REPORT NO. UMTA-MA-06-0025-75-9

URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM FISCAL YEAR 1974 YEAR END SUMMARY

Ronald J. Madigan

MARCH 1975

FINAL REPORT

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Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
Office of Research and Development
Washington DC 20590

Technical Report Documentation Page

1. Report No. UMTA-MA-06-0025-75-9	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM FISCAL YEAR 1974 YEAR END SUMMARY		5. Report Date March 1975
		6. Performing Organization Code
		8. Performing Organization Report No. DOT-TSC-UMTA-75-7
7. Author(s) Ronald J. Madigan		
9. Performing Organization Name and Address U.S. Department of Transportation Transportation Systems Center Kendall Square Cambridge MA 02142		10. Work Unit No. (TRAIS) UM404/R5708
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration Office of Research and Development Washington DC 20590		13. Type of Report and Period Covered Final Report Fiscal Year 1974
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Urban Rail Supporting Technology Program, managed by the DOT Transportation Systems Center for the Urban Mass Transportation Administration, is described for the 1974 fiscal year period. Major areas include program management, technical support and application engineering, facilities development, test and evaluation, and technology development. Specific technical discussion includes track measurement systems; UMTA facilities development at the DOT High Speed Ground Test Center,* Pueblo, Colorado; rail car test and evaluation; instrumentation for data acquisition and processing; noise abatement technology; tunneling; and car crashworthiness studies.

*The former High Speed Ground Test Center (HSGTC), Pueblo, CO, referred to herein, has, since 1974 been officially designated the Transportation Test Center (TTC).

17. Key Words Urban Rail Technology; Track Geometry Measurement; Noise Abatement; Tunneling; Applications Engineering; Test and Evaluation;	18. Distribution Statement DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 102	22. Price

Form DOT F 1700.7 (8-72)

PREFACE

This is the third of a series of fiscal year summaries of the Urban Rail Supporting Technology Program. Under system management of the DOT Transportation Systems Center, URST is a program of the Urban Mass Transportation Administration, Office of Research and Development, Rail Programs Branch.

URST Program activities are designed to meet goals and objectives of UMTA in support of the advancement of urban rail technology. While the emphasis in URST activities is in the area of rail rapid transit, the long range applications will also benefit commuter rail systems and light rail systems as well.

This year end summary presents fiscal year 1974 accomplishments and provides an outline of the work to be undertaken in the future. Prior accomplishments are reported in the summaries for fiscal years 1972 and 1973:

Fiscal Year 1972

R.J. Madigan, "Urban-Rail Supporting-Technology Program (UM-204), Fiscal Year 1972, Year End Summary," Report No. UMTA-MA-06-0025-73-1 (NTIS PB-220846). Available from the National Technical Information Service, Springfield, Virginia 22161.

Fiscal Year 1973

Ronald J. Madigan, "Urban Rail Supporting Technology Program Fiscal Year 1973 Year End Summary," Report No. UMTA-MA-06-0025-74-9 (NTIS PB 238602/AS). Available from the National Technical Information Service, Springfield, Virginia 22161.

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1. INTRODUCTION

Rail rapid transit, commuter rail, and light rail passenger systems in operation in this country are being expanded and new systems are being planned and constructed. Further, large parts of existing systems are in various stages of deterioration and must be improved. Much of the cost of improving the existing systems and constructing new systems will be assisted by the Federal Government through the Urban Mass Transportation Administration Capital Assistance Program. Accordingly, the UMTA Office of Research and Development is conducting research, development, and test and evaluation programs directed toward cost effective methods for improvement of urban rail transportation systems. These programs include prototype vehicles and components designs, ways and structures and structural components, and engineering design data on rail system component interaction, all of which contribute to effective use of the Capital Assistance Program funds and grants of other funds under Federal sponsorship.

A Project Plan Agreement, (PPA) sponsored by the UMTA Office of R&D, Rail Programs Branch, defines the role of the DOT Transportation Systems Center as Systems Manager for the Urban Rail Supporting Technology Program providing necessary technical support in urban rail transit development.

1.1 THE URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM

The primary goal of the program, summarized herein for the third fiscal year, is directed toward the systematic improvement and evolutionary development of rail system technology.

As Manager for the Urban Rail Supporting Technology Program, the Transportation Systems Center is charged with the:

- Development of a comprehensive program of test and evaluation of vehicles, structures, and the related components,

- Design, construction, and operation of facilities and equipment to support test and evaluation activity,
- Conduct of selected programs of R&D for industry-wide application, and
- Provision of all technical requirements, analyses, specifications, and plans necessary for UMTA evaluation and program development.

Management of these activities is coordinated by the program organization consisting of six subprograms or tasks. The scope of the six tasks is summarized as follows:

Program Management provides overall program plans and engineering direction; establishes resource requirements and test and demonstration schedules; identifies industry interfaces; assesses accomplishments; recommends implementation; and reports results.

Technical Support and Application Engineering provides direct assistance to operating properties to develop and establish overall operations and maintenance procedures; facilities and equipment requirements; and to identify significant transit industry problems. Further, this task develops R&D projects for UMTA review and approval; supports other UMTA system managers as directed; and evaluates new proposals.

Facilities Development provides technical support to design, construct, and operate the facilities and equipment needed to conduct a comprehensive program of test and evaluation of: urban rail cars and car subsystems; track structures and structural components; power systems; and signal systems for train operation and control.

Test and Evaluation plans and conducts system testing and operational evaluations; establishes test objectives, constraints, criteria, and procedures; provides all necessary measurement instrumentation and data acquisition and processing equipment; and prepares final reports and recommendations.

Technology Development conducts research and development and evaluate testing directed toward the introduction of improved technology in urban rail system applications. Major technology projects include:

a) Tunneling Technology

b) Noise Abatement Technology.

HSGTC Field Support TSC engineers are in residence at the DOT HSGTC to assist the rail transit community in defining support requirements, schedule and operational requirements, and procedures. Maintenance and measurement equipment, as well as data acquisition equipment and software, are available.

2. SUMMARY

2.1 PROGRAM MANAGEMENT

The UMTA Urban Rail Supporting Technology Program has developed and expanded during fiscal year 1974.

Efforts are continuing in:

- Track Geometry Measurement for Urban Rail Transit Systems
- Data Acquisition Systems for Track Geometry Measurements
- Test and Evaluation of Urban Rail Transit Cars and Equipment
- Data Acquisition Systems for Testing and Evaluating Rail Car Performance
- Facilities and Equipment for Testing on the UMTA Rail Transit Test Track at the DOT High Speed Ground Test Center
- Noise Assessment and Abatement in Urban Rail Transit Systems
- Tunneling Technology for Urban Rail Transit Systems.

Efforts were initiated in:

- Advanced Concept Train (ACT) Technical Support for UMTA
- Crashworthiness of Urban Rail Transit Vehicles
- System Costs of Rail Rapid Transit Systems (Study)
- Track Electrification Equipment for two Permanent Power Substations to Energize the UMTA RTTT at the DOT HSGTC
- Track Electrification Catenary for Standard Light Rail Vehicle (SLRV) Testing on the UMTA RTTT
- Technology News Dissemination by an Urban Rail Technology Newsletter.

During Fiscal year 1974 there were more than 30 projects (see Appendix A) involving approximately 35 contracts and grants (see Appendix B) and numerous reports, publications, and other documents (see Appendix C).

Program management for the URST Program includes liaison and support for the UMTA approved rail transit tests on the UMTA Rail Transit Test Track and Facilities at the DOT High Speed Ground Test Center, Pueblo, Colorado. During the fiscal year, tests conducted on the UMTA RTTT utilized New York City Transit Authority (NYCTA) type R-42 cars, Figure 2-1, equipped with the TSC designed Track Geometry System; Energy Storage Cars (ESC), modified NYCTA type R-32 car, Figure 2-2, equipped with energy storage flywheels; and the UMTA State-of-the-Art Cars (SOAC).

Other tests on urban rail transit vehicles in fiscal year 1974 included Alternating Current (AC) Propulsion Tests on the Cleveland Transit Authority (CTA) Airporter Car, Figure 2-3, and Revenue Service Demonstration of the DOT State-of-the-Art Cars in New York City, Figure 2-4.

Other related project activities involving the UMTA RTTT included: the design of the Train Dynamics Track, the Tight Turn Loop, the Permanent Power System, the Catenary for Standard Light Rail Vehicle (SLRV) use, and specifications for the Wheel Truing Machine, Track Scale, Rail Spur to the Storage and Maintenance Building, and connection of the Tail Track from the Transit Maintenance Building into the leg of the adjacent Wye Track.

Safety considerations for operating test programs at the HSGTC were thoroughly reviewed following an accident with the SOAC cars in august 1973. "Operational Procedures - Rail Transit Test Track Operations" (TSC-GSP-108) was published by TSC as the safety requirements and operational procedures in the use of the UMTA Rail Transit Test Track for conduct of UMTA approved vehicle and equipment test programs. These procedures define the requirement for a Project Safety Engineer to be on station for such test. A Position of Project Safety Engineer at HSGCT was filled by TSC.

