRA)	OVERALL TRK CLASS (RR/FRA)	POSTED CLASS
126	125	5307	1	2	4	1/4	4/4	4/4	3/3	1/3	4
* 125	124	5314	1	3	3	1/4	4/4	3/4	0/1	0/1	4
* 124	123	5278	1	0	3	2/4	2/3	2/3	0/0	0/0	4
* 123	122	5285	1	4	4	4/4	4/4	1/3	3/4	1/3	4
* 122	121	5295	1	2	4	0/3	4/4	1/3	1/2	0/2	4
* 121	120	5276	1	4	4	4/4	4/4	4/4	3/3	3/3	4
* 120	119	5271	1	3	4	4/4	4/4	4/4	4/4	3/4	4
* 119	118	5297	1	3	4	4/4	4/4	3/3	2/3	2/3	4
* 118	117	5266	1	4	4	4/4	4/4	4/4	4/4	4/4	4
* 117	116	5268	1	3	4	2/4	4/4	1/3	0/1	0/1	4
* 116	115	5276	1	3	4	2/4	4/4	3/4	0/1	0/1	4
* 115	114	5312	1	3	4	4/4	4/4	3/3	0/1	0/1	4
* 114	113	5218	1	3	4	2/4	4/4	2/3	1/2	1/2	4
* 113	112	5322	1	4	4	3/4	4/4	3/4	3/4	3/4	4
* 112	111	5239	1	4	3	4/4	4/4	2/3	0/0	0/0	4
* 111	110	5324	1	4	4	4/4	4/4	2/3	2/2	2/2	4
* 110	109	5230	1	3	4	2/4	4/4	1/3	3/3	1/3	4
* 109	108	5285	1	0	4	2/4	4/4	1/3	2/2	0/2	4
* 108	107	5293	1	2	4	1/4	3/3	3/3	1/2	1/2	4
* 107	106	5317	1	4	4	2/4	4/4	1/2	0/1	0/1	4
* 106	105	5249	1	4	4	2/4	4/4	0/1	0/1	0/1	4
* 105	104	5293	1	3	4	1/4	4/4	1/3	0/1	0/1	4
* 104	103	5230	1	3	3	0/3	4/4	1/3	0/1	0/1	4

Figure 3-16. MOWS One Mile Class Summary Report

MAINTENANCE OF WAY STANDARDS - ONE MILE EXCEPTION SUMMARY REPORT   ACQUISITION 11/ 3/7 6   PROCESSED 02/04/77 PAGE 1

	MILEPOST			T R K	C L S	CURVATURE		ROCK+ROLL		PROFILE EAST RAIL		PROFILE WEST RAIL		GAGE		XLEVEL		WARP	
	START	END	DIST			EXC	SEV	EXC	SEV	EXC	SEV	EXC	SEV	EXC	SEV	EXC	SEV	EXC	SEV
	126	125	5307	1	4	7	1			11		6						1	1
*	125	124	5314	1	4	3		1	1	12		18				6		16	9
*	124	123	5278	1	4	118	72	1		1		4		2	2	10	9	13	10
*	123	122	5285	1	4											40	13	1	
*	122	121	5295	1	4	31	6			6	1					17	13	15	4
*	121	120	5276	1	4													1	1
*	120	119	5271	1	4	1													
*	119	118	5297	1	4	7										14	3	6	4
*	118	117	5266	1	4														
*	117	116	5268	1	4	2				4		3				41	15	7	3
*	116	115	5276	1	4	10				12		9				4		8	4
*	115	114	5312	1	4	3										14	10	21	9
*	114	113	5218	1	4	3				6		7				18	8	13	9
*	113	112	5322	1	4					3		1				5		10	
*	112	111	5239	1	4			1								5	2	19	8
*	111	110	5324	1	4											3	3	15	8
*	110	109	5230	1	4	3				5		6				22	10	5	4
*	109	108	5285	1	4	47	15			7						72	40	8	5
*	108	107	5293	1	4	16	1			23		5		5	5	24	2	22	7
*	107	106	5317	1	4					4		6				127	66	28	8
*	106	105	5249	1	4					7		8				82	26	42	20
*	105	104	5293	1	4	2						20				77	23	49	24

Figure 3-17. MOWS One Mile Exception Summary Report

MAINTENANCE OF WAY STANDARDS - DETAILED REPORT ACQUISITION 11/ 3/76 PROCESSED 02/04/77 PAGE 1

LOC X39 (MP125.4-123.4) CLASS 4 THRESHOLDS

RAILROAD------ THRESHOLDS(IN.) (1.250) T-(57.25) C-(57.50) T-(1.000) C-(1.000) T-(1.000) S-(1.000) T-(1.000) S-(1.000) (1.000)

	MP	DIST	TRK	PROFILE (62.0 FT) EAST RAIL	PROFILE (62.0 FT) WEST RAIL	GAGE MAXIMUM EXCEPTION	CURVATURE MAXIMUM EXCEPTION	XLEVEL MAXIMUM EXCEPTION	OVERALL DISTANCE	WARP EXC	WARP LENGTH	ROCK+ROLL (19.5 FT) EXCEPTION	SPD(MPH) POSTED/ MAXIMUM ALLOW	AVERAGE CURVATURE (DEG/MIN)	FACT	
	126	3461	1		-1.48				2						T	
	126	3637	1	-1.48					5						T	
	126	3789	1		-1.40				5						T	
	126	3797	1	-1.83					12						T	
	126	4908	1	-2.03					10						S	
	126	4908	1		-1.68				7						S	
	126	4959	1				-1.46		4						S	
	125	4961	1				-1.54		2						S	
	126	4966	1				-1.32		2						S	
	126	5005	1				.54L	-4.21L	5				45/ 34	-4/13	C	
	126	5053	1				-1.64*		2						S	
	126	5114	1							1.25*	28.9				S	3
	126	5114	1				1.29		2						S	
	126	5121	1				1.22		2						S	
	125	-1443	1				1.25L	-3.67L	5				45/ 40	-3/42	C	
*	125	-1974	1							1.17	45.9				T	
*	125	-2035	1							1.17	24.1				T	
*	125	-2061	1							-1.48*	41.0				T	3
*	125	-2105	1							1.25	57.9				T	
*	125	-2791	1							-1.17*	28.9				S	3
*	125	-2823	1							1.17*	28.9				S	3
*	125	-2854	1							-1.48*	28.9				S	2
*	125	-2859	1				-1.33		7						S	
	125	-3200	1				1.17L	-5.15L	203				45/ 33	-4/43	C	
	125	-3412	1				1.25L	-5.39L	46				45/ 33	-5/ 7	C	
	125	-3518	1				.86L	--5.07L	106				45/ 32	-4/49	C	
*	125	-3777	1	-2.03					14						S	
*	125	-3787	1		-1.60				22						S	
*	125	-3816	1							-1.32*	28.9				S	3
*	125	-3852	1							1.25 R	12.0				T	
*	125	-3934	1	-1.64					12						T	
*	125	-3944	1		-2.03				22						T	
*	125	-3949	1							-1.17	41.0				T	
*	125	-3966	1									0-0 0*			T	
*	125	-3992	1							2.11*	21.7				T	1
*	125	-4016	1					-1.17	2						T	
*	125	-4016	1							-1.87*	21.7				T	2

Figure 3-18. MOWS Detailed Report

STANDARDS output. Specifically, MOWS examines rock-and-roll and provides additional curve-limiting speed information to the user.

The MOWS output provides detailed point-by-point and summary exception information.

3.4.2.2 Maintenance-of-Way Planning (MOWP) Report

In contrast to the specific exception information provided by MOWS, the MOWP output provides a summary measure of overall track quality by parameters.

The MOWP output replaces the previous GEOPLOT and INDEX outputs. The report provides a numerical quality or index value to profile, crosslevel and curvature data. It also computes and displays the standard deviation of the gage values. These values are computed for each quarter or multiple quarter of a mile segment of track in a given area. The values for any given segment may be compared with those for other segments as a means of quality determination. A sample of this output is shown in Figure 3-19.

MOWP also provides an output tape in more readable format for location and index information. This tape can be provided to railroads for further data processing use.

3.4.2.3 SORT Program

The SORT program takes the output from MOWP and sorts the segments into orders of severity for each parameter. This provides a quick comparison of overall quality for each parameter and allows the easy location of areas of severe deterioration. A sample of the SORT output is shown in Figures 3-20 through 3-23.

3.4.3 OTHER RELATED DATA PROCESSING ACTIVITIES

In addition to maintenance, production and development of software and reports, there have been several important accomplishments in the data processing area. These include maintenance and

KO JCT XOVER TO CE (TK 1) 546 SAMPLES PER 0.25 MILE TRACK SEGMENT

START		END			GAGE				PROFILE			XLEVEL		CURVATURE	
MP	DIST	MP	DIST	TRK	INDEX	STD DEV	99% VALUE	NO. SAMP	INDEX	SLOPES	NO. SAMP	INDEX	NO. SAMP	INDEX	NO. SAMP
LOC X27					(MP91.6-93.6)TK 1										
91	2915	91	4235	1	-712	0.170	57.07	503	2392	42	546	1530	546	2529	546
91	4237	92	245	1	-931	0.100	56.76	401	1498	19	546	731	546	620	546
92	247	92	1567	1	-377	0.083	56.68	546	1573	35	546	679	546	640	546
92	1569	92	2889	1	-322	0.097	56.76	398	1434	20	546	476	546	659	546
92	2891	92	4211	1	-1674	0.072	56.59	464	1733	24	546	664	546	689	546
92	4213	93	299	1	-641	0.096	56.70	445	1649	39	546	1056	546	940	546
93	301	93	1621	1	195	0.078	56.71	435	1268	13	546	714	546	712	546
93	1623	93	2626	1	266	0.111	56.86	375	896	26	415	1032	415	1010	415
LOC X29					(MP93.6-97.0)TK 1										
93	2848	93	4168	1	1389	0.100	56.84	368	2694	92	546	1893	546	1542	546
93	4170	94	212	1	1417	0.098	56.87	546	2027	43	546	1427	546	1230	546
94	214	94	1534	1	1204	0.085	56.81	402	2355	48	546	1358	546	1027	546
94	1536	94	2856	1	1806	0.115	56.93	546	2788	84	546	1361	546	1619	546
94	2858	94	4178	1	-678	0.080	56.67	546	1810	30	546	925	546	1227	546
94	4180	95	266	1	-59	0.099	56.73	406	1617	27	546	987	546	1126	546
95	268	95	1588	1	1267	0.094	56.83	376	3168	90	546	1590	546	1912	546
95	1590	95	2910	1	1776	0.101	56.86	546	2170	52	546	1498	546	1310	546
95	2912	95	4232	1	948	0.106	56.94	546	1872	43	546	1301	546	1391	546
95	4234	96	293	1	553	0.116	56.85	546	2453	82	546	1413	546	1536	546
96	295	96	1615	1	340	0.105	56.83	546	2413	85	546	1890	546	1460	546
96	1617	96	2937	1	-316	0.110	56.72	546	1799	46	546	1043	546	974	546
96	2939	96	4259	1	-502	0.097	56.78	546	2308	72	546	1413	546	1162	546
96	4261	96	5013	1	82	0.083	56.76	311	815	45	311	451	311	529	311
LOC X30					(MP97.0-102.7) TK1										
96	5105	97	1324	1	1486	0.089	56.82	546	2379	63	546	1571	546	1191	546
97	1326	97	2646	1	1137	0.107	56.87	546	2649	69	546	1490	546	1498	546
97	2648	97	3968	1	1806	0.090	56.87	546	2242	64	546	1267	546	1604	546
97	3970	97	5290	1	812	0.096	56.92	546	2202	59	546	1019	546	1057	546
97	5292	98	1303	1	1391	0.102	56.95	546	1731	39	546	1129	546	1238	546
98	1305	98	2625	1	1275	0.127	56.90	546	2471	75	546	1496	546	1104	546
98	2627	98	3947	1	1664	0.100	56.87	507	2173	47	546	1438	546	997	546
98	3949	98	5269	1	1001	0.135	56.86	448	1940	33	546	1350	546	1352	546
98	5271	99	1311	1	884	0.119	56.88	546	2448	70	546	2075	546	1529	546
99	1313	99	2633	1	1082	0.112	56.95	546	2058	64	546	1802	546	1590	546
99	2635	99	3955	1	1050	0.162	57.08	546	2545	77	546	1905	546	1681	546