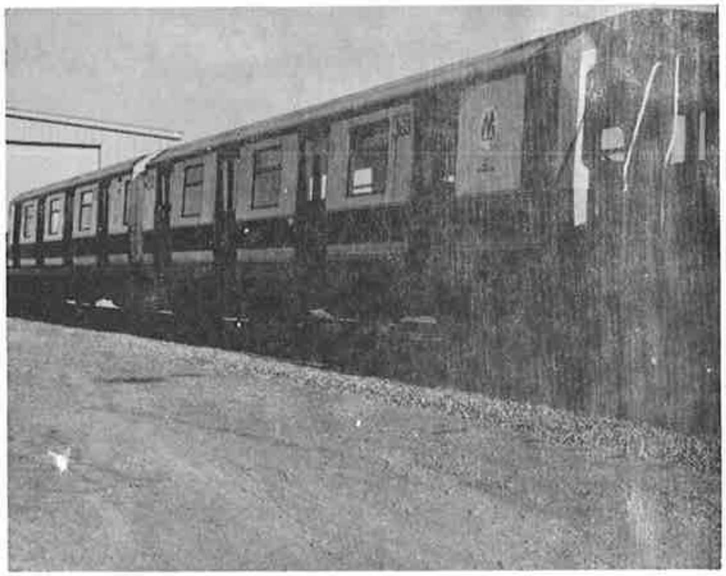


Figure 2-1. NYCTA Type R-42 Car

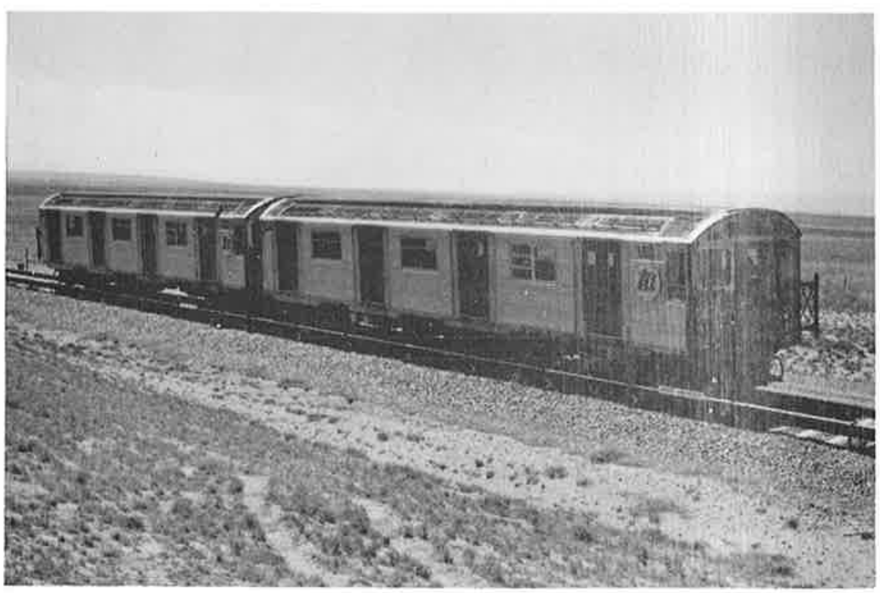


Figure 2-2. Energy Storage Car

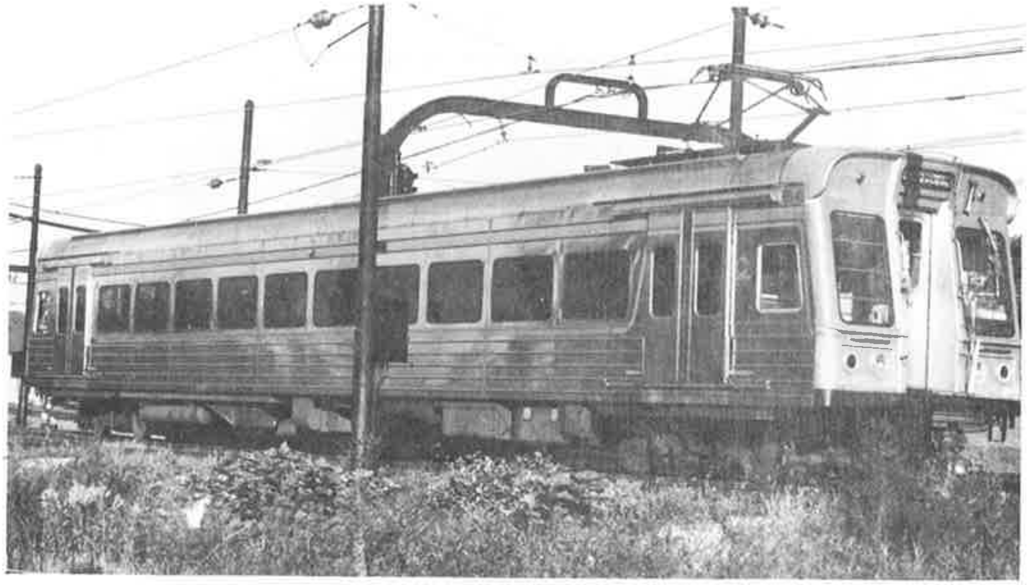


Figure 2-3. AC Propelled Car 154, Cleveland Transit System

Figure 2-4. The SOAC in New York City

2.1.1 ATA Rail Transit Conference

Members of the Urban Rail Program Participated on a panel moderated by Joseph Silien, Director of the Rail Programs Branch, UMTA, Office of Research and Development, at the American Transit Association Rail Transit Conference in San Francisco in April 1974. The following papers were presented by TSC:

1. "Test and Evaluation Capability Development, The Program Philosophy" by Ronald J. Madigan, Jr.
2. "UMTA Rail Facilities at the DOT High Speed Ground Test Center" by Harold D. Decker.
3. "Track Structures Research and Development" by Harold D. Decker.
4. "Flexibility of the UMTA Power System at HSGTC" by Harold D. Decker.
5. "Urban Rail Supporting Technology Applied Research" by Frederick J. Rutyna.
6. "UMTA Urban Rail Test and Evaluation Program" by George W. Neat.
7. "On the Bechtel Model for Optimization of the Rapid Transit Tunneling Process" by Dr. George Kovatch.
8. "Safety and Automatic Train Control for Rail Rapid Transit Systems" by George J. Pastor and Robert J. Pawlak.
9. "Details of Urban Tunnel Research" by Frederick J. Rutyna.

2.1.2 IRT Annual Conference

At the June 1974 Institute for Rapid Transit (IRT) Annual Conference in Los Angeles, California the Urban Rail Supporting Technology Program was represented on panels co-moderated by Ronald J. Madigan, Jr. (Advanced Vehicle Systems) and Frederick J. Rutyna (Noise and Vibration Control).

2.1.3 Urban Rail Technology Newsletter

An Urban Rail Technology Newsletter was initiated, and the first issue was approved for distribution. The Newsletter is designed to keep the urban transportation community advised of the activity and progress of the UMTA Urban Rail Supporting Technology Program.

2.2 TECHNICAL SUPPORT AND APPLCIATIONS ENGINEERING

Projects of Technical Support and Applications Engineering in fiscal year 1974 included:

2.2.1 Crashworthiness

An assessment of crashworthiness of existing urban rail vehicles (five) has been developed by Calspan Corporation under contract DOT-TSC-681.

Boeing Vertol Company, under contract DOT-TSC-791, has developed for TSC a SOAC structural model using the SOAC accident data (August 1973 at HSGTC) and the Calspan train occupant model for a crashworthiness analysis of the SOAC.

2.2.2 Rail Transit System Costs (Study)

Contract DOT-TSC-808 was awarded to T.K. Dyer, Incorporated, to identify and develop the cost elements associated with operation and maintenance of urban rail, commuter rail, and light rail transit systems. A final report prepared in the interest of city planners and transit property managers will be available about May 1975.

2.2.3 Advanced Concept Train (ACT) Program Support to UMTA

TSC provided technical support to UMTA at all program and critical design reviews on the Advanced Concept Train (ACT) Program.

2.2.4 Solar Emergency Lighting System

Two cars on the Boston MBTA "Orange Line" were equipped with the TSC designed Solar Energy Emergency Lighting System and tested for operational compatibility. The system will be evaluated on all lines. Test results will be made available in 1975.

2.3 FACILITIES DEVELOPMENT

Projects of Facilities Development in fiscal year 1974 included:

2.3.1 Electrical Equipment for Substations of Permanent Power System

A low bid for substation electrical equipment was more than twice the government estimate. It was determined to be in the best interests of the government to proceed with this procurement. Consequently funds were made available, with sponsor concurrence, by deferring other fiscal year 1974 tasks into fiscal year 1975.

2.3.2 Electrification Catenary, Emergency Power Shutdown, and High Visibility Switch Stands

Other facility improvements and modifications include an emergency power shut-down system, high visibility switch stands and modifications to permit testing of the Boeing standard light rail vehicles. The modifications include the addition of a simple catenary system and the installation of signal blocks.

2.3.3 Wheel Truing Machine

Increased costs were a problem with the Wheel Reconditioning Equipment (wheel truing machine) also. Reallocation of program funds was made in order to make the procurement. A contract DOT-TSC-876 UM404 was awarded to Hegenscheidt Corporation of America in June 1974.

2.3.4 Train Dynamics Track and Tight Turn Loop for UMTA RTTT

A single bid received on the train dynamics track and the tight turn loop was approximately twice the estimated cost. It was set aside as excessive and no award was made. These features will be reviewed and the requirements modified to enhance competition and reduce costs.

2.3.5 Spur Track into Maintenance and Storage Building

A spur track has been completed into the Maintenance and Storage Building, making this building usable for light repairs and test equipment installation activities. Design of the track work necessary to connect the tail track at the rear of the UMTA Transit Maintenance Building into the adjacent leg of the wye has also been completed.

2.4 TEST AND EVALUATION

Projects of Test and Evaluation in fiscal year 1974 included:

2.4.1 Testing on the UMTA RTTT

Test activity on the UMTA Rail Transit Test Track at the DOT HSGTC this year included: test equipment and procedures checkout using the R-42's, SOAC engineering testing, Energy Storage Car (ESC) checkout and evaluation, and Gas-Turbine/Electric (GT/E) commuter car checkout.

Testing came to a stop in August 1973 when an accident to the SOAC occurred. The SOAC vehicles were repaired at Boeing Vertol Company and returned to HSGTC for post repair testing. The track was reopened for testing in January 1974. A new set of operational procedures were issued and a TSC Safety Engineer was sent to HSGTC to monitor all UMTA rail test projects.

SOAC engineering tests under revenue service conditions in New York City were completed in May 1974. The General Vehicle Test Plan, (guideline plan for all vehicles tested on the UMTA RTTT at HSGTC) was revised to reflect SOAC testing experience and will be reissued early in fiscal year 1975. Two of the Garrett Gas-Turbine/Electric (GT/E) cars are at HSGTC preparing for test.

2.5 TECHNOLOGY DEVELOPMENT

Projects of Technology Development in fiscal year 1974 included noise abatement and tunneling projects:

2.5.1 Noise Abatement

Noise Abatement projects are developing technology for evaluation and control of acoustic noise so that noise abatement measures for urban rail systems can be recommended to system operators and planners.

Wheel Rail Noise Control

An Interim Report, Development of an Acoustic Rating Scale for Assessing Annoyance Caused by Wheel/Rail Noise in Urban Mass Transit, report number UMTA-MA-06-0025-74-2 was published by Bolt, Beranek, and Newman in February 1974. The report critically analyzes present and future possible methods for control of wheel/rail noise and presents the best current data on the effectiveness of many of the existing methods.

Noise Assessment in New York City and Chicago

Grants to the Polytechnic Institute of New York (PINY) and to the University of Illinois at Chicago Circle (UICC) were made for noise assessments in New York City and Chicago respectively, by the UMTA Office of University Research and Training. Preliminary surveys of both these cities have been completed. Interim assessment reports are expected about mid-fiscal year 1975.

Track and Elevated Structure Noise Control

An Interim Report, Prediction and Control of Rail Transit Noise and Vibration, a State-of-the-Art Assessment, report number UMTA-MA-06-0025-74-5 was published by Cambridge Collaborative, Incorporated in April 1974. The Interim Report presents a user-oriented method for predicting the range of expected noise levels for various system design options and operating speeds. A Final Report is in preparation.

2.5.2 Tunneling

Fiscal year 1974 is the second of two years of UMTA participation in the Department of Transportation Tunneling Program. In the latter half of fiscal year 1974, the Office of the Secretary of Transportation redirected the efforts of participating administrations.

Five Year Plan for UMTA Tunneling R&D Elements of the DOT Tunneling Program

The newly assigned responsibilities in the DOT Tunneling Program necessitated revising the UMTA Tunneling Program Plan. The plan was under revision and was in the process of UMTA review at the close of fiscal year 1974.

System Analysis, Modeling and Optimization of Rapid Transit Tunneling

Work on systems analysis modeling and optimization in rapid transit tunneling, contract DOT-TSC-601, has been completed by Bechtel, and a report is expected in mid-fiscal year 1975.

Environmental Impact and Safety Guidelines for Improved Rapid Transit Tunneling

A contract, DOT-TSC-802, was awarded to A.A. Mathews, Incorporated, for a study and development of a set of guidelines. A report is expected in mid-fiscal year 1975.

2.6 HSGTC FIELD SUPPORT

Primary effort at the HSGTC has been the scheduling of track and maintenance facilities and providing support to UMTA test programs. This project area provides for monitoring urban rail test activity and facilities construction at HSGTC.

2.6.1 UMTA Test Program Support Activity

UMTA test programs in fiscal year 1974 included:

- NYCTA R-42 (R&D Testing)
- State-of-the-Art Cars (SOAC)
- Energy Storage Cars (ESC)
- Gas-Turbine/Electric Cars (GT/E)

2.6.2 Facility Construction

Facility construction related to UMTA Rail Transit Test Track and facilities in fiscal year 1974 included:

- Central Emergency Power Shut-off Station
- Lease of a third 600-volt power generator to provide power to Transit Maintenance Building
- High Visibility Switch Stands

3. TECHNICAL DISCUSSION

3.1 GENERAL

This section describes briefly the overall work in each of the tasks in the Urban Rail Supporting Technology Program.

3.2 TECHNICAL SUPPORT AND APPLICATIONS ENGINEERING

3.2.1 Transit Vehicle Crashworthiness Assessment -- Calspan Effort

In June 1973 TSC awarded contract DOT-TSC-681 to Calspan Corporation (formerly Cornell Aeronautical Laboratory, Inc.) to perform a study (recently extended) to assess crashworthiness of existing urban rail vehicles. The objective is to establish a data base for car design and occupant protection schemes which will lead to methods for reducing the number of injuries that might result from the collision of two trains. Rail car structural configurations and impact absorption devices are also being investigated.

In order to conduct analyses of probable injury as a function of collision speed, five cars have been selected as generic representatives of United States structural design practices both in new and old car designs. The five cars are

- BART (San Francisco)
- R-32 Car (New York)
- R-44 Car (New York)
- MBTA Silverbird (Boston)
- Silverliner (Penn Central)

The reasons for selecting these cars are summarized below.

BART - Represents modern aluminum extruded construction now in service on BART and likely to be proposed frequently in the future.

R32 (NYCTA) - Representative of heavy-gage steel design. Has been in service since 1962 and should see several more years of service.

R44 (NYCTA) - New steel type construction. About 200 recently delivered to NYCTA. Service records exist.

Silverbird (MBTA) - Aluminum exterior construction. Car has the lightest weight per unit length of any of the cars reviewed (0.92 KIPS per foot). Design buff load of 200,000 pounds.

Silverliner (Penn Central, Reading) - Self-powered, stainless. Represents significantly higher design buff load, (800,000 pounds) and has different anticlimbing construction than the other four cars considered here. The basic methodology being followed for the crashworthiness study is shown in Figure 3-1.

Figure 3-2, depicts the two basic types of rail-car crash conditions which are being analyzed. They are impact with no override and impact with override.

An interim report has been completed by Calspan. The report contains penetration deflections and probable injuries and fatalities for five car types as a function of speed and number of vehicles in the train. The data indicate a three to one difference in crush distance of the first car in each train in a collision of two identical four-car trains, among the five car types. A final report will be available to the public through the National Technical Information Service about April 1975.

A significant structural parameter surfacing from this work appears to be the strength/weight ratio of the cars studies. The calculated strength/weight ratios for the cars investigated were found to range from 4.8 to 14.8.

The analysis to date indicates that the most fruitful near-term R&D effort which could be directed toward reducing the number of injuries resulting from the collision of two like trains would be:

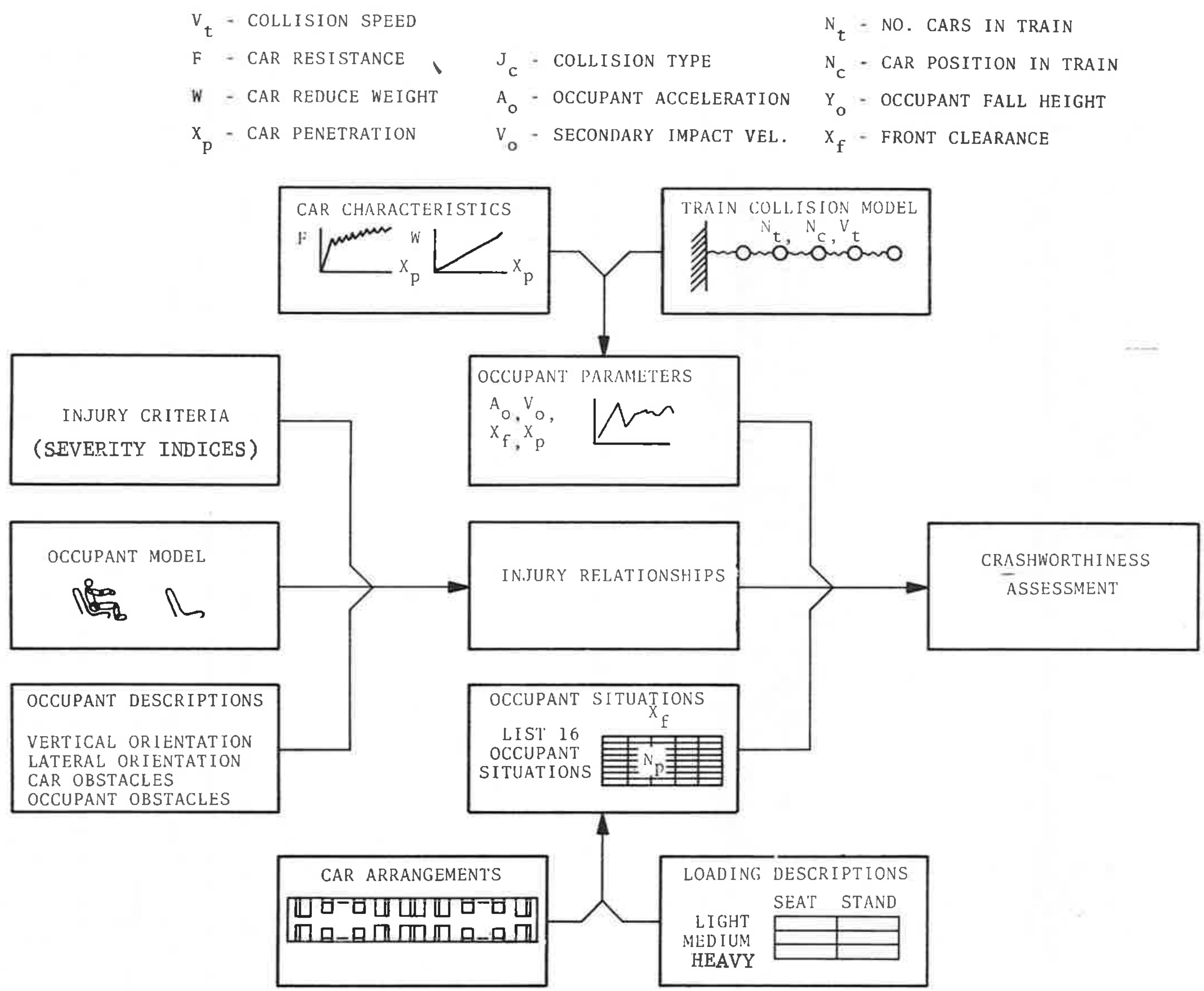
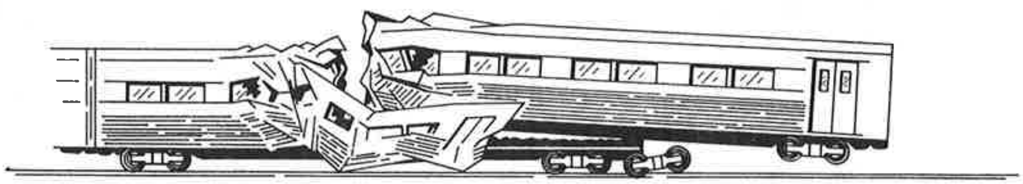


Figure 3-1 Methodology for Crashworthiness Study

FLAT FACE CRUSH



OVER RIDE

Figure 3-2 Two Basic Types of Rail Car Crash

a. improved anticlimbing characteristics

b. increased vertical stiffness between the bolster and front anticlimber coupled with increased strength/weight ratios.

3.2.2 SOAC Assessment

Boeing-Vertol, under contract DOT-TSC-791, is conducting an in-depth assessment of the crashworthiness of the State-of-the-Art Cars. The contract was awarded in April 1974 with a final report due in early 1975.

This activity involves a detailed analysis of the structural load deformation characteristics and an engineering assessment of the crashworthiness of the SOAC.

The data obtained from the SOAC accident of August 1973, together with that from the ensuing analysis, in particular the load-deflection information, allows for a first order validation of the methodology developed under the Calspan effort mentioned in the preceding paragraph.

The data derived from both of these efforts will be used in the design and development of the Advanced Concept Train (ACT).

Figures 3-3 and 3-4 depict some preliminary findings in this effort. Figure 3-3 indicates the coupler force deflection characteristics. Figure 3-4 shows crush force versus deflection with overriding.

Based on these efforts, work will be initiated during fiscal year 1975 to develop detailed structural data and gudelines.

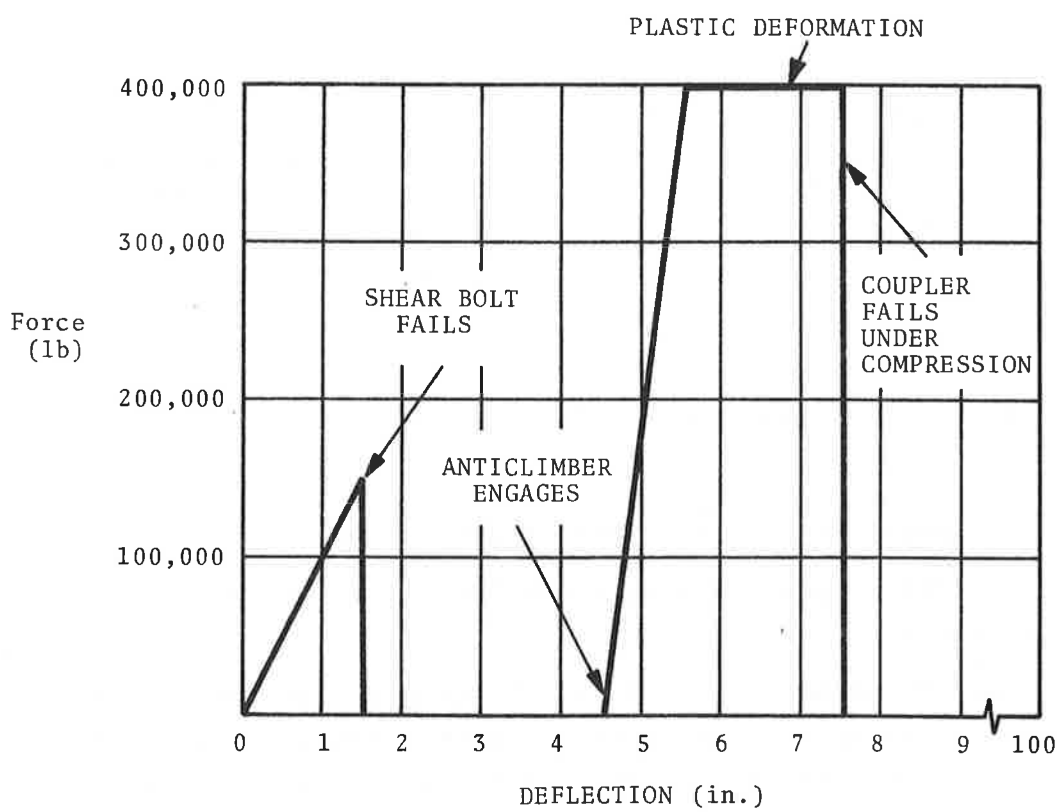
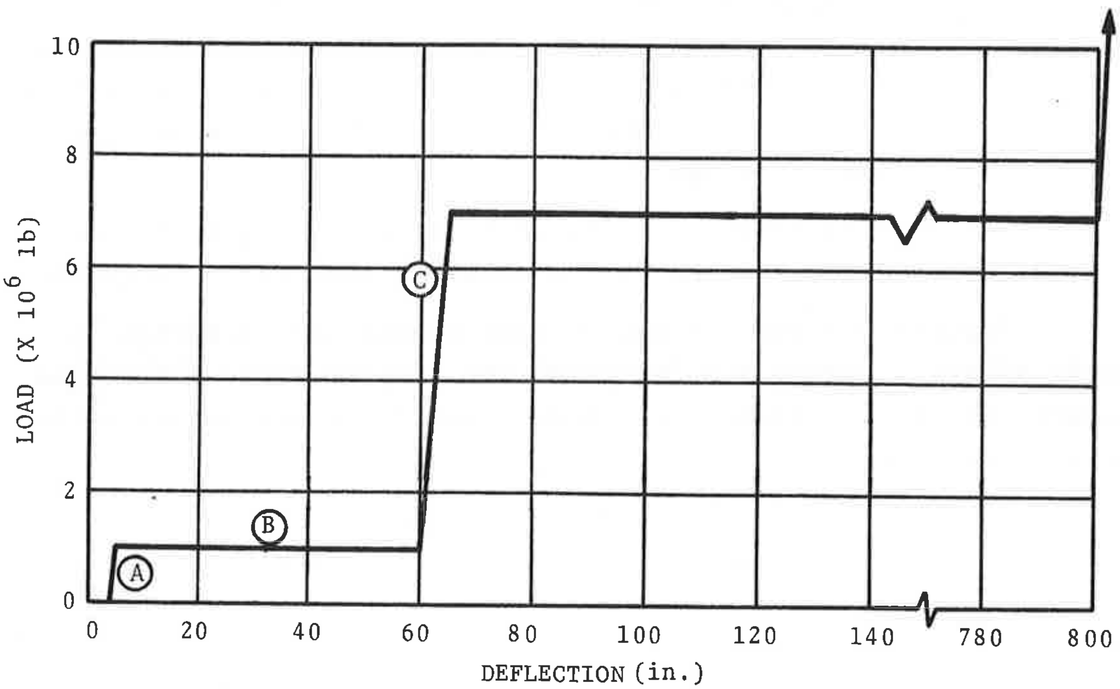


Figure 3-3 Coupler Force Deflection Characteristics



Notes

A Cars contact fiberglass shells; collision post welds fail; car sides, coves and roof pickup load.