S = SHORT SEGMENT

Figure 3-19. MOWP Program Output

INDEX SORTED BY GAGE

MILEPORT START	MILEPORT DIST	MILEPORT END	MILEPORT DIST	GAGE INDEX	GAGE STD. DEV.	GAGE 99% VALUE	PROFILE INDEX	PROFILE SLOPES	CROSSLEVEL INDEX	CURVATURE INDEX
109	4269	110	336	8910	0.327	57.67	2036	51	1539	2658
107	2921	107	4241	6935	0.236	57.45	2211	46	2053	3005
103	5044	104	1084	5720	0.175	57.23	1666	14	1438	3119
110	4304	111	339	5562	0.162	57.36	2786	56	2460	2206
106	1591	106	2911	5336	0.195	57.35	2473	58	1702	3002
122	781	122	2101	5299	0.140	57.26	2571	69	1156	1790
104	4226	105	264	5195	0.156	57.31	1984	31	1121	2323
115	2158	115	3478	5127	0.158	57.34	3486	117	2183	3758
110	338	110	1658	5074	0.171	57.36	2225	43	1429	2153
122	2103	122	3423	5040	0.177	57.31	1806	27	1264	2766
122	3425	122	4745	5028	0.188	57.32	1831	28	1166	1557
121	4741	122	779	4660	0.165	57.23	1805	32	983	1344
105	266	105	1586	4123	0.124	57.05	1982	27	984	948
122	4747	123	782	4106	0.119	57.04	1588	15	1287	1736
114	809	114	2129	4042	0.136	57.04	1607	18	1334	3168
113	806	113	2126	4015	0.156	57.36	2528	68	1491	3738
105	2910	105	4230	3775	0.131	57.17	1816	13	761	796
110	1660	110	2980	3756	0.157	57.12	2419	57	1284	1191
105	1588	105	2908	3686	0.125	57.06	1614	22	852	995
110	2982	110	4302	3613	0.120	57.09	2519	42	1499	1606
115	3480	115	4800	3595	0.183	57.24	1452	23	1124	1119
120	2419	120	3739	3502	0.145	57.17	1708	26	1423	1939
116	846	116	2166	3487	0.145	57.24	1559	34	922	1212
109	1625	109	2945	3448	0.192	57.21	1720	53	1195	1554
109	2947	109	4267	3447	0.239	57.43	2656	65	1481	3689
123	1795	123	3115	3423	0.383	57.72	4895	108	2105	3904
112	4415	113	462	3340	0.132	57.12	3640	126	1956	1812
107	1599	107	2919	3000	0.145	57.14	2554	39	2470	4230
105	4232	106	267	2953	0.156	57.06	2118	40	1010	1321
108	1590	108	2910	2931	0.121	56.98	1999	21	1945	1882
112	1771	112	3091	2642	0.121	57.06	2242	66	1898	2137
115	836	115	2156	2465	0.152	57.05	1599	36	1557	1844
106	269	106	1589	2416	0.144	57.08	1900	44	1377	1354
124	476	124	1796	2399	0.292	57.34	2897	117	2034	3146
108	4234	109	301	2386	0.203	57.43	2543	78	2035	4988
120	1097	120	2417	2347	0.140	57.12	1827	32	1345	1310
115	4802	116	844	2285	0.150	57.06	2671	69	1531	1547
109	303	109	1623	2276	0.186	57.27	1839	36	898	2157
101	3911	102	36	2275	0.173	57.05	2050	34	1575	3681
111	341	111	1661	2241	0.117	56.97	2139	43	1571	1698
108	2912	108	4232	2241	0.144	56.99	1501	29	960	1219
106	2913	106	4233	2222	0.179	57.11	1981	46	2228	2662
103	3722	103	5042	2080	0.162	57.17	1945	23	1143	1923
119	4999	120	1095	1988	0.118	56.95	2078	53	1063	1187
119	3677	119	4997	1964	0.167	57.12	2631	71	1411	2170
112	449	112	1769	1862	0.102	56.96	3286	120	1766	1545

Figure 3-20. SORT Output - Gage

INDEX SORTED BY PROFILE

MILEPOST				PROFILE		GAGE			CROSSLEVEL	CURVATURE
START	DIST	END	DIST	INDEX	SLOPES	INDEX	STD. DEV.	99% VALUE	INDEX	INDEX
123	1795	123	3115	4895	108	3423	0.383	57.72	2105	3904
112	4415	113	462	3640	126	3340	0.132	57.12	1956	1812
115	2158	115	3478	3486	117	5127	0.158	57.34	2183	3758
112	3093	112	4413	3462	111	1438	0.119	57.06	1896	1858
99	3957	100	24	3380	130	865	0.110	56.86	2285	1674
112	449	112	1769	3286	120	1862	0.102	56.96	1766	1545
100	1348	100	2668	3227	126	1403	0.107	56.86	1982	1625
95	268	95	1588	3168	90	1267	0.084	56.83	1590	1912
100	26	100	1346	3141	118	222	0.110	56.78	2178	1679
123	4439	124	474	3137	74	-602	0.096	56.79	1181	1533
123	784	123	1618	3005	106	1619	0.155	57.08	1609	1665
123	3117	123	4437	2916	141	-9	0.092	57.17	3207	6465
124	476	124	1796	2897	117	2399	0.292	57.34	2034	3146
103	1078	103	2398	2844	55	-171	0.158	56.90	1836	1677
111	2985	111	4305	2824	55	1249	0.112	56.84	2213	2183
94	1536	94	2856	2788	84	1806	0.114	56.93	1361	1619
110	4304	111	339	2786	56	5562	0.162	57.36	2460	2206
93	2848	93	4168	2694	92	1389	0.100	56.84	1893	1542
115	4802	116	844	2671	69	2285	0.150	57.06	1531	1547
109	2947	109	4267	2656	65	3447	0.239	57.43	1481	3689
97	1326	97	2646	2649	69	1137	0.107	56.87	1490	1498
119	3677	119	4997	2631	71	1964	0.167	57.12	1411	2170
120	5063	121	1096	2608	69	0	0.000	0.00	1441	2071
117	1061	117	2381	2608	75	-64	0.122	56.85	1492	1657
113	2128	113	3448	2597	51	945	0.139	56.96	1488	2147
114	3453	114	4773	2595	57	-1001	0.127	56.86	1741	1197
122	781	122	2101	2571	69	5299	0.140	57.26	1156	1790
102	3719	102	5039	2568	52	1662	0.114	56.91	1228	3318
107	1599	107	2919	2554	39	3000	0.145	57.14	2470	4230
114	4775	115	834	2548	56	-374	0.102	56.73	1779	1871
99	2635	99	3955	2545	77	1050	0.162	57.08	1905	1681
108	4234	109	301	2543	78	2386	0.203	57.43	2035	4999
113	806	113	2126	2528	68	4015	0.156	57.36	1491	3738
110	2982	110	4302	2519	42	3613	0.120	57.09	1499	1606
106	1591	106	2911	2473	58	5336	0.195	57.35	1702	3002
111	1663	111	2983	2472	36	210	0.110	56.79	2115	1965
98	1305	98	2625	2471	75	1275	0.127	56.90	1496	1104
95	4234	96	293	2453	82	553	0.116	56.85	1413	1536
98	5271	99	1311	2448	70	884	0.118	56.88	2075	1529
110	1660	110	2980	2419	57	3756	0.157	57.12	1284	1191
96	295	96	1615	2413	85	340	0.105	56.83	1890	1460
118	2398	118	3718	2413	81	750	0.132	56.93	1967	2794
91	2915	91	4235	2392	42	-712	0.170	57.07	1530	2529
96	5105	97	1324	2379	63	1486	0.089	56.82	1571	1191
121	2097	121	3417	2377	49	0	0.000	0.00	1394	2526
94	214	94	1534	2355	48	1204	0.085	56.81	1358	1027

Figure 3-21. SORT Output - Profile

INDEX SORT BY CROSSLEVEL

MILEPOST				CROSSLEVEL	GAGE			PROFILE		CURVATURE
START	DIST	END	DIST	INDEX	INDEX	STD. DEV.	99% VALUE	INDEX	SLOPES	INDEX
124	1798	124	3118	4658	843	0.108	57.19	0	0	18227
124	4442	125	431	3593	0	0.000	0.00	575	224	8388
124	3120	124	4440	3515	0	0.000	0.00	1946	230	8154
123	3117	123	4437	3207	-9	0.092	57.17	2916	141	6465
125	433	125	1753	2959	0	0.000	0.00	0	0	12460
107	1599	107	2919	2470	3000	0.145	57.14	2554	39	4230
110	4304	111	339	2460	5562	0.162	57.36	2786	56	2206
99	3957	100	24	2285	865	0.110	56.86	3380	130	1674
106	2913	106	4233	2228	2222	0.179	57.11	1981	46	2662
111	2985	111	4305	2213	1249	0.112	56.84	2824	55	2183
115	2158	115	3478	2183	5127	0.158	57.34	3486	117	3758
100	26	100	1346	2178	222	0.110	56.78	3141	118	1679
111	1663	111	2983	2115	210	0.110	56.79	2472	36	1965
123	1795	123	3115	2105	3423	0.383	57.72	4895	108	3904
114	2131	114	3451	2087	796	0.157	56.96	2344	47	1860
98	5271	99	1311	2075	884	0.118	56.88	2448	70	1529
118	1076	118	2395	2072	1329	0.191	57.09	2156	77	2387
107	2921	107	4241	2053	6935	0.236	57.45	2211	46	3005
108	4234	109	301	2035	2386	0.203	57.43	2543	78	4988
124	476	124	1796	2034	2399	0.292	57.34	2897	117	3146
100	1348	100	2668	1982	1403	0.107	56.86	3227	126	1625
118	2398	118	3718	1967	750	0.132	56.93	2413	81	2794
112	4415	113	462	1956	3340	0.132	57.12	3640	126	1812
113	3450	113	4770	1954	1181	0.121	57.06	1861	43	2009
108	1590	108	2910	1945	2931	0.121	56.98	1999	21	1882
99	2635	99	3955	1905	1050	0.162	57.08	2545	77	1681
112	1771	112	3091	1898	2642	0.121	57.06	2242	66	2137
112	3093	112	4413	1896	1438	0.119	57.06	3462	111	1858
93	2848	93	4168	1893	1389	0.100	56.84	2694	92	1542
96	295	96	1615	1890	340	0.105	56.83	2413	85	1460
103	1078	103	2398	1836	-171	0.158	56.90	2844	55	1677
99	1313	99	2633	1802	1082	0.112	56.95	2058	64	1590
114	4775	115	834	1779	-374	0.102	56.73	2548	56	1871
112	449	112	1769	1766	1862	0.102	56.96	3286	120	1545
114	3453	114	4773	1741	-1001	0.127	56.86	2595	57	1197
106	1591	106	2911	1702	5336	0.195	57.35	2473	58	3002
123	784	123	1618	1609	1619	0.155	57.08	3005	106	1665
95	268	95	1588	1590	1267	0.084	56.83	3168	90	1912
101	3911	102	36	1575	2275	0.173	57.05	2050	34	3681
111	341	111	1661	1571	2241	0.117	56.97	2139	43	1698
96	5105	97	1324	1571	1486	0.089	56.82	2379	63	1191
115	836	115	2156	1557	2465	0.152	57.05	1599	36	1844
109	4269	110	336	1539	8910	0.327	57.67	2036	51	2658
106	4235	107	275	1538	950	0.104	56.81	2127	52	1286
111	4307	112	376	1537	1847	0.121	57.00	2097	50	2099
115	4802	116	844	1531	2285	0.150	57.06	2671	69	1547