B Target penetrates car at constant load until truck bolster contacts anticlimber.

C Car Center strength developed.

Figure 3-4. Crush Force Versus Deflection with Overriding

3.2.3 Transit System Construction Cost Study

In April 1974, an effort was initiated with a two-fold purpose of:

1. Developing up-to-date estimates of the various cost elements encountered in constructing, operating and maintaining urban rail transit systems.

2. Identifying elements of urban rail transit systems where the application of technology would effect cost reductions.

T.K. Dyer, Inc., under contract DOT-TSC-808, is responsible for collecting pertinent information from transit operations, normalizing the data, and reporting the information in a manner useful to transportation policy makers and planners in their preliminary selection and evaluation of transportation alternatives. This effort is divided into three transportation modes; rapid transit rail, light rail, and commuter rail.

To date all pertinent information on rapid transit rail systems has been obtained from U.S. and Canadian transit systems. The data being converted to 1974 national average values. The gathering of cost data on commuter rail will be completed by September 1974. Recent data on U.S. and Canadian Light Rail Systems is limited and consequently the necessary information is being obtained from light rail operations in Western Europe. A report on this effort will be available for public release in the spring of 1975.

3.2.4 Track Geometry Measurement System

The initial TSC plan for a track geometry diagnostic capability that would link the UMTA research and development efforts with the real world problems of the operating transit systems called for the manufacture of a specially-configured diagnostic vehicle. The vehicle was to be capable of acquiring data on track geometry, ride quality, noise, and vibration, at operating speeds, without interrupting normal revenue operations. This concept, after considerable research, was changed to cover a track geometry instrumentation package adaptable to transit cars normally operating on the line being measured. This approach rather than a special diagnostic vehicle was deemed more consistent with the needs of the majority of the operating properties because a properties' own revenue vehicle would give the desired loads. truck spacing, vehicle foot-print, etc. on that properties' trackage.

The information gained from New York, Pueblo and Boston test programs was used to formulate the requirements and specifications for a track measurement system for which a contract was awarded to MB Associates, in June 1973. Figures 3-5 and 3-6 depict this system mounted on the New York City R42 Cars. The contract calls for delivery of two complete systems including sensors, signal conditioning equipment, and associated hardware for measuring track gage, alignment, profile, and cross level, from a moving car. This system is not dependent on chord length which, in fact, can be varied as desired as an algorithm in the computer. Final acceptance and checkout will be accomplished at the Pueblo Test Track using New York City R-42 cars during April and May of 1975. After checkout, the systems will be used for engineering evaluation on a selected transit property.

Figures 3-7 and 3-8 depict typical gage measurement detail and summary data for a section of the Boston MBTA Green line. This print-out technique was developed at TSC subsequent to FY74 Green Line tests. The other measurements, i.e., alignment, profile, and cross level, were prepared in a similar format.

3.3 FACILITIES DEVELOPMENT

The urban rail test facilities at the High Speed Ground Test Center (HSGTC), Pueblo, Colorado, are comprised of:

a. The UMTA Rail Transit Test Track (RTTT)

b. The power system for energizing the transit vehicles,

c. The repair and maintenance facilities and equipment,

d. The Rail Dynamics Laboratory, (joint FRA and UMTA usage), and

e. Instrumentation and data acquisition equipment.

The fiscal year 1974 year end summary for these items is described in the following paragraphs.

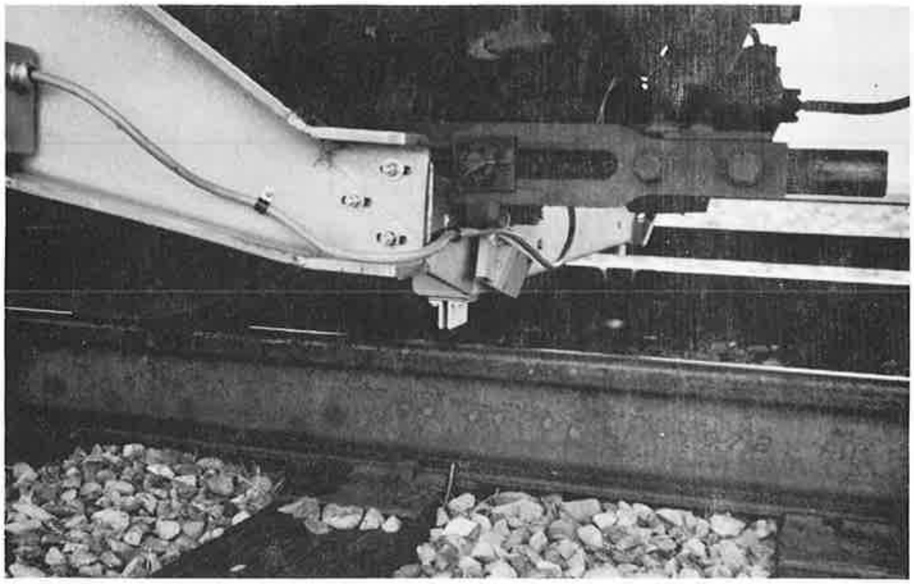


Figure 3-5 Sensor Installation of Track Measurement System Mounted on the New York City R-42 Car (Side View)

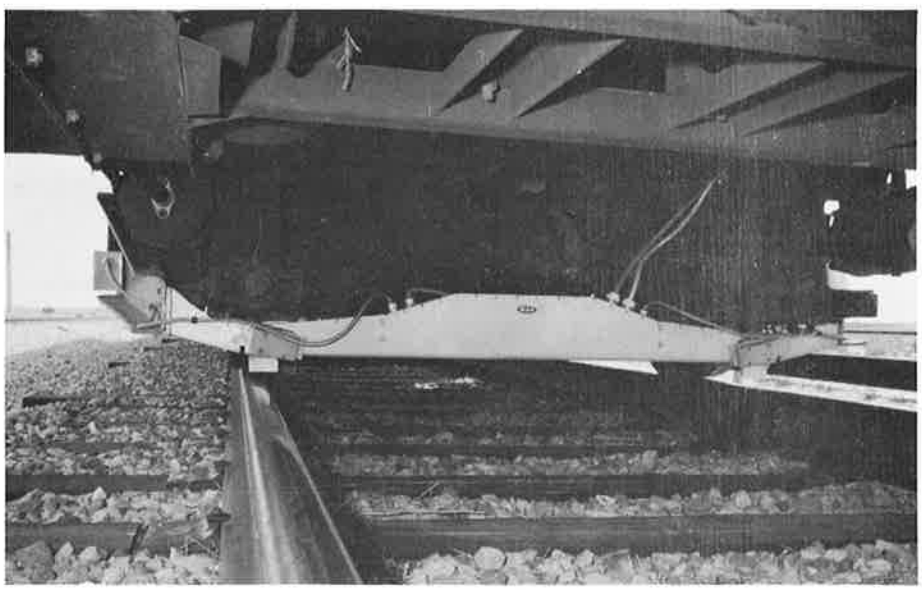


Figure 3-6 Sensor Installation of Track Measurement System Mounted on the New York City R-42 Car (Track Line View)

FROM - KENMORE
TO - AUDITORIUM
GAGE

FEET	ZONE	FEET	ZONE	FEET	ZONE	FEET	ZONE	FEET	ZONE
79.5	0	81.5	2	134.5	0	137.0	2	284.5	0
298.5	2	305.5	0	312.0	2	328.5	0	339.5	2
340.0	0	340.5	2	390.5	0	391.0	2	393.0	4
394.0	2	394.5	0	395.0	1	395.5	2	396.5	0
398.5	2	399.0	4	405.0	2	405.5	0	406.0	2
429.0	0	430.5	2	431.0	4	440.5	0	441.5	2
442.5	0	447.5	2	448.0	0	448.5	4	449.0	2
452.5	0	454.5	1	456.0	0	457.0	1	457.5	0
459.0	1	575.0	0	577.5	2	578.0	4	579.5	2
583.0	0	583.5	4	585.0	2	585.5	4	587.0	2
587.5	4	589.5	2	603.0	0	606.0	2	623.0	4
623.5	6	625.5	4	628.5	2	652.0	0	664.0	2
692.5	4	693.0	0	694.0	2	705.0	4	705.5	2
708.5	4	736.0	2	737.0	4	737.5	2	770.5	4
771.0	2	867.5	4	868.5	2	882.0	4	884.5	2
885.5	4	891.0	2	893.5	4	896.0	2	915.5	4
916.0	2	938.5	4	961.0	2	979.5	4	981.0	2
984.5	4	990.5	2	998.5	4	1015.5	2	1020.0	0
1030.0	2	1178.5	0	1179.5	2	1180.5	0	1183.5	2
1187.0	0	1211.0	2	1214.0	0	1230.5	2	1234.5	0
1251.5	2	1256.5	0	1262.5	2	1275.5	0	1279.0	2
1280.5	0	1282.0	2	1290.0	0	1297.5	2	1306.5	0
1310.0	2	1319.5	0	1321.5	2	1333.0	0	1341.0	2
1344.5	0	1348.0	2	1352.0	0	1365.5	2	1399.5	0
1401.0	2	1403.0	0	1404.5	2	1405.0	0	1406.5	2
1425.5	0	1435.0	2	1436.5	0	1445.0	2	1446.5	0
1447.0	2	1448.5	0	1459.5	2	1460.0	0	1462.5	2
1468.5	0	1474.5	2	1476.0	0	1481.5	2	1558.0	0
1561.0	1	1569.0	0	1598.5	1	1599.5	0	1618.5	1

Figure 3-7 Gage Data Printout, Boston MBTA Green Line

FROM - KENMORE
TO - AUDITORIUM
GAGE

ZONE	UPPER LIMIT	LOWER LIMIT	% OF TOTAL	NO. OCCURANCES	TOTAL FT.
6	99.00	57.75	0.02	1	0.5
4	57.75	57.25	10.23	24	286.5
2	57.25	57.00	14.45	70	404.5
0	57.00	56.25	70.32	80	1969.0
1	56.25	56.00	4.98	30	139.5
3	56.00	-99.00	0.00	0	0.0

ZONES	IRT CLASS	TIGHT	WIDE	% OF TOTAL
0+1+2+4	1+2	56.00	57.75	99.98
0+1+2	3	56.00	57.25	89.75
0+1	4	56.00	57.00	75.30
6+3	BELOW STNDRD	56.00	57.75	0.02

Figure 3-8 Gage Data Printout Summary, Boston MBTA Green Line

3.3.1 UMTA Rail Transit Test Track

The 9.12-mile Rail Transit Test Track was completed in September 1972. The track is designed for continuous 80-mile-per-hour operation and it exceeds the standards for Federal Railroad Administration Class 6 and Institute for Rapid Transit Class 4 track.

The primary purpose of this facility is to serve as a reference track for the test and evaluation of urban rail transit vehicles including light rail, rapid transit, and commuter rail cars. A secondary purpose is the development, test, and evaluation of state-of-the-art and advanced track structures.

Features of the track are described in the Urban Rail Supporting Technology Program Fiscal Year 1973 Year End Summary, Report No. UMTA-MA-06-0025-74-9, NTIS PB 238602/AS.

A rail spur into the Storage and Maintenance Building was completed in April 1974. This building, which has a 100-foot service pit, is being used for light maintenance and repair of transit cars, and for the installation and checkout of instrumentation.

The design of trackwork to connect the tail track behind the Transit Maintenance Building into the adjacent leg of the wye track has been completed and construction of the trackwork is scheduled to be accomplished in fiscal year 1975. See Figure 3-9.

Proposed additions to the track, Figure 3-10 include a train dynamics track, and a tight turn (screech) loop for noise evaluation. A simple catenary (trolley wire) system will be erected for testing the Standard Light Rail Vehicle (SLRV) produced by Boeing Vertol Company for the San Francisco MUNI and the Boston MBTA.

The proposed train dynamics (perturbed) track will contain known perturbations in alignment, profile, cross level, and gage, and will be used for the dual purposes of evaluating vehicle suspension system performance and calibrating track measuring systems.

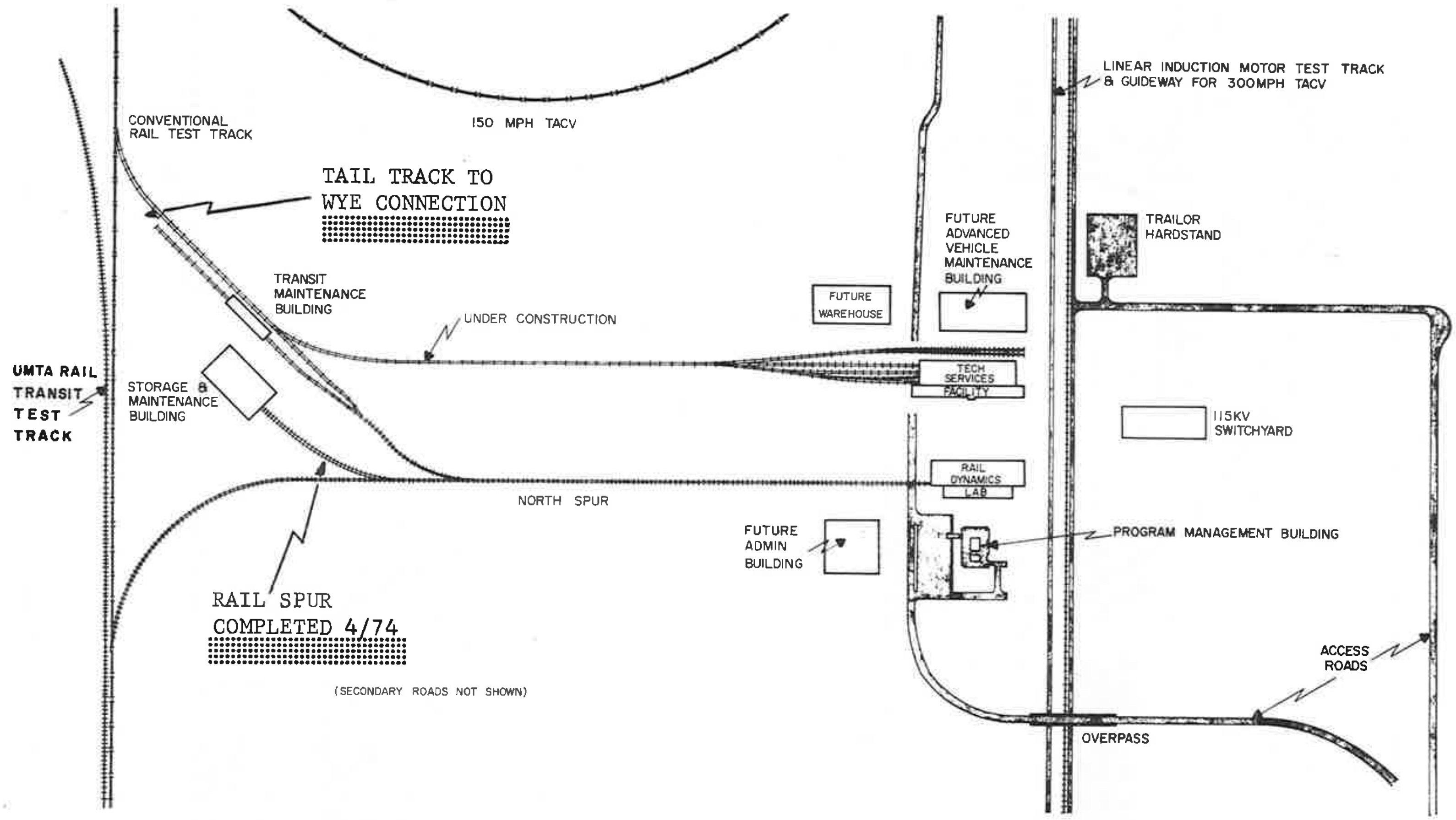


Figure 3-9 Rail Spur and Tail Track Connection

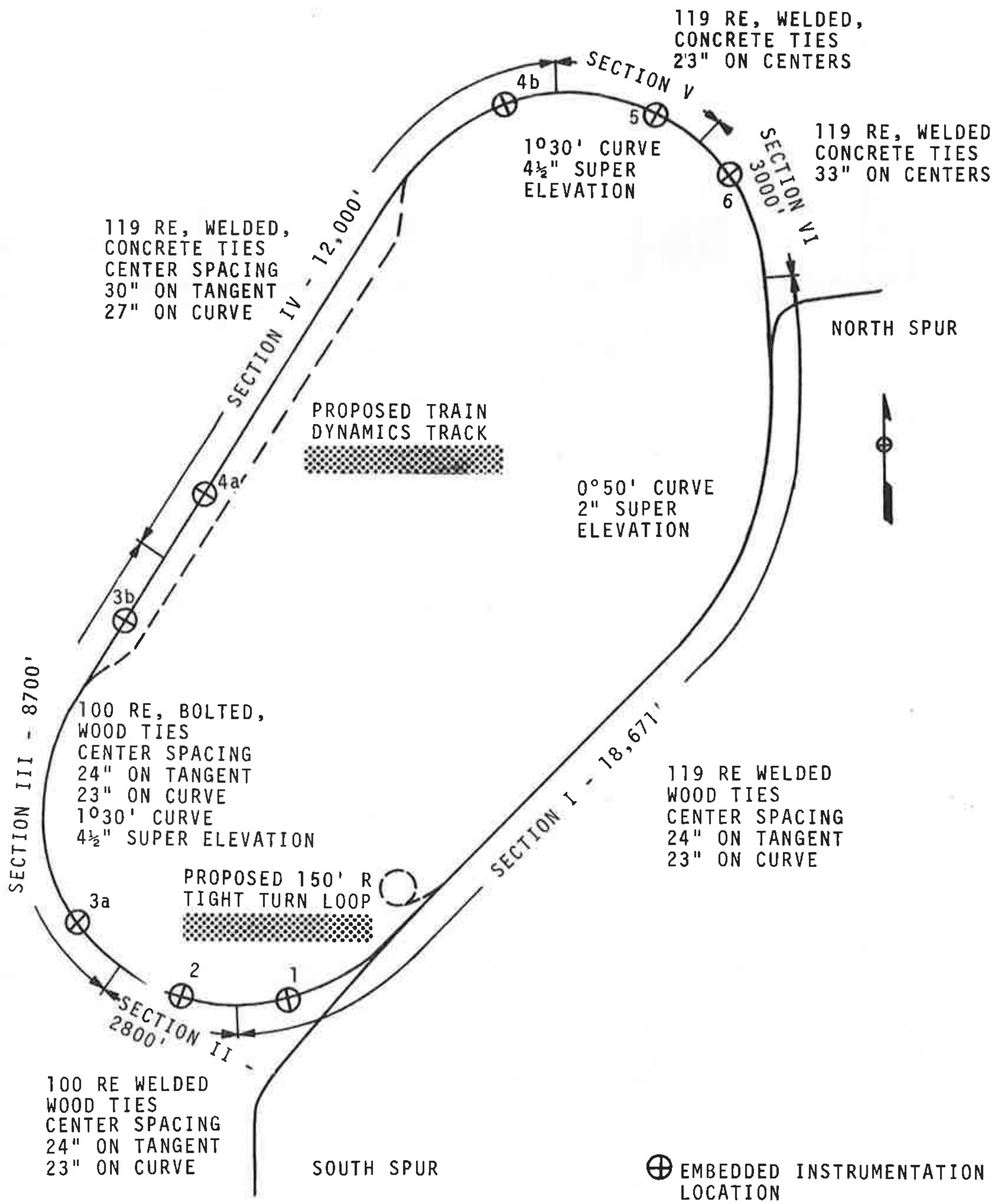


Figure 3-10 UMTA Rail Transit Test Track Proposed Additions

The proposed tight turn loop will be a closed circular loop of a 150-foot radius, which is very near the minimum radius curve that can be traversed by 75-foot-long cars. This loop will be joined to the main track by 488 feet of connector track at a radius of 326 feet. Both the connector track and the tight turn loop will be used in the investigation of car performance in such areas as wheel squeal (screech), internal noise and vibration, and suspension system stability.

Running rail for these track additions will be 119-pound welded rail on wood ties and electrification will use the same construction techniques and materials as the main runs of the test track.

Drawings and specifications for the train dynamics track and the 150-foot radius tight turn loop were completed in March 1974 and forwarded to Federal Highway Administration Region 8, Denver, for preparation of the detailed construction drawings, specifications, and a bid package. An invitation for bids was issued in April 1974, a single bid was received and set aside as excessive, and no award was made. A decision was made to defer this track construction and to reallocate the fiscal year 1974 track construction funds for completion of the permanent power system. When additional funds become available, the drawings, specifications, and schedule for the track construction will be critically reviewed and modified to enhance competition and decrease costs.

3.3.2 Power System for the Rail Transit Test Track

In addition to the third rail electrification described in the 1973 year end summary, plans call for construction of a single catenary, operating at 600 volts nominal over part of the westerly tangent portion of the track. This system will be used for test and evaluation of the new light rail vehicles being built by Boeing Vertol Co. for San Francisco MUNI and Boston MBTA. The vehicles are equipped with a pantograph power collector. Materials are being procured for approximately two miles of the catenary (trolley wire) system.

The design of the permanent power system was initiated in February 1973 and continued throughout fiscal year 1974. In August 1973, additional funding was provided for a second required substation. Final specifications for the electrical equipment for both substations were received in November 1973 and, after internal review, a decision was made to employ a two-step procurement. A total of 21 bid sets were issued and two technical proposals were received. After review and discussions with each proposer, both proposals were considered satisfactory and step two, pricing, was initiated.

A firm fixed price contract was considered to be most advantageous to the government and the invitation for bids was so prepared. The low bid was received from Wismer and Becker and contract DOT-TSC-847 was awarded in June 1974.

3.3.3 Maintenance and Service Facilities

In addition to the Maintenance and Service Facilities described in the 1973 year end summary, four electric jacks, an air compressor, and additional lead ballast have been procured. Contract DOT-TSC-829 has been let to Murphy Scale and Equipment Co. for the installation of a track scale in the leg of the wye track adjacent to the Transit Maintenance Building and completion is expected in December 1974.

A two-step negotiated procurement for an under-floor wheel-trueing machine has been initiated and two technical proposals received, one of which was considered unsatisfactory for technical reasons. Negotiations with the successful proposer, Hegenscheidt Corporation of America, resulted in contract DOT-TSC-876 award in June 1974.