Figure 3-22. SORT Output - Crosslevel

INDEX SORTED BY CURVATURE

MILEPOST				CURVATURE	GAGE			PROFILE		CROSSLEVEL
START	DIST	END	DIST	INDEX	INDEX	STD. DEV.	99% VALUE	INDEX	SLOPES	INDEX
124	1798	124	3118	18227	843	0.108	57.19	0	0	4658
125	433	125	1753	12460	0	0.000	0.00	0	0	2959
124	4442	125	431	8388	0	0.000	0.00	576	224	3593
124	3120	124	4440	8154	0	0.000	0.00	1946	230	3515
123	3117	123	4437	6465	-9	0.092	57.17	2916	141	3207
108	4234	109	301	4988	2386	0.203	57.43	2543	78	2035
107	1599	107	2919	4230	3000	0.145	57.14	2554	39	2470
123	1795	123	3115	3904	3423	0.383	57.72	4895	108	2105
115	2158	115	3478	3758	5127	0.158	57.34	3486	117	2183
113	806	113	2126	3738	4015	0.156	57.36	2528	68	1491
109	2947	109	4267	3689	3447	0.239	57.43	2656	65	1481
101	3911	102	36	3681	2275	0.173	57.05	2050	34	1575
102	3719	102	5039	3318	1662	0.114	56.91	2568	52	1228
114	809	114	2129	3168	4042	0.136	57.04	1607	18	1334
124	476	124	1796	3146	2399	0.292	57.34	2897	117	2034
121	3419	121	4739	3142	1256	0.116	57.02	1911	41	1291
103	5044	104	1084	3119	5720	0.175	57.23	1666	14	1438
107	2921	107	4241	3005	6935	0.236	57.45	2211	46	2053
106	1591	106	2911	3002	5336	0.195	57.35	2473	58	1702
118	2398	118	3718	2794	750	0.132	56.93	2413	81	1967
122	2103	122	3423	2766	5040	0.177	57.31	1806	27	1264
106	2913	106	4233	2662	2222	0.179	57.11	1981	46	2228
109	4269	110	336	2658	8910	0.327	57.67	2036	51	1539
91	2915	91	4235	2529	-712	0.170	57.07	2392	42	1530
121	2097	121	3417	2526	0	0.000	0.00	2377	49	1394
118	1076	118	2396	2387	1329	0.191	57.09	2156	77	2072
104	4226	105	264	2323	5195	0.156	57.31	1984	31	1121
110	4304	111	339	2206	5562	0.162	57.36	2786	56	2460
102	5041	103	1076	2206	-95	0.125	56.85	1974	24	1064
111	2985	111	4305	2183	1249	0.112	56.84	2824	55	2213
113	4772	114	807	2180	983	0.117	56.85	1866	63	1223
119	3677	119	4997	2170	1964	0.167	57.12	2631	71	1411
109	303	109	1623	2157	2276	0.186	57.27	1839	36	898
110	338	110	1658	2153	5074	0.171	57.36	2225	43	1429
113	2128	113	3448	2147	945	0.139	56.96	2597	51	1488
112	1771	112	3091	2137	2642	0.121	57.06	2242	66	1898
111	4307	112	376	2099	1847	0.121	57.00	2097	50	1537
120	5063	121	1096	2071	0	0.000	0.00	2608	69	1441
113	3450	113	4770	2009	1181	0.121	57.06	1861	43	1954
111	1663	111	2983	1955	210	0.110	56.79	2472	36	2115
120	2419	120	3739	1939	3502	0.145	57.17	1708	26	1423
103	3722	103	5042	1923	2080	0.162	57.17	1945	23	1143
95	268	95	1588	1912	1267	0.084	56.83	3168	90	1590
108	1590	108	2910	1882	2931	0.121	56.98	1999	21	1945
114	4775	115	834	1871	-374	0.102	56.73	2548	56	1779
114	2131	114	3451	1860	796	0.157	56.96	2344	47	2087

Figure 3-23. SORT Output - Curvature

organization of the data bank, production of write-ups describing the Standards Report and strip charts, special processing for validation of T-2/T-4 consist data, and abandonment of the time-sharing terminal system.

3.4.3.1 FRA Data Bank Maintenance

The FRA data bank consists of over 300 boxes of reports, tapes, Brush charts and other information relating to tests performed over the past seven years. This material has been relocated twice in an effort to attain better organization. During each move the inventory was updated and improved. Much of the material has now been moved to warehouse storage to reduce the demands of costlier office space. A tape index program has been written which provides information about individual data tapes in the data bank.

3.4.3.2 STANDARDS and Strip Chart Write-up

At the request of the Office of Safety, a document was prepared to describe the output data that is provided to a railroad after it has been surveyed. A previous description of the STANDARDS report existed but it was combined with a description of strip chart output to provide a brief, non-technical description of how data was gathered.

The document has proven valuable to FRA field inspectors in interpreting the results of a survey. This document is given to representatives of the selected railroad in the pre-test planning meeting and used as a basis for explanation of the materials and reports they will receive following the survey.

3.4.3.3 Special Processing for Validation of T-2/T-4

When the T-2/T-4 survey consist was accepted, a validation/repeatability test was run on the cars. Special programs were developed and processing work performed to examine the results of the test. Software was modified to provide a measure of variance, mean, and correlation among several runs at different speeds and in different directions, or with other variables.

The processing effort produced information that indicated the cars were operating well within their design specifications.

3.4.3.4 Removal of the UNA Time-sharing Terminal

Due to the conversion of MOW and Office of Safety processing for use on the in-house RDS-500, the requirement for a time-sharing terminal owned by Utility Network of America was eliminated.

The cost of using this machine had been running in the order of $15-25K per month before conversion began. Now that conversion has been completed, costs are running approximately $2K per month with greater output being produced.

3.5 CONCLUSION

The anticipated Track Geometry Survey mileage did not materialize due to the December, 1976 derailment of consist T-2/T-4 and the extended test program for consist T-6. Refurbishment occupied most of the year for consist T-2/T-4. The T-6 consist was devoted to track geometry repeatability testing and Rail Flaw Detection Vehicle functional checkout. Track geometry testing was accomplished almost entirely by the T-1/T-3 consist.

New developments and improvements in instrumentation were incorporated in the test consists to improve data quality. Software improvements included increased measurement resolution, new programs to standardize T-1/T-3 and T-2/T-4 data formats, reduced processing times and increased accuracy in locating defects. The entire MOW package was rewritten with improved formats and a 90 percent computer cost reduction was realized.

4.0 FACILITY FOR ACCELERATED SERVICE TESTING

4.1 INTRODUCTION

The dynamic performance of the rail car/track system changes substantially with accumulated mileage. These changes are caused primarily by the degradation of track structure and vehicle components with usage and, as a result, economic losses are incurred due to increased lading damage and maintenance costs. In response to the need for detailed knowledge of this problem, the Dynamic Hopper Car Test Program was undertaken to quantify the changes in the dynamic performance of rail vehicles with mileage accumulation. Specific objectives are to:

- Establish the relationship between ride performance and track degradation with usage.
- Establish the relationship between ride performance and vehicle component wear with usage.
- Establish the relationship between ride performance and the combined effects of rail degradation and vehicle component wear.
- Quantify the dynamic response of freight vehicles to different track structures.

4.2 DESCRIPTION OF TESTS AND INSTRUMENTATION

In order to meet the objectives listed in paragraph 4.1, two 100-ton hopper cars were selected for test purposes. One car, designated the high-mileage car, was included in the consist which is operating on the Facility for Accelerated Service Testing (FAST) and accumulating mileage at an accelerated rate. The second hopper car, designated the low-mileage or control car, was utilized to determine the effects of track degradation independent of component wear.

Both cars were instrumented at prescribed intervals of accumulated mileage and operated over the FAST track and sections of the RTT track.

Instrumentation on the high-mileage car consisted of accelerometers mounted on the truck and carbody. The low-mileage car was also instrumented with accelerometers in a similar manner and the B truck was equipped with two instrumented wheelsets for the measurement of lateral and vertical wheel-to-rail forces.

The analog signals from these transducers were cabled to the Data Acquisition Vehicle T-5 where the signals were filtered and conditioned. The conditioned signals were connected to an analog multiplexer and converted to digital form at a rate of 128 samples per second. The digital data were recorded for subsequent processing on magnetic tape. As a partial check on the integrity of the recording system, the incoming digitized data was reconverted to analog form and selected channels displayed on an 8-channel analog recorder.

4.3 DATA PROCESSING

The recorded acceleration measurements were reduced to a set of accelerations in the direction of the six, rigid-body, degrees-of-freedom. These generalized accelerations are called modes. One additional mode is included in the set of truck modes to account for the relative motion of truck components with respect to one another, basically to the axles and side frames. The use of modes is helpful in visualizing the dynamics of the test cars and analyzing related phenomena. In the case of the trucks, the modes have an almost one-to-one correspondence with track geometry parameters. This characteristic is useful in analyzing the effect of track degradation on vehicle performance.

The FAST track is comprised of 22 individual sections of track, each designed for a different track-study experiment. For each of these sections, the rms values of each mode as well as wheel/rail forces were calculated and plotted against the test section on which they were measured.

The transfer function gain or transmissibility was calculated by forming the ratio of output amplitude for a given carbody mode to input amplitude for a given truck mode. For the purposes of this study, the transmissibility was actually calculated using power spectral densities (PSDs); that is, the PSD of a given carbody mode was divided by the PSD of a given truck mode. The result is a spectrum of gains as a function of frequency.

4.4 CONCLUSIONS AND RECOMMENDATIONS

One basic conclusion of this study is that the instrumentation and data processing techniques developed for the Dynamic Hopper Car Test Program proved successful in evaluating the dynamic performance of rail cars. The use of mode accelerations yielded concise, clear engineering results which correlated well with observed physical phenomena. For example, a comparison of truck mode accelerations for two different trucks has shown that these accelerations can be used to characterize track conditions. These results indicate that truck mode accelerations will be a useful tool in the study of track degradation.

Along these same lines, wheel-to-rail force measurements were found to be reasonable and in general agreement with truck mode accelerations. Although the results of the transmissibility analysis are somewhat more difficult to relate to physical phenomena, these results parallel those obtained from carbody and truck mode acceleration data.

Conclusions related to the objective of quantifying vehicle dynamic response to different track structures are as follows. Variations in track structure such as ballast shoulder width and depth, spiking patterns, tie material and rail anchors had little if any effect on truck and carbody accelerations or wheel/rail forces. In contrast, curves greater than four degrees and discrete events such as turnouts had a marked effect on vehicle dynamics. Section five of the FAST track containing unsupported, bonded joints produced the highest carbody accelerations while truck mode accelerations over this same section of track were moderate to low.

As was mentioned previously, lateral wheel/rail forces agreed with truck accelerations. In addition, it was observed that the outside wheel experienced larger forces on curves than did the wheel on the inner rail. Physical considerations lend credence to this observation. A second observation was that there was appreciable difference in wheel/rail forces measured in left and right-hand curves. The causes of this seeming anomaly are not readily apparent and warrant further investigation.

Conclusions related to the objectives of determining the relationship between ride performance and track-vehicle component degradation are as follows.

- As anticipated, the low-mileage car provided marginally better ride performance than did the high-mileage car.
- Further tests are needed at higher mileage accumulation points in order to determine conclusively the effects of degradation in the vehicle/rail system.

5.0 LIGHTWEIGHT FLAT CAR PROGRAM

5.1 INTRODUCTION

Presently, the Trailer-on-a-Flat Car (TOFC) and Container-on-a-Flat Car (COFC) configurations represent a highly efficient mode of freight transportation in terms of both energy consumption and time. Recently, specially designed TOFC/COFC flat cars have been proposed which weigh substantially less than existing flat cars. The motivation for using lightweight flat cars lies in the potential savings in fuel consumption.

Two such lightweight flat cars are shown in Figure 5-1. The car in the upper left (TLDX 62) is designed for COFC service only and the car below (TLDX 61) is a modified design intended for TOFC service. These cars weigh 20 and 30 percent less (respectively) than the conventional TTX flat car presently in widespread use in both TOFC and COFC service. The Lightweight Flat Car (LWFC) Evaluation Program was designed specially to evaluate the lightweight flat cars shown in Figure 5-1 and to quantify the lading acceleration environment at the same time. Both the fuel savings and lading acceleration represent economic aspects of TOFC/COFC operation and any improvement in these areas will enhance the future of the railroad industry.

In order to accomplish the evaluation of the lightweight flat cars, the following specific objectives were established:

(1) Obtain a quantitative comparison of the ride vibration between conventional flat car designs and lightweight flat car designs.

(2) Obtain quantitative measurements of the ride vibration experienced by containers and trailers in typical service-operating conditions.

(3) Experimentally determine the relationship between component wear and ride vibration for flat car and truck configurations.

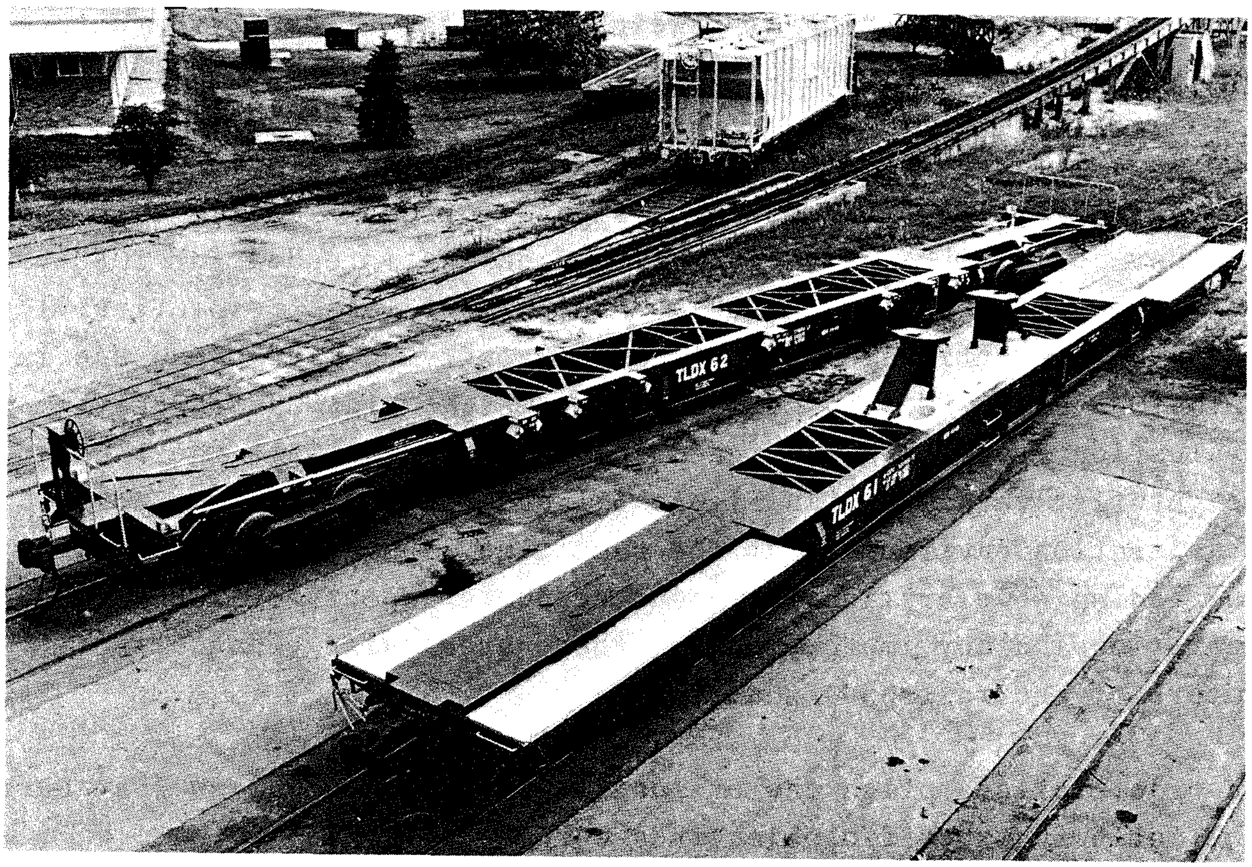


Figure 5-1. Lightweight Flat Cars TLDX61 and TLDX62

(4) Experimentally determine the relationship between component wear and distance traveled for flat car and truck under in-service conditions.