3.3.4 Track Structures Analysis and Design Criteria

Under a contract DOT-TSC-563 to develop design criteria applicable to track for urban rail systems, the Battelle Columbus Laboratories delivered the Final Report, Design Tools and Criteria for Urban Rail Systems. The report is in two volumes;

Volume I, Report No. UMTA-MA-06-0025-74-3, is subtitled "At-Grade Tie-Ballast Track" (NTIS PB233016/AS) and Volume II, Report No. UMTA-MA-06-0025-74-4, is subtitled "At-Grade Slab Track" (NTIS PB233017/AS). Both volumes are available through the National Technical Information Service, Springfield, Virginia 22161.

An extension to the contract has been negotiated with Battelle Columbus Laboratories to define embedded instrumentation for the measurement of forces and deflections at critical points in track structures.

3.3.5 Data Acquisition Systems

Data acquisition systems and related equipment are being developed, built and checked out and preparation of instructions and software for the application of these systems is underway. The equipment which makes up these systems includes three data acquisition systems (DAS): The DAS-1 generally designated for vehicle testing; the DAS-2 generally designated for van installation and track wayside embedded-sensor data collection; and the DAS-3, generally designated for Track Geometry System data acquisition. Data acquisition systems and related equipment are discussed under Test and Evaluation projects technical discussion.

3.4 TEST AND EVALUATION

3.4.1 Test Plans and Requirements

The General Vehicle Test Plan (GSP-064), originally published by TSC in fiscal year 1972, provides test procedures and data specifications for evaluative testing of urban rail vehciles. This document was used as the basis for engineering tests on the State-of-the-Art-Cars at the High Speed Ground Test Center (HSGTC) in Pueblo, Colorado.

The GVTP, being revised in fiscal year 1974 to reflect the SOAC test experience, is scheduled for re-publication in fiscal year 1975. Specifications for 28 different tests are included in the revised version. The tests are listed in Table 3-1 along with recommended parameter variations to make up a baseline test plan.

The purpose of the GVTP is to standardize test procedures; instrumentation and data collection specifications; and data presentation format to facilitate comparison of vehicle characteristics. The primary intent is for comparison of vehicles tested on the "reference" UMTA Rail Transit Test Track. The application of the GVTP to vehicle tests on the operating properties is a logical extension, thus providing further data comparisons.

Specifications for each GVTP test include an objective, a test description, test procedures, instrumentation and equipment requirements, test output and preliminary analysis requirements. These specifications control those elements of testing which must be consistent from test to test and provide sufficient latitude for adapting to specific vehicles. The GVTP is also being used to define sensor requirements, data acquisition specifications and software requirements for the test equipment development effort.

A user's document for General Vehicle Test Equipment is being prepared by TSC. It includes a description of the sensors available to carry out these tests and instructions for installing the instrumentation on vehicles to be tested. The document is designed to facilitate implementation of the General Vehicle Test Plan and will be consistent with the General Vehicle Test Plan.

The Guideline Specification for Urban Rail Cars was developed by UMTA to be used as a basis for vehicle specifications by the operating properties. Section 17 of this document defines the testing required to verify compliance with the specifications. Many of the required tests correspond to tests in the General Vehicle Test Plan. A revision to Section 17 has been prepared in draft form and will be issued in fiscal year 75 for industry review.

TABLE 3-1 BASELINE TEST PLAN

TEST SET	TITLE	VEHICLE WEIGHTS	CONSISTS	SPD. MPH	CONTROL LEVEL	INPUT VOLT.	REMARKS	TEST REC
P-2001-TT	Acceleration	AW0,AW2,AW3	Single&Train	(2)	1.0&.75	600(1)	(1) Do 450&700 VDC with Single	24
P-3001-TT	Deceleration-Blended Braking	AW0,AW2,AW3	Single&Train	(2)	0.0&.25	600(1)	(2) 15,25,35,50 MPH	48
P-3002-TT	Deceleration-Service Friction	AW0,AW2,AW3	Single&Train	(2)	0.0&.25	600		48
P-3003-TT	Deceleration-Dynamic	AW0,AW2,AW3	Single&Train	(2)	0.0&.25	600		48
P-3004-TT	Deceleration-Emergency	AW0,AW2,AW3	Single&Train	(2)	-	-		24
P-4001-TT	Drift Test	AW0,AW2	Single&Train			600		4
P-5001-TT	Duty Cycles-Friction Brake	AW2	Single			600	Repeat for Two Cycles	2
P-2011-TT	Spin/Slide-Acceleration	AW0	Single			600		1
P-3011-TT	Spin/Slide-Deceleration	AW0	Single			600	Repeat for Brake Modes	3
PC-5011-TT	Power Consumption	AW2	Single&Train			600		2
A-3021-TT	Adhesion	AW0	Single			600		1
CN-0001-TT	Equipment Noise Survey	AW0						1
CN-1001-TT	Speed Effect-Wayside	AW0,AW3	Single&Train	(2)		600		16
CN-1201-TT	Screech Loop-Wayside	AW0,AW3	Single			600		1
PN-1001-TT	Speed Effect-On Car	AW0,AW3	Single	(2)		600	Four Interior Locations	32
PN-1101-TT	Track Type Effect-On Car	AW0	Single	35		600		1
PN-1201-TT	Screech Loop-On Car	AW0,AW3	Single			600		2
PN-1301-TT	Interior Survey	AW0	Single	35		600		1
PN-2001-TT	Acceleration-On Car	AW0,AW3	Single			600		2
PN-3001-TT	Deceleration-On Car	AW0,AW3	Single			600	Repeat for Brake Modes	8
R-3001-TT	Deceleration	AW0,AW2,AW3	Single			600	Repeat for Brake Modes	12
R-0010-TT	Component Induced Vibration	AW0	Single			600		1
R-2001-TT	Acceleration	AW0,AW@,AW3	Single			600		3
R-1101-TT	Worst Speeds	AW0,AW2,AW3	Single	(2)		600		12
PSI-6001-TT	Radio Frequency Interference	AW0	Single&Train	(2)		600		8
S-1001-TT	Constant Speed	AW0,AW2,AW3	Single	(2)		600		12
S-2001-TT	Acceleration	AW0,AW2,AW3	Single			600		3
S-3001-TT	Deceleration	AW0,AW2,AW3	Single			600	Repeat for Brake Modes	12

AW0 = Vehicle Empty Weight
AW1 = Vehicle Empty Weight plus Normal Load
AW2 = Vehicle Empty Weight plus Full Load
AW3 = Vehicle Empty Weight plus Crush Load

A study of techniques for the evaluation of the dynamic characteristics of rail vehicles was completed by the General Electric Company and a report will be made available in fiscal year 75. This study addresses the analysis and simulation requirements to complement the test program and includes requirements for investigative testing.

3.4.2 Test Program Implementation

SOAC Engineering Tests

Contract DOT-TSC-580 was awarded to Boeing Vertol Co. in February 1973 to conduct Engineering Tests on the SOAC's at HSGTC in accordance with the General Vehicle Test Plan. Some preliminary results from these tests are shown in Figures 3-11 and 3-12. The contract included conducting limited Engineering Tests on each of five properties on a New York, Boston, Cleveland, Chicago, and Philadelphia, demonstration tour. Expansion and re-publishing of the GVTP was also covered by the contract. The SOAC engineering tests at HSGTC were completed in July 1973.

On August 11, 1973, during simulated demonstration runs, the SOAC vehicles collided with a parked gondola car and locomotive. The SOAC vehicles were shipped to Philadelphia for repair and then returned to HSGTC in January 1974.

After initial checkout and post repair acceptance tests, an abbreviated engineering test program was conducted to verify the data collected earlier. Additional simulated demonstration runs were conducted and the cars were then shipped to New York City.

During May 1974, SOAC engineering tests were conducted on four NYCTA operating lines as part of the engineering test program. Similar tests will be conducted in Boston, Cleveland, Chicago and Philadelphia. Such data will help in extrapolating future HSGT test results to the respective properties.

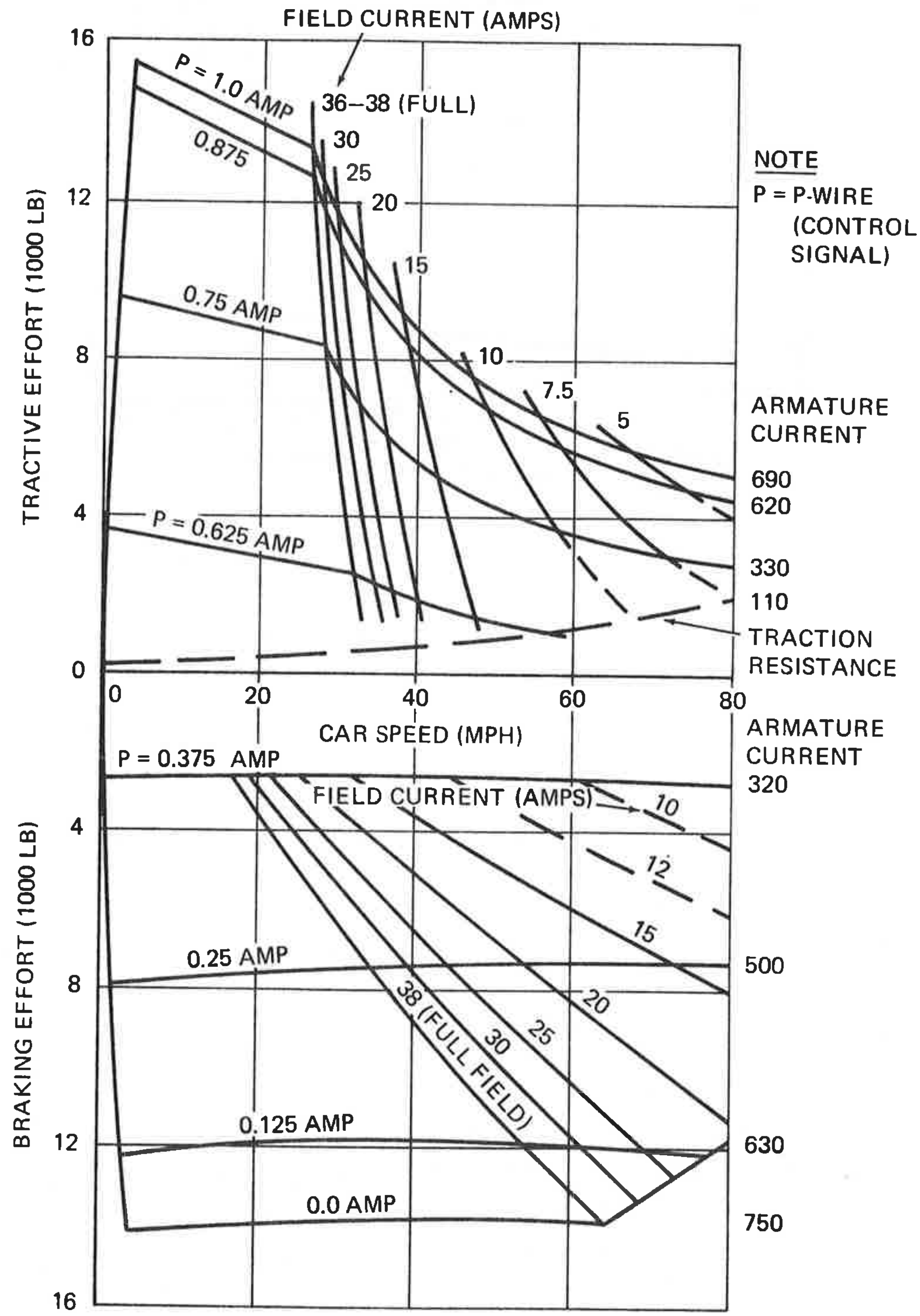


Figure 3-11 SOAC Traction and Braking Characteristics (Single Car, 600 Volts)

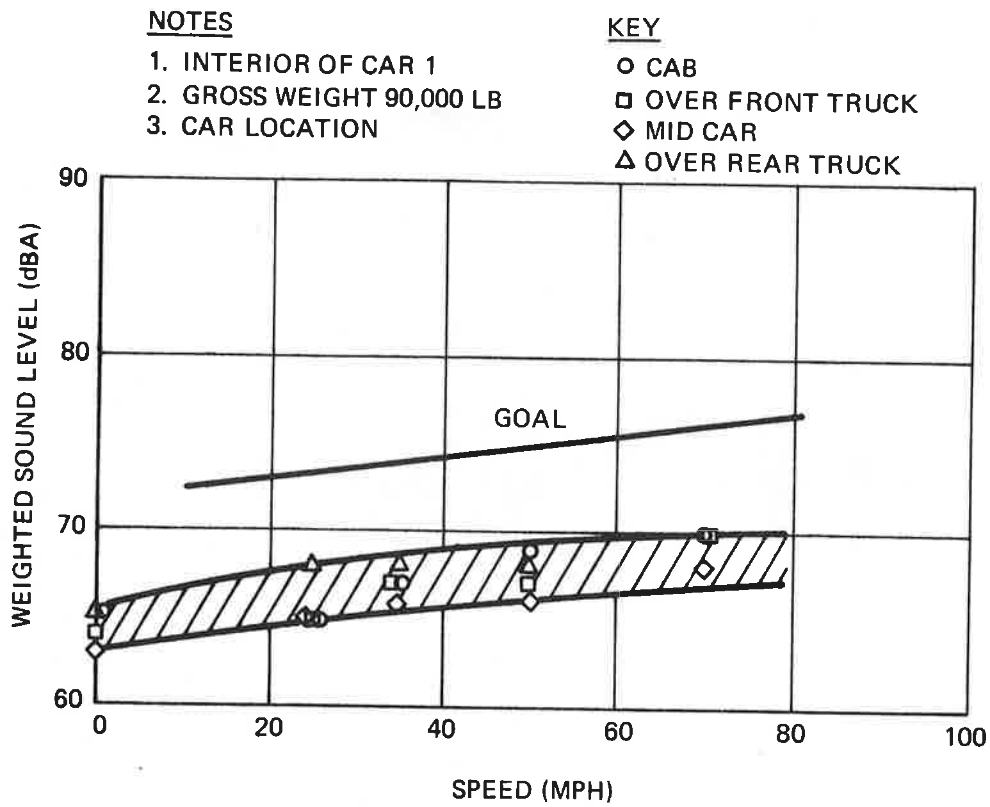


Figure 3-12 SOAC Noise Levels Compared With Goals

The test report for the original HSGTC test program has been reviewed and is being prepared for final publication by Boeing Vertol. This six volume report is scheduled for release in fiscal year 1975. A separate report for the post-repair test phase will also be published. The property demonstration tests will be combined in a single report, which will include the results from all five demonstration property tests.

Energy Storage Car Tests

Garrett AiResearch, under a contract to the New York Metropolitan Transportation Authority funded by an UMTA R&D grant, has modified two New York City Transit Authority, R-32 vehicles (See Figure 2-2.) to include energy storage flywheels. These Energy Storage Cars (ESCs) arrived at HSGTC in February 1974. Checkout and debugging has been completed and the cars have been demonstrated to operate successfully on flywheel power.

Gas-Turbine/Electric Cars

Garrett AiResearch is developing four advanced commuter cars with gas turbines to provide electrical power for propulsion beyond the electrified section of track. This effort is funded by an UMTA R&D grant to MTA similar to the ESC program. Pullman is building the cars under a subcontract from AiResearch. The first two cars have arrived at HSGTC and the second pair is due about September 1974. All four cars will be at HSGTC until late 1974.

R-42 Tests

Two R-42 cars, shown in Figure 2-1, on loan from the New York City Transit Authority, have been used for development and checkout of test equipment and test procedures for the Urban Rail Program. In January 1974, the R-42's were operated on the test track to successfully accomplish the following test objectives:

1. Acceptance tests on the digital data acquisition system (DAS-3) in the (dynamic) rail car environment.
2. R-42 propulsion system and general operation checkout.
3. Compatibility assessment for ESC trainline tests.

The vehicles were used in trainline with the ESCs in April. They will be used for checkout and acceptance of additional test equipment including the track geometry sensor system and the general vehicle test system during fiscal year 1975.

Cleveland Transit System Tests

Ride roughness tests were conducted on the Cleveland Transit System in September 1973. The objective of these tests was to quantify the difference in ride roughness between an AC powered transit car, Figure 2-3, and a conventional DC powered car. During acceleration and deceleration, ride quality on the AC cars was noticeably smoother along the longitudinal axis of the car. A report of the test was submitted to the Cleveland Transit Authority in October 1973, to be incorporated in a final report for the AC propulsion system project. The TSC test report, internal working document PMP-5, Ride Roughness Tests, Cleveland Transit System, was published in November 1973.

3.4.3 Data Acquisition and Processing

Digital Data Acquisition Systems

Contract DOT-TSC-561 was awarded to Sperry Univac in fiscal year 1973 to develop three digital data acquisition systems for collection and processing of rail test data. These systems were delivered during fiscal year 1974. One system, designated DAS 1, will be mounted on an urban rail car to collect general vehicle test data, Figure 3-13, in accordance with the GVTP.

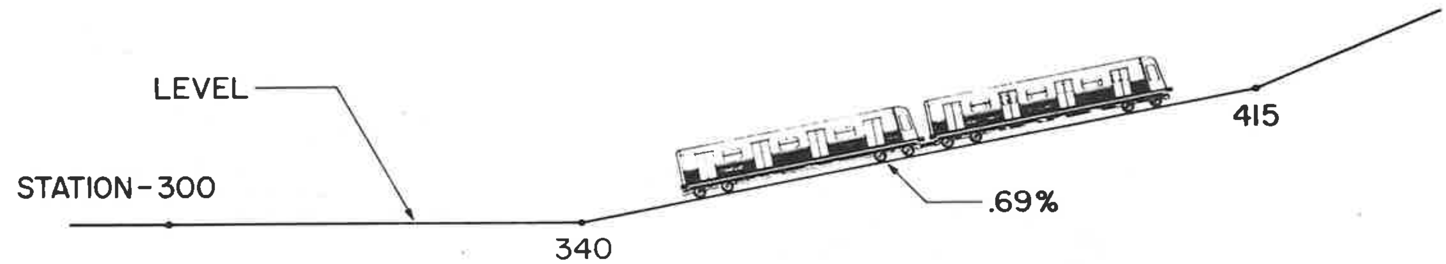
The second system, DAS 2, a reduced version of DAS 1, will be used in a mobile van, Figure 3-14, for collection of ways and structures test data from embedded instruments at each of eight wayside test stations on the RTTT at HSGTC. The mobile van was procured under a contract with the Pickwick Corporation, Cedar Rapids, Iowa. The third system, DAS 3, is interchangeable with the DAS 1. The DAS 3 will be used for real time on board processing, Figure 3-15, of track geometry data.

Additional equipment required for these systems includes power conditioning systems, signal conditioners, electronic filters, and sensors. Figure 3-16 illustrates a Track Geometry System layout for the NYCTA R-42 vehicle.

DAS Operational Software

Sperry Univac has provided the following support programs with documentation for operating the DAS as part of the DAS equipment contract:

1. Core Resident Routines - the System Controller and Input/Output Controller
2. The ULTRA/16-1 Assembler for UNIVAC 1616 Assembly Language.
3. The Text Editor (having list, edit, and build source statement images functions).
4. The Relocatable Loader Routine.



HSGTC TEST TRACK
PERFORMANCE SECTION - WESTERLY TANGENT

TEST CATEGORIES (GSP-064)

PERFORMANCE
RIDE ROUGHNESS
STRUCTURAL
ADHESION
POWER SYSTEM INTERACTION

Figure 3-13 DAS 1 General Vehicle Testing

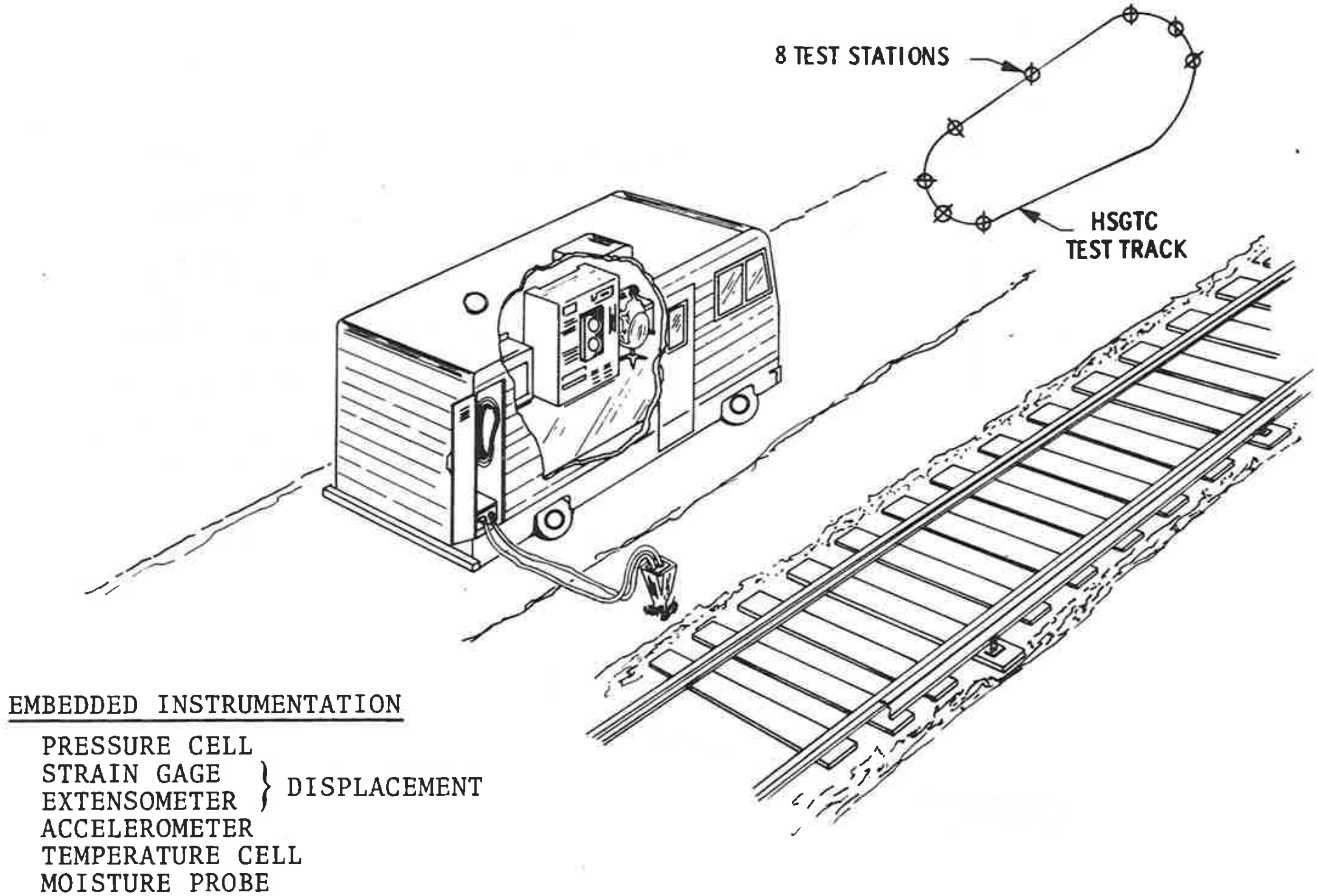


Figure 3-14 DAS 2 Collection of Test Data from Embedded Instruments

TRACK PARAMETERS

GAGE
CROSSLEVEL
TRUE PROFILE
TRUE ALIGNMENT

OUTPUT FORMAT

REALTIME: ANALOG CHARTS
DEFECTS LISTING

POST TEST: TRACK SECTION
SUMMARY
POWER SPECTRAL
DENSITIES OF
PARAMETERS

APPLICATIONS

SAFETY (DEFINE IRT CLASSIFICATION)
MAINTENANCE TOOL
ESTABLISH REFURBISHMENT PRIORITIES
R & D SUPPORT (W/R LAB INPUTS)