(5) Determine the influence of load and load configurations on ride vibration performance of the flat car and truck.

(6) Obtain data on the dynamic characteristics of flat cars, trucks and loads to permit extrapolation of test results to other track conditions.

During the past 12 months, the LWFC program has advanced from the planning stage to a point where a general purpose technique for flat car evaluation and comparison is now readily available to the rail-vehicle-design engineer. In addition, a data base has been established for both a conventional flat car and one design of a lightweight flat car.

5.2 TEST DESCRIPTION

Testing during this period has been extensive and can be broken down into three test series:

- Functional Checkout at TTC.
- Vehicle Dynamics Characterization at La Junta, CO.
- Over-the-Road Testing - Kansas City, MO to Los Angeles, CA.

The test consist for these three test series was identical and is shown in Figure 5-2. The TLDX 62 car is to the far left carrying two standard 40-foot containers and the TLDX 61 car is to the far right carrying two trailers used extensively for highway transportation. The conventional TTX flat car is shown in the middle loaded with trailers similar to those on the TLDX 61. Other load configurations were studied. Figure 5-3 shows TLDX 62 being reconfigured by a straddle buggy. This operation requires less than ten minutes.

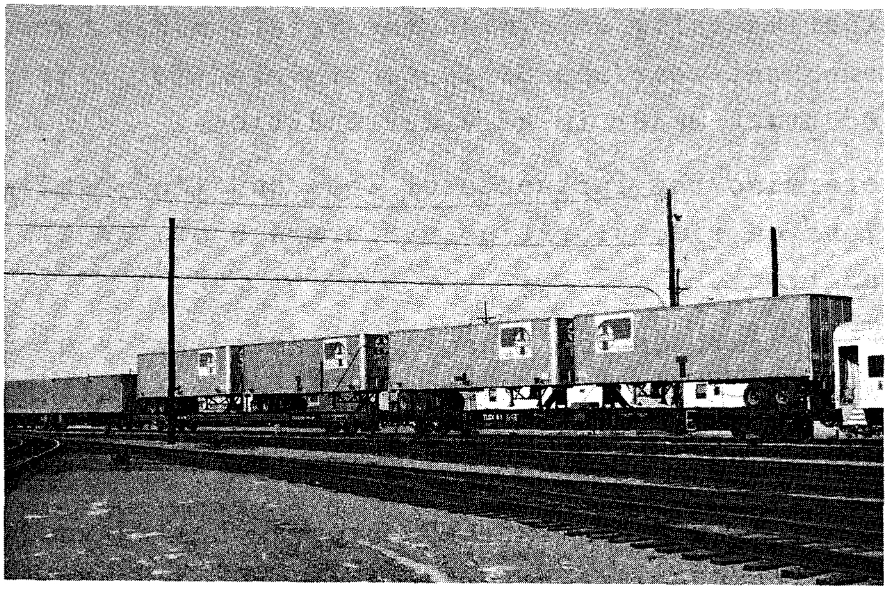


Figure 5-2. Lightweight Flat Car Test Consist

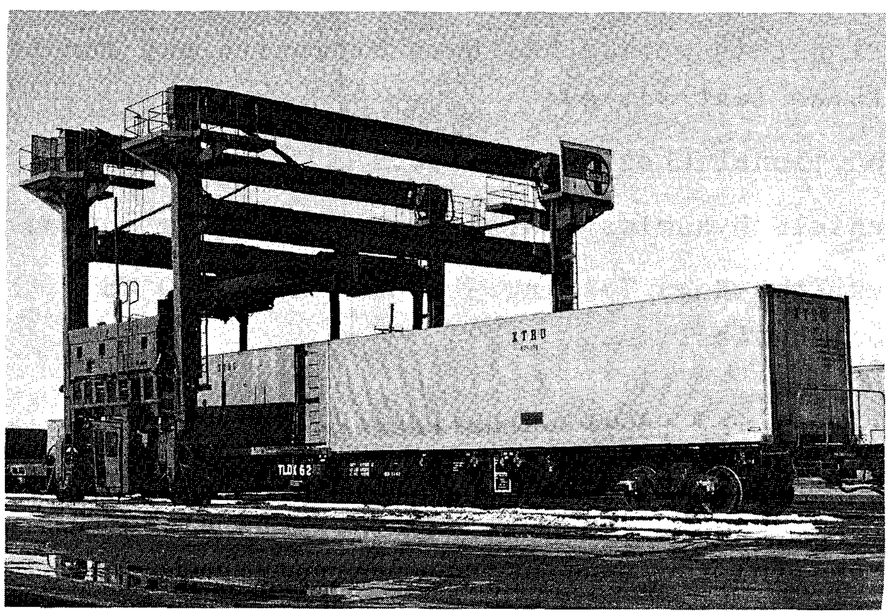


Figure 5-3. Reconfiguring Loads

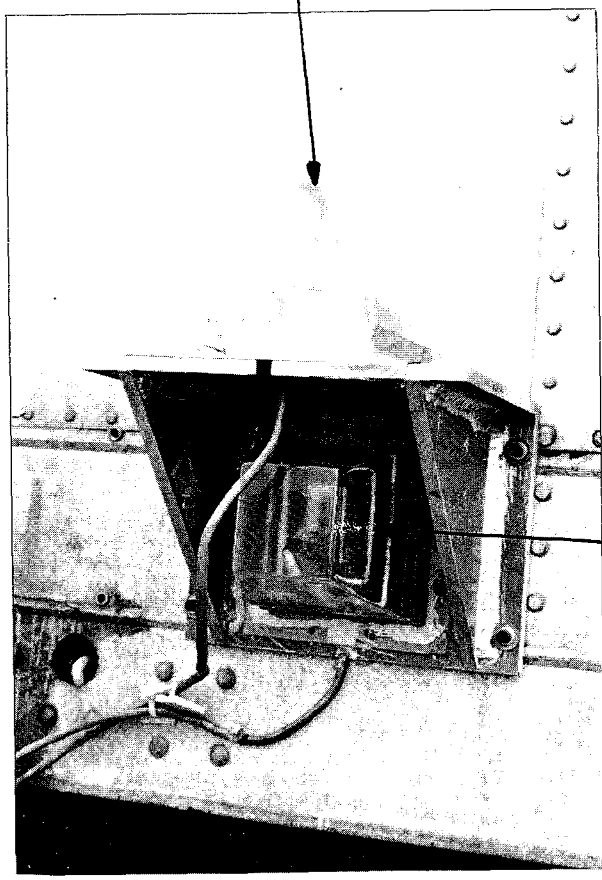


Figure 5-4. Accelerometer-Transducer Installation

The Functional Checkout Test series was performed at the Transportation Test Center. Physical measurements of truck components were made including wheel profile in anticipation of meeting the objectives involving component wear. The test consist was visually inspected for wheel lift, excessive coupler angle, and machining of wheel flanges during negotiation of maximum curvature turnouts and artifically perturbed track. Carbody roll-angle and twist were measured over the latter using a gyroscope and displacement transducers. These tests were used to certify the test consist safe for operation on revenue service track. Additionally, the instrumentation and its attendant conditioning and recording equipment were verified for reliability under the severe conditions to be encountered in later tests.

Following these tests, the Vehicle Dynamic Characterization Tests were carried out at La Junta, CO. Test zones were established on Class 3 and Class 5 tangent track and the consist was operated over the track at constant speed in increments of 10 mph up to the track limit (40 mph on Class 3 and 79 mph on Class 5). Load configurations were also varied to include empty, half-loaded, and loaded flat cars.

Acceleration was measured on the axles, carbody, and loads to meet objectives 1 and 5. Track geometry was also measured using a high-resolution, laser-based, track survey device to obtain a linear system analysis. This analysis will be used eventually to extrapolate these results to other track conditions (objective 6).

A series of OTR round trips between Kansas City and Los Angeles was conducted in an actual revenue service environment. Aceleration measurements were made in a manner identical to the measurements made in the Vehicle Dynamic Characterization Test to quantify the ride performance of the test vehicles in typical service operation (objective 2).

5.3 INSTRUMENTATION

The instrumentation used for this test program consisted primarily of precision servo-accelerometers. Specially developed mechanical isolators were used to protect the accelerometers from high-level accelerations above 150 Hz. Figure 5-4 shows one of the bi-axial instrumented stations hermetically sealed. This technique proved extremely effective in dramatically reducing the failure rate of these accelerometers. Only one failure was experienced in over 4,000 miles of revenue service.

The analog signals from the accelerometers were cabled to data acquisition car T-5, where the signals were filtered for processing. Up to 120 channels of acceleration data were digitized at a rate of 128 samples per second. A specially programmed mini-computer on board the data collection car then buffered this data onto a magnetic tape in a packed format. The digitized data was also reconverted for visual inspection. The on-board computer and Brush chart are shown in Figure 5-5.

5.4 DATA PROCESSING

The acceleration measurements made at specific locations (17 on the carbody, 8 on each trailer or container, and 5 on each axle) were reduced to accelerations along a set of generalized coordinates designated the modal coordinates. For the carbody and loads, the modal coordinates consisted of both rigid- and elastic-body coordinates (carbody - 6 rigid and 4 elastic, loads - 6 rigid and 1 elastic). The use of modal coordinates offers a number of distinct advantages in the analysis of rail vehicles. First, the modal coordinates are easy to visualize and, as a result, are helpful to the design engineer. Second, since these coordinates are orthogonal or independent, phenomena such as cancellation and re-enforcement do not obscure details of analysis. Third, modal coordinates may be used to obtain the actual acceleration level at any point on the vehicle. This is particularly important considering that a finite number of measurements were made to obtain the modal coordinates.

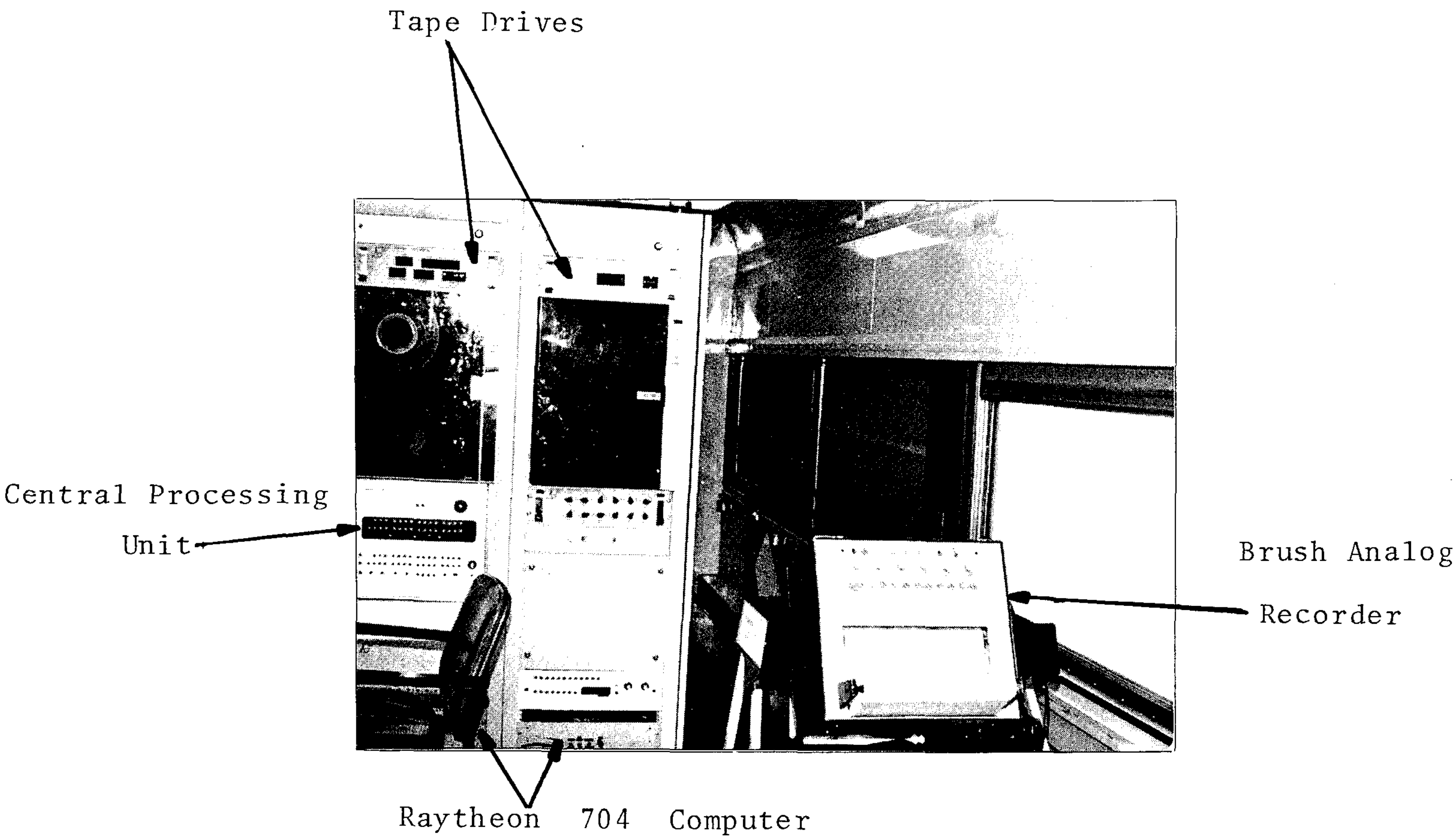


Figure 5-5. Data Acquisition and Inspection System

Modal coordinates are calculated using the least squares technique to fit a specified number of time-dependent coefficients of the measured data. This is done using specially developed algorithms on the RDS-500 mini-computer (64k). The modal coordinates are then presented in four basic formats. First, in the form of power spectral densities which show the power content as a function of frequency. Second, the positive zero crossings of the time history of each modal coordinate is displayed in the form of a histogram. The third form of presentation is a probability density plot including the mean standard deviation and rms values. The fourth form of data presentation is perhaps the most informative. This is an rms time history of each modal coordinate. In addition, the rms values of 4 octaves are also shown with center frequencies at 2, 4, 8 and 16 Hz. Speed is shown in an adjoining plot which is important in interpreting the time histories.

5.5 RESULTS AND CONCLUSIONS

To date, the LWFC program has been highly successful in providing the data necessary to compare the ride performance of lightweight and conventional flat cars (objective 1). These results have shown that lightweight flat cars in COFC and TOFC service provide a ride environment comparable to that of the conventional flat car. This finding was surprising to some program participants. As a result of the ride environment finding, the use of premium trucks was dropped from the program.

Results have also shown that fully loaded flat cars provide a substantially better ride performance than other load configurations (objective 5). In particular, it was found that the trucks of the conventional flat car carrying a single load had a tendency to go into a lateral oscillation or hunting mode. This in turn had an extremely adverse effect on the acceleration levels in the load.

Finally, data has been obtained for the first time which characterize the vibrational environment of containers and trailers during revenue operation (objective 2). This data should prove extremely helpful to both shippers and railroads in evaluating the use of this mode of freight transportation. In particular, it should now be possible to determine what packing arrangements need to be made or what goods can be shipped with assurance of delivery without damage.

Testing will continue during the upcoming year to provide similar data at specified points in the mileage accumulation of the test cars. This will allow a determination of the effects of component wear on the ride performance of these cars (objectives 3 and 4).

This program has been successful in developing an effective tool for rail vehicle evaluation. For this reason, an effort should be made to disseminate this information to engineers who will be designing and evaluating the future generation of lightweight flat cars.

6.0 FULL SCALE AERODYNAMIC VALIDATION TESTS OF TRAILER-ON-A-FLAT CAR

6.1 INTRODUCTION

The introduction of new car designs, specifically rack and piggyback cars, has caused a renewed interest in the aerodynamic resistance of freight trains. Railroads have experienced the need for additional power when pulling a trail of rack or piggyback cars as compared to standard rail cars. As a result, A. H. Hamitt and Associates performed a series of wind tunnel tests to obtain basic information applicable to railroad car aerodynamics and particularly TOFC and COFC configurations. The aerodynamic resistance of the standard configurations and of modified configurations designed to decrease the air resistance was determined.

The primary purpose of the Full Scale Aerodynamic Validation Tests of Trailer-on-a-Flat-Car was to collect data to validate the results of the wind tunnel tests. The secondary purpose of the tests was to measure the entire tractive resistance of the TOFC configuration in order to determine the rolling resistance.

6.2 OPERATIONS

The tests (performed on the Railroad Test Track at the Transportation Test Center in Pueblo, CO) were conducted by running a consist which included two TTX flat cars, each of which was loaded with two van-trailers, over the test zone at constant speeds. The first flat car in the consist was used as a buffer car and the second flat car was the test car. Checkout and initial tests indicated that speeds in excess of 50 mph were needed to produce measurable aerodynamic forces on the instrumented van-trailers. Train speeds in excess of 70 mph produced dynamic forces which masked the aerodynamic forces. As a result, a majority of the tests were conducted at speeds between 50 and 70 mph.

6.3 INSTRUMENTATION

The instrumentation for the test series was implemented according to the requirements specified by A. H. Hammitt and Associates. The aerodynamic forces were measured by supporting the van-trailers on a mechanical balance system consisting of load cells.

Accelerations needed for final aerodynamic-force measurements were acquired from nine servo-accelerometers located on the van-trailers and the body of the test rail car. The accelerometers were grouped in sets of three and mounted mutually perpendicular to measure vertical, lateral and longitudinal accelerations.

Other measurements were collected for use in the analysis. Train speed was measured by an optical tachometer attached to an axle on the data collection vehicle and train location was determined by a magnetic location detection device. Relative wind speed and direction were measured by a wind sensor mounted to a mast attached to data acquisition vehicle T-5.

Signals from these instruments were conditioned by electronic units mounted on the deck of the test vehicle. The signals were then transmitted to the data acquisition vehicle for filtering, digitizing and recording on digital magnetic tape.

6.4 DATA REDUCTION

Data collected at the wayside weather station was used to generate air density values which were needed to determine dynamic pressure and subsequent force areas and moment values.

Data collected by the T-5 data collection vehicle were reduced in two ways. Initially, average values and standard deviations were calculated for each of the data channels on each run segment. Forces and moments on each van-trailer and the total force and moments on both van-trailers were then computed using the average values of transducer outputs.

6.5 ANALYSIS

The following results were determined from the data collected on the tests:

- Interpretation of the test data was difficult due to lack of reliable calibration factors and large zero shifts.
- It appeared from the questionable nature of the calibration data that the trailer-flat-car system was not perfectly rigid.
- The appreciable zero shifts between pre- and post-run transducer readings implied that the dynamics of the test vehicle led to non-elastic deformations in the trailer-flat-car system.
- Drag force data was the least susceptible to the above mentioned difficulties and compared within 25 percent with wind tunnel data when the buffer flat car was loaded with two van-trailers and the angle of yaw was near zero. The comparison was somewhat better when the buffer flat car was empty.
- No conclusive results were obtained for the rolling resistance because of erratic variation of coupler forces.

6.6 CONCLUSIONS

The first series of TOFC aerodynamic tests suffered from two major problems. First, there was a lack of reliable calibration data and secondly, the trailer flat car system underwent appreciable non-elastic deformations. These difficulties had their origins, at least in part, in the original concept of a mechanical balance system. As a result, alternatives have been reviewed and a second series of aerodynamic tests has been scheduled.

7.0 DODX RAIL CAR STABILITY TESTING

7.1 INTRODUCTION

Since 1971, efforts have been made to determine the roll stability, wheel lift, and derailment tendencies of 100-ton rail cars loaded with high center-of-gravity containers. The stability testing was started because railroads had been experiencing roll-stability difficulties with this type of rail car. In addition, it was imperative to find ways of minimizing the probability of derailment since the containers carried nuclear materials and equipment.

Twelve DODX rail cars have been tested to insure compliance with AAR specifications for carbody roll angle, wheel lift and derailment tendencies. Two of these 12 tests were conducted during this reporting period.

7.2 OPERATIONS

Each test vehicle was towed over a pre-selected section of track at the Transportation Test Center in Pueblo, CO. These track sections had been perturbed to excite the test vehicle in the roll mode. Each vehicle was operated at a series of speeds with different load configurations. During each pass over the test section, vehicle behavior in the roll mode was measured and observed. If a vehicle did not meet performance requirements, modifications were made to its suspension system and it was retested. This procedure was repeated until optimum results were achieved.

7.3 INSTRUMENTATION

Five types of transducers were used to collect the required data. A vertical gyroscope was employed to measure the absolute angle of the roll and pitch axes of the test vehicle. Rotational accelerometers were used to measure linear accelerations in the vertical, lateral, and longitudinal directions and rotational accelerations about the roll, pitch and yaw axes. Potentiometer displacement transducers were used on each car to measure spring-group travel and carbody-to-truck-bolster travel. Train speed was measured using an optical tachometer connected to and driven by an axle of the data collection vehicle. A magnetic location detection sensor was used to identify the exact position of the test vehicle along the track section. Signals from these measuring instruments were conditioned and filtered by programmable filters on board the T-5 data collection vehicle and then digitized and recorded on digital magnetic tape.

In addition to the transducers, two motion picture cameras and one video camera monitored wheel lift conditions. The cameras were used to view the right side of the leading and trailing truck of each vehicle. Video signals were recorded for each test run while the motion picture cameras were employed only during those test runs where wheel lift was anticipated.

7.4 MATHEMATICAL MODELLING EFFORT

During the course of these tests, it became apparent that an easier, less expensive method of predicting rail car roll stability was needed. A search for existing computer simulation models revealed a mathematical model developed by Yan Hai Tse and Gregory Martin of the Association of American Railroads which could be used with only minor modifications.

Initial attempts to make the computer model operational were only partially successful. Since July 1976, ENSCO has made modifications to the program resulting in a computer simulation model which fulfills FRA requirements.

During the evaluation of the initial attempt, it was decided that a number of changes should be made in order to make the model more effective in the prediction of DODX rail car roll stability. Some of these modifications were prompted by the desire to reduce the amount of computer time required to simulate a test run. Therefore, changes were made to reduce processing time.

Changes were also made to the track input function, the non-linear friction dampers and to the output format. Another change involved the simulation of the Stucki hydraulic damping device which was not considered in the original AAR model.

The modified mathematical model was validated by using data collected during field tests on four different car types in a total of eight configurations. Conclusions drawn from the model validation are that the model can accurately simulate the rock and roll response of freight cars with conventional two-axle trucks provided that these cars are not excessively long or flexible. The model can be used for multi-truck cars but with a reduced accuracy in predicting peak roll angle response and wheel lift.

7.5 ANALYSIS

A substantial number of the test vehicles met or exceeded the required specifications; however, in those cases where a standard configuration failed to meet the specifications, specific modifications were implemented and the vehicle was retested.

In addition, the computer simulation studies revealed the following cause/effect relationships:

- Softer truck suspensions generally result in improved roll stability.
- Lowering the vehicle center of gravity improves its stability.
- The Stucki hydraulic damper improves vehicle roll stability.

- Increased truck-axle spacing reduces the effective track input from half-staggered rails and thus reduces vehicle roll response.
- The on-center spacing of trucks has a dramatic effect on the roll and torsional inputs transmitted to the vehicle from half-staggered rails, and thus has a marked effect on vehicle rock and roll response.

7.6 CONCLUSIONS

The DODX Rail Car Stability tests were successful in that all trucks tested now meet or exceed applicable specifications.

8.0 VEHICLE VIBRATION AND RIDE QUALITY TESTING

8.1 INTRODUCTION

Ride quality is principally a subjective estimate of how well a vehicle isolates a passenger from disturbances externally produced by irregularities in a roadbed. Although ride quality in this report alludes primarily to railroads, the concept is applicable to airplanes, buses, automobiles and other vehicles.

Passenger evaluation of ride quality is generally quantified using a statistical approach. After riding a particular vehicle or vehicles, a number of individuals are then asked to subjectively rate the ride as good, fair, or bad, or they may be asked to rank different vehicles against each other. The results are assigned numerical values and averaged to obtain a numerical rating of ride quality.

It has been known for many years that vertical, lateral and, to a lesser degree, longitudinal accelerations experienced within the vehicle body correlate with estimates of ride quality, although not necessarily on a one-to-one basis. This correlation with ride quality only applies to accelerations over a certain frequency range. More recent studies have shown that the correlation is even greater if certain frequencies are weighted or given more importance than other frequencies. In fact, an ISO Human Response Curve has been published which can be used to weight the acceleration signals used for estimating ride quality.

The measurement of vehicle accelerations is also important in the area of freight car operation since acceleration amplitudes generally correlate directly with lading damage. This is because acceleration levels are normally a direct measure of energy input to the lading system. Where specific mechanical resonance or similar frequency response phenomena are known to exist, the measured accelerations can be weighted to obtain a better measure of their effect.

The Federal Railroad Administration is involved in the improvement of rail vehicle ride quality. As a tool to aid in the study of ride quality, ENSCO has developed hardward and software capabilities that can be used in evaluating certain dynamic parameters associated with the ride quality of a rail vehicle.

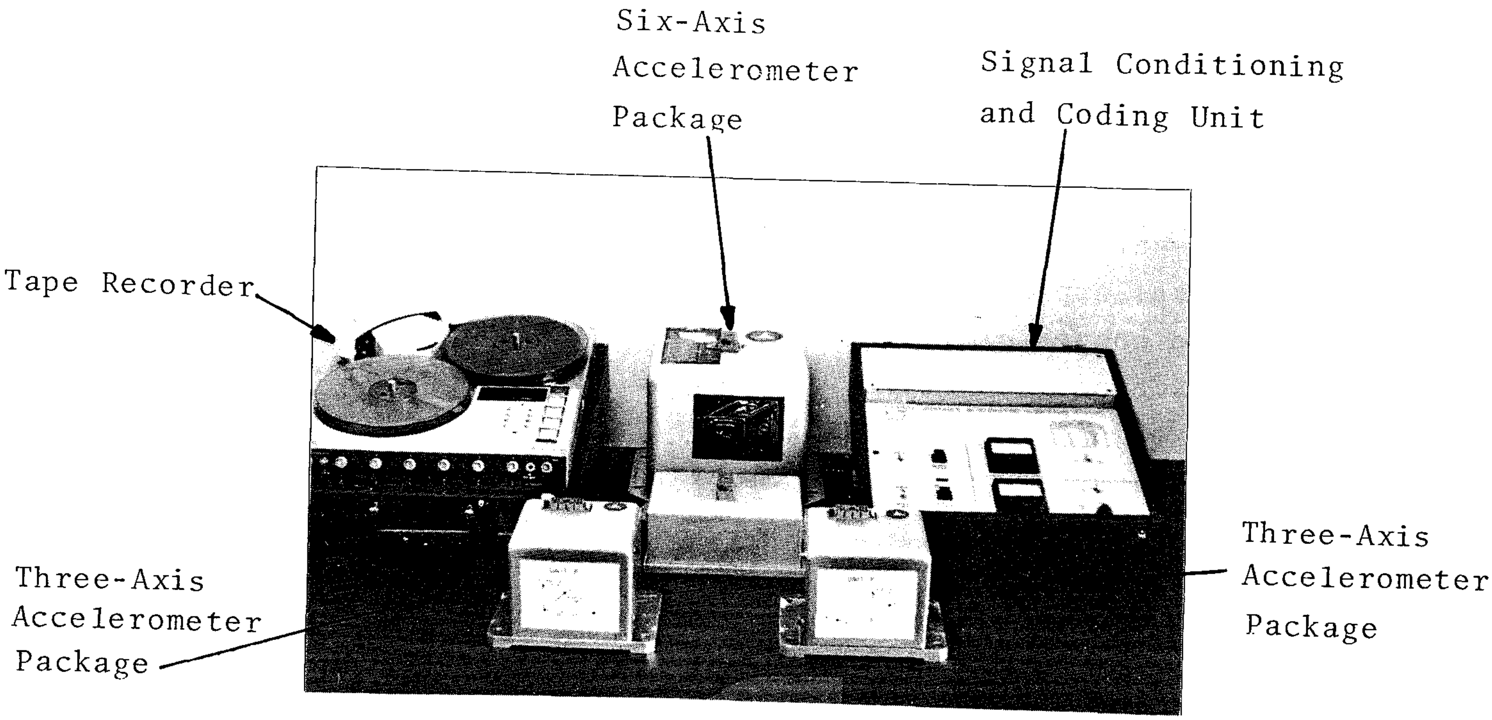
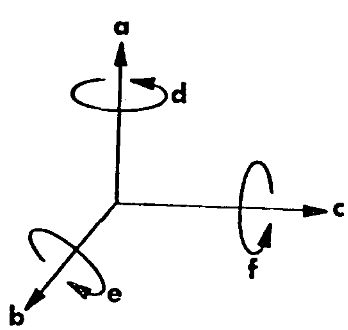


Figure 8-1. Portable Acceleration Data Acquisition System

The Portable Acceleration Data Acquisition System (Figure 8-1) is designed to measure, record and regenerate linear and angular accelerations which occur in three mutually orthogonal axes, as shown in Figure 8-2.



a. Vertical Axis
b. Lateral Axis
c. Longitudinal Axis
d. Yaw Rate
e. Pitch Rate
f. Roll Rate

Figure 8-2. Axes Measured by Portable Acceleration Data Acquisition System

The Accelerometer Package generates basic analog signals which represent accelerations occurring in its immediate environment. Each acceleration signal is conditioned and then recorded on a discrete FM channel in the Tape Recorder. The Tape Recorder also accepts correlation data such as speed, location, and voice annotation. The Conditioning and Coding Unit provides complete controls for generation and display of coded correlation data.

Wow and flutter distortion is minimized by the use of an internal reference oscillator signal which is recorded with acceleration data. When data is played back, any deviations in reference signal are detected and data is compensated accordingly. Self-test features allow calibration of each accelerometer channel and requires no additional equipment.

A set of tri-axial accelerometer packages allows the flexibility of collecting data at two locations at the same time. In addition, sound level equipment is available to collect noise data.

A Vehicle Vibration Software Package has been developed to reduce the data collected with the Portable Acceleration Data Acquisition System. The output of this package consists of 22 pages of summaries, graphic estimates and plots. This output includes:

- Time series plots
- Probability density estimates and plots
- Distribution function estimates and plots
- One-third octave band rms levels
- The ISO exposure time for the reduced comfort criteria
- Power spectral density levels and plots
- Cepstrum plots for PSD levels
- RMS time series plots
- W_z rating criteria .

The results of this package are very useful in studying the basic dynamic characteristics of a rail vehicle. The time series plots are indicative of the vibration levels within the carbody. The

ISO and W_z criteria introduce human conditioning criteria into certain aspects of ride quality evaluation. Finally, PSD plots indicate the frequencies at which certain key characteristics exist and provide an insight into truck and carbody behavior.

8.2 IMPLEMENTATION

8.2.1 ROHR TURBOLINER (RR-214)

On 29 September 1976, ride quality data was collected on a Rohr Turboliner between Washington, D.C. and New York City. The purpose of this test was to determine the ride characteristics of the turboliner and compare these characteristics with those of other vehicles tested on the Northeast Corridor.

8.2.2 CANADIAN LRC TESTING (RR-251)

During March 1977, ride quality measurements were taken on the Canadian Lightweight-Rapid-Comfortable Train which remains level while travelling around curves and provides a more comfortable ride than standard rail vehicles. The first test zone was over a perturbed track at speeds up to 120 mph. A curved section of track near New Haven, CT was used as the second test zone. Although AMTRAK vehicles were limited to 60 mph on this section of track, the LRC traversed the curve at 90 mph.

8.2.3 PULLMAN STANDARD RIDE QUALITY TESTING

In May 1977, ride quality data was collected on two new Pullman Standard bi-level cars. The purpose of this test was to determine whether or not the ride quality of the new Pullman Standard car was better than that of the AMTRAK El Capitan car.

8.2.4 GSI METROLINER TRUCK IMPROVEMENT PROGRAM (RR-254)

As part of the overall program to improve the ride characteristics of Metroliners, ENSCO participated in instrumenting a newly modified truck and collected both dynamic and ride quality data. The processed data was used to evaluate the performance of the modified vehicle as compared to that of a standard Metroliner.

9.0 VERTICAL SHAKER SYSTEM LABORATORY TESTS OF TRAILER-ON-A-FLATCAR

9.1 INTRODUCTION

Trailer-on-a-flat car (TOFC) optimization tests were performed for FRA at the Rail Dynamics Laboratory in Pueblo, Colorado in a continuing effort to develop efficient and safe intermodal systems that would result in minimum damage during the shipment of goods. The reason for using the RDL facilities was to evaluate the usefulness and practicability of the RDL Vertical Shaker System. The purpose of the tests was to determine the effect of variations in configuration of the TOFC system components on lading acceleration levels. Selected configurations of full-scale loaded and unloaded TOFC systems were tested by exciting all four wheels of one truck of a TTAX flat car using the Vertical Shaker System.

9.2 OPERATIONS

The Vertical Shaker System, used for TOFC testing, consisted of four 40,000-force-pound, computer-controlled, hydraulic shakers. The shakers were positioned under one end of the TTAX flat car and were operated to simulate pitch and roll. Instrumentation was located throughout the TOFC vehicle to determine the natural frequencies and modes of vibration of the flat car, the van and the trailer and the resulting effect on the lading in the van and trailer.

9.3 INSTRUMENTATION

Extensive instrumentation was utilized during TOFC testing to permit detailed analysis of the response of the TTAX flat car, the trailer, the van and the lading in the van to VSS excitation.

Pitch VSS operation (all shakers in-phase) used to excite TOFC suspension group bounce, pitch and elastic body-bending modes was monitored on the body of the railcar using three centerline vertical accelerometers. Vertical accelerometers were located on the van and were used to measure van-body accelerations.

Various vertical accelerometers located in the lading and a triaxial accelerometer group located near the center of the lading were used to measure lading accelerations. Other data channels monitored included a B-end bolster accelerometer, a sill strain gage, a van-tandem load cell and the VSS piston accelerometer.

Out-of-phase VSS operations used to excite TOFC rigid body roll and elastic body torsional modes were monitored by off-centerline vertical accelerometers. The most important out-of-phase measurement, however, was made from a roll gyro located on the centerline directly above the B-end truck.

The VSS utilized a data acquisition system consisting of a bank of 128 analog signal-conditioning and filtering units, a multiplexer and a 12-bit, high-speed, analog-to-digital converter.

9.4 SOFTWARE

A number of data reduction procedures were available for application to TOFC optimization test data. The on-line SWEEP program was used to step the shaker through preselected frequency ranges. Data collected by this routine was processed by the Transfer Function Analysis program and the Root Mean Square program. The SWELL/DECAY program permitted selection of amplitude excitation frequency, data sampling rate, recording time and real-time analysis for up to 15 operator-specified channels of data. Data collected by this latter on-line program were processed to provide both Power Spectral Density and single-point, transfer function, data outputs. Although the primary data reduction procedure used to evaluate test data was the Transfer Function Analysis SWEEP program, all of the above mentioned software was employed throughout the series of tests.

9.5 ANALYSIS

The TOFC optimization test program resulted in a thorough and successful study of the Vertical Shaker System and provided a detailed analysis of the effect of TOFC system configuration changes on lading acceleration levels. The tests indicated that average vertical lading acceleration reduction of about 20 percent was achieved when hydraulic stabilizers were used on the ASF trucks. In addition, the tests showed that different acceleration levels can exist across the body of the flat car.

Out-of-phase VSS tests provided the most significant results. These tests showed a substantial amplification of TOFC roll inputs in the lading. Depending on the point of measurement in the lading, lateral acceleration amplification of 10 to 15 times the rail/wheel input level was normally observed. The need for cribbing and lateral blocking of a palletized TOFC load is supported by these results. In addition, the test showed that reduction of the net height of the lading would minimize potentially dangerous rock and roll resonance effects.

9.6 CONCLUSIONS

The results of the Rail Dynamics Laboratory TOFC optimization tests are not only important because they relate TOFC system configuration changes to lading vibration levels, but also because they provide a means for presenting detailed information on VSS full-scale, laboratory, railcar-testing, capabilities. The ability to measure railcar dynamics readily is a valuable laboratory tool. In fact, the ability to control and measure accurately the effects of full-scale, railcar, dynamic testing is considered to be a significant and important result of this effort and represents a major breakthrough in the use of laboratory facilities to measure and analyze the dynamics of rail vehicles. It is expected that this effort will be the forerunner of many extremely productive full-scale railcar tests that will be performed over the next few years.

10.0 SDP-40F, LOCOMOTIVE SAFETY EVALUATION PROGRAM

10.1 INTRODUCTION

AMTRAK owns a fleet of 150 SDP-40F diesel-electric, passenger locomotives. These six-axle units represent a dollar investment in excess of 100 million and were intended to be a key component in providing high-speed, passenger, rail service outside the Northeast Corridor.

Since their introduction into service in mid-1973, however, the SDP-40F locomotives (Figure 10-1) have been involved in 19 major derailments.

Following the derailments of two AMTRAK SDP-40F consists on 16 December 1976 and 16 January 1977, the National Transportation Safety Board (NTSB) issued recommendations to the Administrator of the Federal Railroad Administration.

The NTSB recommendations to FRA were as follows:

> "Investigate immediately the interaction between SDP-40F----locomotives of passenger trains and track conditions to determine the causes for the widening of the track gauge and act to correct the causes. (Class I, Urgent Follow Up, R77-1)"

> "Until such investigation and corrections are completed, restrict passenger trains with SDP-40F----locomotives to speeds that will permit safe operation around curves of one degree, 30 minutes or more on Class 4 or less track. The speeds should not exceed the equilibrium speed on such curves. (Class I, Urgent Follow Up, R77-2)"

FRA and AMTRAK had been concerned with and working on this derailment problem since the statistics began to show that the SDP-40F had been involved in a steadily increasing number of derailments.

Figure 10-1. SDP-40F Test Consist

Figure 10-2. E-8 Test Consist

To convince railroads that the SDP-40F was a safe locomotive at existing speed limits, they undertook extensive testing on the ICG railroad in early 1976. ENSCO had a significant role in these tests. However, the tests were inconclusive and did not pinpoint the cause of the high SDP-40F derailment record. As the derailment record continued to mount, a second series of tests were conducted on the BN railroad in March 1977 to try to identify causes of SDP-40F derailments and to justify a slow order placed on the SDP-40F by BN. The results of this series of tests are still being analyzed.

As a follow-on to the BN tests and to collect data on parameters suspected of causing derailments over a wider cross section of revenue track (as related to derailment-causing track characteristics), FRA Office of Rail Safety Research authorized the Chessie System Test. The objectives of this test were to provide for the practical comparison of the SDP-40F with a similar 6-axle locomotive which might lead to the identification of possible causes of SDP-40F derailments.

The Chessie System Test was designed to be intense and to include the collection of as much data as possible on parameters which might identify derailment causing situations.

A baseline locomotive (the E-8) shown in Figure 10-2, which was considered a stable performer by professional railroad personnel, was introduced into the test for comparison purposes. Also, the SDP-40F was physically modified to simulate various stages of wear or states of maintenance and tested after these modifications for comparison with the tests run on a locomotive in "like-new" condition.

Nine major organizations participated in and contributed to the test effort. These organizations included the Federal Railroad Administration, The Transportation Systems Center, ENSCO, INC., AMTRAK, The Chessie System, Battelle Columbus Laboratories, Association of American Railroads, Electromotive Division of General Motors and A. D. Little Company.

10.2 IMPLEMENTATION AND INSTRUMENTATION

The Chessie test was undertaken to collect additional data that might reveal the cause or causes of derailments of the SDP-40F due to variations in track geometry or equipment condition (how well and to what degree it was maintained) by operating an SDP-40F consist and a baseline locomotive (E-8) in consist with track-geometry-measurement cars over a broad spectrum of revenue track. The SDP-40F consist was instrumented and operated by AAR and EMD. ENSCO instrumented and operated the E-8 test consist.

Site selection runs were made over a three-day period with both the SDP-40F and E-8 test trains, one following the other. During these runs, vertical and lateral wheel/rail forces, vertical/lateral force ratios and other data were recorded. The trains traveled 644 miles making a round trip from Huntington, WV to Clifton Forge, VA to Charlottesville, VA, and return to Huntington, WV. After each day of running, collected data was analyzed and tabulated; at the end of three days, the data was presented to the FRA/TSC Site Selection Committee. After considering 14 different sites; the committee selected a test site at Milepost 257.5 about five miles west of Goshen, VA. The selected site was instrumented to provide point force measurements of wheel/rail forces at 12 locations. Testing actually began three days after the site was selected.

Testing at the selected site began with a series of baseline test runs using the E-8 consist. The test runs were made at speeds from 30 to 60 mph in power, drift and brake modes. Following the E-8 baseline runs, a similar series of tests were conducted using the SDP-40F test consist. After testing both consists in this manner to simulate normal maintenance conditions under different train handling conditions, modified testing of the SDP-40F consist was conducted to simulate worn suspension components and wheels as might exist in revenue service.

Under task 429, Support for SDP-40F Locomotive Testing, ENSCO took a major role in the actual test planning and coordination.

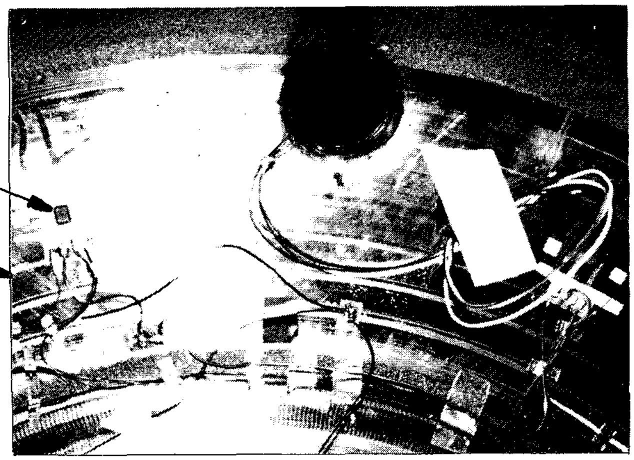


Figure 10-3. Strain Gage Installation on Wheel Plate

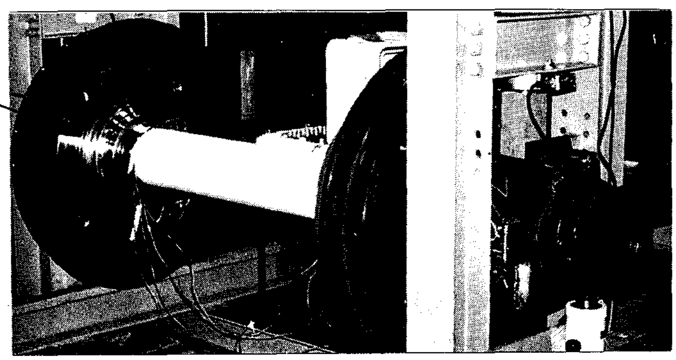


Figure 10-4. Laboratory Calibration of Instrumented Wheelset

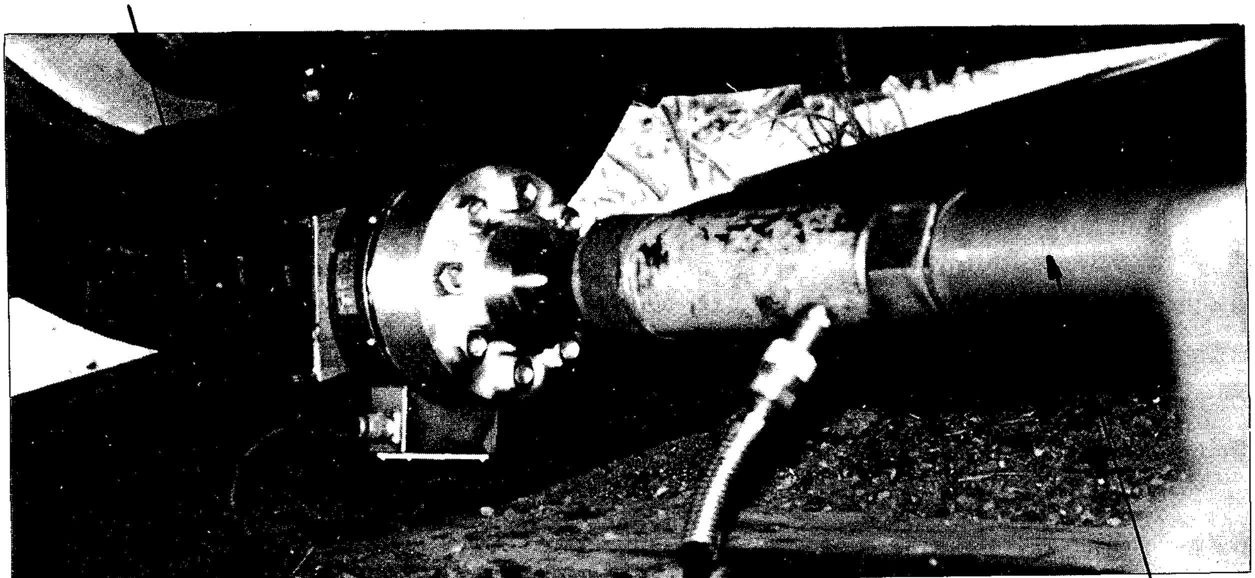


Figure 10-5. Field Calibration of Instrumented Wheelset

In addition, ENSCO was responsible for instrumenting and operating the baseline E-8 locomotive consist which included FRA track geometry cars T-1/T-3. This task also required design and fabrication of an instrumented wheelset for the E-8 and a real-time, wheel-signal, processing unit, and the installation of acceleromters on the locomotive carbody.

Cabling had to be provided to the T-7 Data Acquisition Car and the car had to be prepared to receive, process and record data from the locomotive and from the track geometry survey cars.

ENSCO coordinated the design of the instrumented wheelset with EMD to maintain compatibility with the instrumented wheelset they had produced for the SDP-40F locomotive.

The Hitec Corporation in Westford, Massachusetts was contracted to strain gage and calibrate the E-8 wheelset (Figure 10-3, 10-4 and 10-5) per ENSCO specifications. When the fabrication and checkout were completed all instrumentation was shipped to Huntington, WV for installation at the Chessie System shops in preparation for the test.

Following the over-the-road tests and the speed runs at the selected site, the E-8 locomotive instrumentation system was thoroughly checked out and the wheelset was recalibrated as part of the intensive post-test data validation activities.

10.3 ANALYSIS

At present ENSCO is actively participating in the FRA/TSC Data Analysis Task Force to support the reduction and analysis of the locomotive dynamic and track geometry data. Results of the ongoing analysis will be reported by the task force as soon as data reduction and analysis are completed.

10.4 CONCLUSIONS

Conclusions are not germane at this point since data reduction and analysis have not been completed.

11.0 AUTOMATED WAYSIDE INSPECTION STATION (AWIS)

11.1 INTRODUCTION

The Automated Wayside Inspection Station concept is envisioned as a means for providing an integrated capability for automatically inspecting railroad-vehicle-components (primarily wheels, axles, and trucks) while the consist is moving at operating speeds. To evaluate this concept, a centralized research and development facility will be established at the Transportation Test Center. This facility will allow the evaluation of the performance and reliability of various automated inspection devices. These devices, when operated in an integrated fashion, will allow the classification of defect-signatures. The operation of such a facility will establish a data base of defect signatures to support FRA inspection standards. Another objective of such a facility will be to demonstrate a mobile inspection capability for FRA Office of Safety inspectors.

11.2 OVERVIEW

The major objective is to design a centralized research and development inspection facility at TTC. The design includes four major subsystems. They are (1) Wayside Field Sites (WFS), (2) a Data Transmission Link (DTL), (3) a Processing and Display Central (PDC), and (4) a Mobile Data Van (MDV). Conceptually, this integrated system will receive data from various automated inspection devices installed at the WFS on a by-pass track at TTC and at other remote locations. The system will format and transfer the data in digital form through the DTL, and process, display, and record the digital data in the PDC for further analysis. This approach provides an automated analysis facility for demonstrating the performance of existing and implementing research on proposed automated rail-vehicle-inspection devices.

11.3 ENGINEERING

Previous work has defined the performance parameters of the candidate inspection devices. With this background, two levels of effort are underway. First, the present system specification development involves defining the functional performance of the AWIS system and allocating the required functions to the various subsystems. Secondly, detailed work is being done on the layout and installation criteria for the inspection devices on the by-pass track and remote sites. This work also involves detailed definitions of the floor space and power requirements for the Processing and Display Central and the Mobile Data Van. After the preliminary design is approved, detailed work on all subsystems will be started. Detailed subsystem design based on the allocated system functions will include hardware, software, and interface definitions. In general, the hardware design will be based on commercially available off-the-shelf equipment, while the software and interface designs will be internally developed. This type of approach (systems integration) will require careful attention to the equipment performance parameters to insure compatibility with the interface definitions and system requirements.

11.4 SOFTWARE

Software will be the heart of the AWIS system. It will provide system control, data reduction and analysis capabilities, display drives and control, recording and playback capability, plus built-in tests for the system. The inspection device outputs are primarily analog signals, and therefore, require analog-to-digital conversion to be handled in a digital processing system. In addition to the digital data, the AWIS will have closed circuit TV and Thermal Vision signals to process, display and record. Since the closed circuit TV and Thermal Vision require wide bandwidths for transmission (5-10 MHz), the design envisions impressing the digital data on a subcarrier in the video frequency band and stripping it out with a subcarrier discriminator at the receiving end for use by the processor. This approach will allow a full duplex mode of polling and receiving inspection device outputs. To accomplish this task, the software must control the timing and polling characteristics. Once the data is received, the processor must be capable of formatting the data for display and recording. Operator interactive displays controlled by the software are required for system monitoring and control. Digital-to-analog conversions will also be supplied for analog-record outputs of various devices.

The Mobile Data Van will be designed to incorporate the major functions of the Processing and Display Central except on a reduced scale. To accomplish this task, the software developed for the MDV must be similar in functional operation to the PDC but reduced in processing, display, and recording capability. Since the MDV only operates with one site at a time, either the by-pass or a remote site, the total processing capability may be reduced by having separate operating software for different operating configurations. Also, data analysis (play-back mode) may be handled as a non-real-time task.

11.5 FUTURE PLANS

To accomplish the AWIS task with a building-block concept, a logical development approach must be used. Using this development approach, the AWIS can be defined as the total of the functional performance requirements that were allocated to the subsystems and it can be implemented by these same functional performance requirements. The first two major subsystems to be designed are the WFS by-pass site and the Mobile Data Van. Integrating the inspection devices and building and outfitting the MDV will comprise the major hardware development efforts. Development of the software to integrate the operation of the hardware will be a parallel effort. These two efforts will produce a demonstrable mobile automated wayside inspection capability. Once this capability is demonstrated, the detailed design of a total AWIS can be implemented by the addition of a Data Transmission Link, and increasing the software and display capabilities of the MDV to implement the Processing and Display Control. Depending on funding and schedule constraints, the AWIS can be implemented in a logical fashion to provide any level of performance from the simplest integration of inspection devices and a mobile recording and display capability to a full system-capability.

APPENDIX A

DESCRIPTION OF TEST CODES

TEST CODES

Test Vehicle		Type of Test	
R	Research Cars	C	Power Collection
D	Dynamometer Car	P	Propulsion
T	Track Survey Device	B	Braking
S	Metroliner or Special Demonstration Car	G	Guideway (Track Geometry)
C	Conventional Car	V	Vehicle (General)
M	Maintenance Vehicle	T	Truck
X	Miscellaneous	R	Ride Quality
L	Locomotive	M	Maintenance
W	Wayside	I	Instrumentation
H	Hospital Car	X	Demonstrations and Miscellaneous
		D	Vehicle (Track Dynamics)

The first digit indicates the type of test vehicle, while the second digit indicates the type of test. The remaining digits are assigned in chronological sequence. For example, LT-175 means the test vehicle was a locomotive, the test was performed on a truck, and the number 175 is the 175th test assigned under the FRA testing program. Some test numbers are missing in the Appendix. These numbers were either included in previous annual reports, canceled after being assigned, or were assigned in FY76 and scheduled for FY77.

APPENDIX B

ENGINEERING AND TEST SUPPORT SERVICES PUBLICATIONS

Internal Report Number	Title	Date Published
DOT-FR-71-1	DOT Test Train Program System Instrumentation Manual--Second Edition	January 1971
DOT-FR-71-2	Test Train Program Third Annual Progress Report	June 1971
DOT-FR-71-3	Inventory of Government Property	September 1971
DOT-FR-71-4	Tape Summary Program Manual	October 1971
DOT-FR-71-5	Post-Calibration Program Manual	October 1971
DOT-FR-71-6	Interim Crosslevel Program Manual	October 1971
DOT-FR-72-1	DOT Test Train Program System Instrumentation Manual--Third Edition	January 1972
DOT-FR-72-02	Maximum Ranges of Excursion of the Proximity Sensors on the DOT Test Cars	March 1972
DOT-FR-72-03	Gage Program Manual	March 1972
DOT-FR-72-04	Power Spectral Density Program Manual	March 1972
DOT-FR-72-06	Index Program Manual	June 1972
DOT-FR-72-07	Brush Chart Reproduce Program Manual	June 1972
DOT-FR-72-09	Test Train Program Fourth Progress Report	December 1972
DOT-FR-72-10	Hardware Bootstrap Manual	August 1972
DOT-FR-72-11	Metroliner Ride Data Collection System	July 1972
DOT-FR-72-12	Ride Quality Data Analysis	February 1973
DOT-FR-72-14	Technical Manual for Speed/Distance Processor	October 1972

Internal Report Number	Title	Date Published
DOT-FR-72-15	Instrumented Truck Project Phase I Boxcar Specifications	December 1972
DOT-FR-72-16	Wayne-Kerr Amplifier Operation/ Calibration	October 1972
DOT-FR-72-17	Technical Manual--Operator Console System	February 1973
DOT-FR-72-18	Internal Communications System	January 1974
DOT-FR-72-19	Track Curvature Subsystem	February 1973
DOT-FR-72-20	Ride Quality Package Design Recommendations Report	November 1972
DOT-FR-72-21	DOT Test Train Program System Instrumentation Manual--Fourth Edition	December 1972
DOT-FR-73-01	Shim Program Manual	February 1973
DOT-FR-73-02	Track Survey Device (TSD) Software Support	February 1973
DOT-FR-73-03	Shim Plan: A Systematic Method of Realigning Railway Track for Dynamic Compatibility	May 1973
DOT-FR-73-04	Crosslevel Program Manual	May 1973
DOT-FR-73-05	Profile Program Manual	May 1973
DOT-FR-73-06	Track Geometry Analysis of UMTA Test Track and UMTA and LIMRV Access Spurs	March 1973
DOT-FR-73-07	Methods of Processing Track Geometry Data to Obtain Representations of Profile and Alignment	April 1973
DOT-FR-73-08	Track Geometry System, Validation Report	December 1973
DOT-FR-73-09	Correlation Analysis of Various Track Profile Quality Indices	May 1973
DOT-FR-73-10	Acceptance Test of FRA Ballast Consolidator	May 1973

Internal Report Number	Title	Date Published
DOT-FR-73-11	Catenary and Pantograph Test	May 1973
DOT-FR-73-12	Test Train Program Fifth Progress Report	February 1974
DOT-FR-73-13	First Annual Report (Kansas Test Track)	March 1974
DOT-FR-73-14	Track/Train Dynamic Literature Survey and Work Plan	March 1974
DOT-FR-73-15	Correlation of Track Geometry Indices and Perceived Ride Quality	March 1974
DOT-FR-73-16	Review of Real-Time Spectrum Analyzers for Railroad Track and Vehicle Research Applications	March 1974
DOT-FR-73-17	Vehicle Dynamic Responses by Co-Processing Ride Quality and Track Geometry Data	March 1974
DOT-FR-73-18	Conversion of FRA Track Safety Standards from 62-foot Chord Length to a Different Chord Length	November 1973
DOT-FR-73-19	Global Measures of Track Quality	December 1973
DOT-FR-73-20	GEOPLOT Program Description	March 1974
DOT-FR-73-21	The Use of Automatically Acquired Track Geometry Data in Long-Range Maintenance Planning	May 1973
DOT-FR-74-01	Correlation Analysis of Various Track Gage Quality Indices	April 1974
DOT-FR-74-02	TGDIFF: Program Specifications	March 1974
DOT-FR-74-03	Technical Description of Analog Data Collection System	February 1974
DOT-FR-74-04	Portable Acceleration Acquisition System	April 1974

Internal Report Number	Title	Date Published
DOT-FR-74-05	Power System Upgrade Manual	March 1974
DOT-FR-74-06	Development of an Inertial Profilometer	February 1974
DOT-FR-74-07	Validation of Ride Quality and Track Geometry Co-Processing Techniques	April 1974
DOT-FR-74-08	Sensor Diagnostic Program Description	March 1974
DOT-FR-74-09	All-Weather Gage Measuring Systems	April 1974
DOT-FR-74-11	Curvature Program Manual	May 1974
DOT-FR-74-12	Second Kansas Test Track Summary Report	March 1974
DOT-FR-74-13	DOT Test Train Program System Instrumentation Manual -- Fifth Edition	March 1974
DOT-FR-74-14	Grade Detection Subsystem	March 1974
DOT-FR-74-15	Improved Crosslevel System	May 1974
DOT-FR-74-16	Chord Length Conversion Program Report	April 1974
DOT-FR-74-17	Effect of Ballast Consolidation on the Lateral Stability of Wood Ties in Railroad Track: A Preliminary Analysis	June 1974
DOT-FR-74-18	Rail Research Program Data Base Index: Task 56(E5)	April 1974
DOT-FR-74-19	Test Train Program, Sixth Progress Report	June 1974
DOT-FR-74-20	Brief Notes on Track Geometry Parameter Histograms and Power Spectral Density Plots	August 1974
DOT-FR-74-21	Continuous Vertical and Lateral Force Computations from Strain Gauge Instrumented Rail Wheel Sets	September 1974

Internal Report Number	Title	Date Published
DOT-FR-74-22	Track Geometry Measurements and Data Processing Developments in the Rail Research Program	October 1974
DOT-FR-74-23	DOT Test Train Program, System Instrumentation Manual -- Sixth Edition	December 1974
DOT-FR-75-1	Acquisition and Use of Track Geometry Data in Maintenance-of-Way Planning	March 1975
DOT-FR-75-2	Onboard Track Geometry Data Reduction Study	March 1975
DOT-FR-75-3	Ride Quality Data Analysis Procedures	June 1975
DOT-FR-75-4	Profilometer Sensor Report	September 1975
DOT-FR-75-6	Inertial Alignometer Development Report	January 1976
DOT-FR-75-7	Profilometer System Development Report	March 1976
DOT-FR-75-8	Servomagnetic Gage System	July 1975
DOT-FR-75-9	Computer Implementation of ISO Standard 2631 for Processing Ride Vibration Data	July 1975
DOT-FR-75-10	Ride Quality Meter Manual	January 1976
DOT-FR-75-12	Metroliner Truck Test RG-125.1	July 1975
DOT-FR-75-13	Test Train Program Seventh Progress Report	June 1975
DOT-FR-76-01	DOT Test Train Program System Instrumentation Manual -- Seventh Edition	June 1976
DOT-FR-76-02	The Effects of Accelerated Ballast Consolidation	June 1976

Internal Report Number	Title	Date Published
DOT-FR-76-03	Test Train Program Eight Progress Report	August 1976
DOT-FR-76-04	Inventory of Government Property	August 1976
DOT-FR-77-01	Test Results Report Rhor Turbo-liner Ride Quality Test (Test Request RR-207)	July 1976
DOT-FR-77-02	Safety Manual DOT Test Train	October 1976
DOT-FR-77-03	Test Results Summary Report For DODX Railcar Stability Test	December 1976
DOT-FR-77-04	System Design For Vehicle-Bourne Locomotive Wheel/Rail Force Measurement	December 1976
DOT-FR-77-05	Test Results Report Lightweight Flatcar Evaluation (Functional Checkout) Test Request CV-128.1	December 1976
DOT-FR-77-06	Passenger Locomotive Ride Vibration Data Processing Final Report	December 1976
DOT-FR-77-07	Test Plan for a Prototype Radial Passenger Car Truck	December 1976
DOT-FR-77-08	Derailment of FRA Test Cars T-2 and T-4 on December 13, 1976	January 1976
DOT-FR-77-09	Events of the Accident Involving the Track Survey Device, 18-21 January 1977	February 1977
DOT-FR-77-10	Safety Manual FRA Test Cars	February 1977
DOT-FR-77-11	Special Test Cars Standard Operating Procedures for the Federal Railroad Administration	February 1977
DOT-FR-77-12	Railcars Standard Operating Procedures for the FRA Office of Safety	February 1977
DOT-FR-77-13	Development of an On-Board System for Track Stiffness Measurement	February 1977
DOT-FR-77-14	Safety Manual FRA Rail Flaw Detection Vehicle	March 1977

Internal Report Number	Title	Date Published
DOT-FR-77-15	Presentation on the Federal Railroad Administration Rail Flaw Detection Vehicle	March 1977
DOT-FR-77-16	Test Results Report TOFC Full Scale Aerodynamic Validation Tests CV-192	March 1977
DOT-FR-77-17	Standard Ride Quality Data Reduction Package	April 1977
DOT-FR-77-18	Trailer-on-a-Flatcar Vertical Shaker System Laboratory Test Results Report	May 1977
DOT-FR-77-19	Ride Quality Test Results Canadian LRC Testing in Support of RR-251	June 1977
DOT-FR-77-20	Mathematical Modeling Report for DODX Railcar	June 1977
DOT-FR-77-21	Third Dynamic Hopper Car Test Results Report	June 1977
DOT-FR-77-22	Test Results Report Light-weight Flatcar Evaluation (Mode Shape) CV-128.2	June 1977

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