Figure 3-15 DAS 3 Track Geometry Measurement System

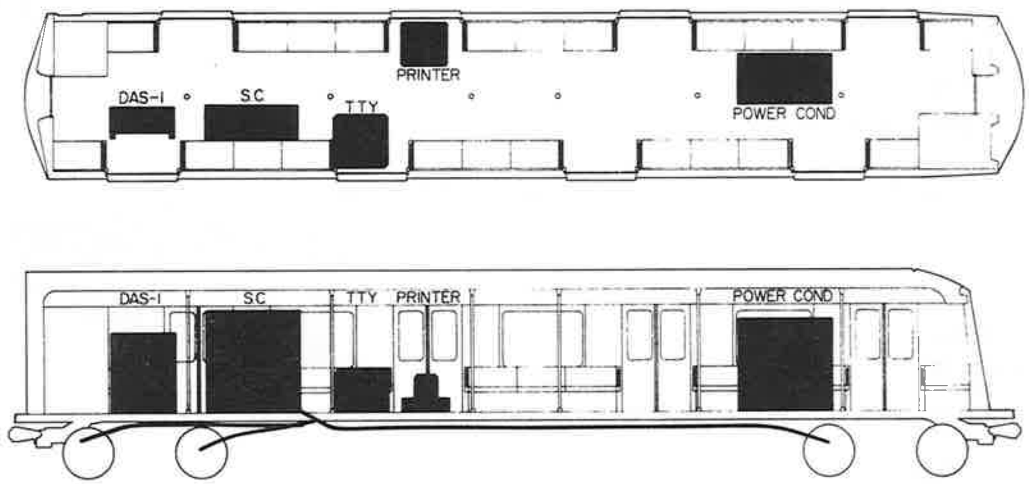


Figure 3-16 Track Geometry System Layout for NYCTA R-42 Vehicle

5. The 1616 Utility Package UPAL1 (containing the following separate program debugging aids: Inspect and Change Memory, Memory Dump on the Printer, Store Constant in Memory, Execution Time Snapshot Dump, User Corrections Loader, Binary Dump, Masked Memory Search and Cross Reference Listing).
6. Object Program Stacker.
7. The Paper Tape Handler Routines.
8. The FORTRAN Compiler Routines Operating on FORTRAN IV.
9. The System Tape Generator.
10. Diagnostic Routines for all Peripheral Equipment in the UMTA System.

Track Geometry Software

The algorithms for processing the track geometry data and providing the desired output format have been developed and demonstrated. These algorithms are being modified to fit the Univac 1616 (16K memory) to provide the desired otuput in real time as the measurements are being made. The complete software package was in the process of check out in FY 1974 using the existing Green Line data. The software will be checked out with the MKII track geometry sensor system at HSGTC in FY 1975. The specification for this software are documented in a TSC GSP-113.

General Vehicle Test Software

Software for carrying out general vehicle tests using the DAS system is being developed in two stages. The first stage involves data collection in a digital format and the second stage includes signal processing to present the data in the desired format. The requirements for both data collection and processing are defined in the General Vehicle Test Plan. This software will be used in the tests planned for the Standard Light Rail Vehicle.

3.5 TECHNOLOGY DEVELOPMENT

Technology development in fiscal year 1974 was directed toward improved technology in urban rail system applications of noise abatement and tunneling.

3.5.1 Noise Abatement

The noise abatement program is directed toward reducing acoustic noise in urban rail systems in order to assist in providing improved environmental quality for users and the systems community. The program is developing technology for evaluation and control of acoustic noise so that noise abatement measures for urban rail systems can be recommended to system operators and planners. The purposes and accomplishments to date in the program are briefly described below with emphasis on work performed in FY 74.

Noise Assessment

Systematic noise measurements are being made on each of the eight urban rapid transit rail systems in the United States. Dominant noise sources and paths relative to system patrons in the transit cars, people in stations, and to the wayside community are being determined from these measurements and other relevant information. The TSC Noise Abatement Program is making estimates, for each system, of cost and of the optimum combination and location of noise control techniques to achieve various possible noise level goals.

A pilot study was conducted on the Boston MBTA rapid transit lines by TSC personnel. Figure 3-17 shows the amount of track footage which exposes wayside residences to various noise levels along the MBTA Red, Orange, and Blue Lines. Noise levels between 83 and 93 dB(A) on cars, in stations, and outside residences in the community were typical; except that new cars were quieter inside. Abatement costs increase sharply as goals are set lower than about 75 to 80 dB(A). During FY74 the final report on the MBTA study was revised substantially, and a computer program was developed at

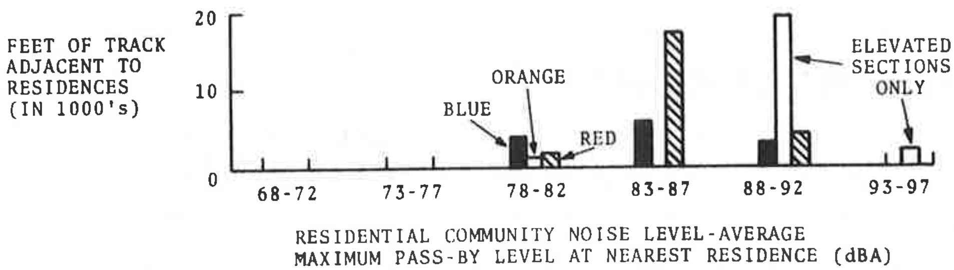


Figure 3-17 Wayside Noise from a Rail Rapid Transit System

TSC to perform the minimum cost optimization. The revised final report has been sent to the National Technical Information Services and will be available through them to the public in the near future. It is expected that the computer program documentation will also be generally available in the near future.

During FY74 plans were developed and implemented for noise measurements in the remaining seven urban transit systems for the estimating abatement costs. Work statements were prepared for noise assessment of two systems in metropolitan New York City (NYCTA and PATH) and for the CTA system in Chicago. Grants to the Polytechnic Institute of New York (PINY) and to the University of Illinois at Chicago Circle (UICC), for this work, were made by the UMTA Office of University Research and Training. Preliminary surveys of both these cities have been completed, measurement sites selected as part of the comprehensive measurement plans, personnel trained, and field measurements begun. Interim assessment reports are expected during FY75. A competitive procurement was initiated for the similar assessment of systems in Philadelphia (SEPTA, and PATCO), Cleveland (CTS), and San Francisco (BART). A contract was awarded to the Boeing Vertol Company at the end of FY74 to perform this work. Noise measurements will be made during early FY75 and reported during the third quarter of FY75. Costs and strategies to achieve lower levels will then be estimated and documented in a final report.

In-Service Test and Evaluation

A number of rail transit noise abatement techniques can now be applied using commercially available goods and services. The In-Service Test and Evaluation effort has been designed to provide definitive engineering data, applicable to all present and planned U.S. urban rail transit systems, on techniques which can be presently implemented but for which adequate long term performance and cost data are lacking. Four techniques originally were selected for evaluation; resilient wheels, resilient rail fasteners, wayside noise barriers, and station sound absorptive treat ment.

During FY74 a detailed statement of work was prepared for the design, test and evaluation of these techniques; one technique in each of four cities. The cost estimates received from responding bidders were considerably beyond the allocated budget, so no contract was awarded. The noise abatement test and evaluation program is now being restructured in an attempt to bring the scope of the work within budgetary realities while still attaining program goals.

New Technology

Two efforts are underway to assess and develop analytical prediction and design tools for the abatement of noise in urban rail systems. The first effort concerns the generation of noise and vibration by direct interaction of the wheel and rail. The second effort concerns the propagation of vibration in rail, track, and elevated structures, and the secondary radiation of noise.

Contracts have been awarded to Bolt, Beranek and Newman, Inc. for work on wheel rail noise control, and to Cambridge Collaborative, Inc. for track and elevated structure noise control. The initial efforts in both areas are scheduled for completion by March 1975. Fabrication of hardware and evaluation of prototype models will follow.

Wheel/Rail Noise Control

An interim report, UMTA-MA-06-0025-73-15, NTIS PB 237-012/AS (see Appendix C) reviews relevant work on wheel/rail noise generation mechanisms (Bolt, Beranek, and Newman Inc., contract DOT-TSC-644). The major elements of such noise and vibration are shown in Figure 3-18. The report analyzes present and future possible methods for control of wheel/rail noise and presents the best current data on the effectiveness of many of the existing methods. The report also gives a method for computing the costs associated with a noise control installation on a rail transit system. The installation of resilient wheels on all cars of the NYCTA (Estimated cost: about $30 million) is given as a specific, step-by-step example of train noise control.

Equivalent A-weighted sound level (L_{eq}) has been determined to be an acceptable measure for annoyance correlation. The U.S. Environmental Protection Agency (EPA) has also adopted a form of L_{eq} as a general measure for noise from all noise sources. Data from a French survey of annoyance along a wayside due to train noise is shown in Figure 3-19 to illustrate the type of considerations made in the study.

New analysis and full and reduced scale experiments were performed to develop the quantitative relationships among noise levels of squeal, impact, and roar and such parameters as rail and wheel roughness and discontinuities, wheel and rail mechanical impedance (mass, stiffness, and damping), curve radius, and vehicle speed. Data such as those shown in Figure 3-20 were used to determine such relationships. A device was developed to measure wheel and rail roughness. A scale model of the London

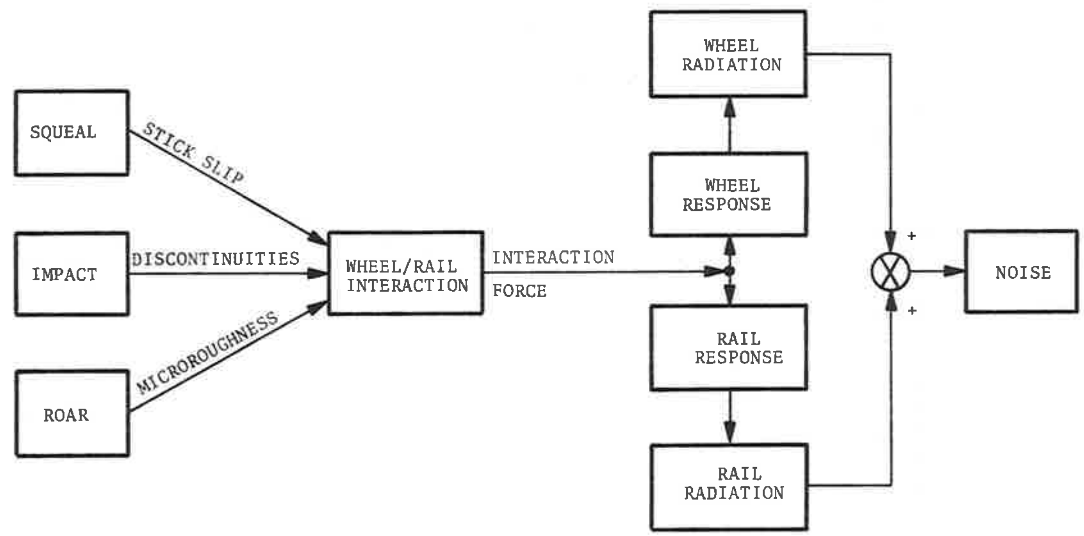
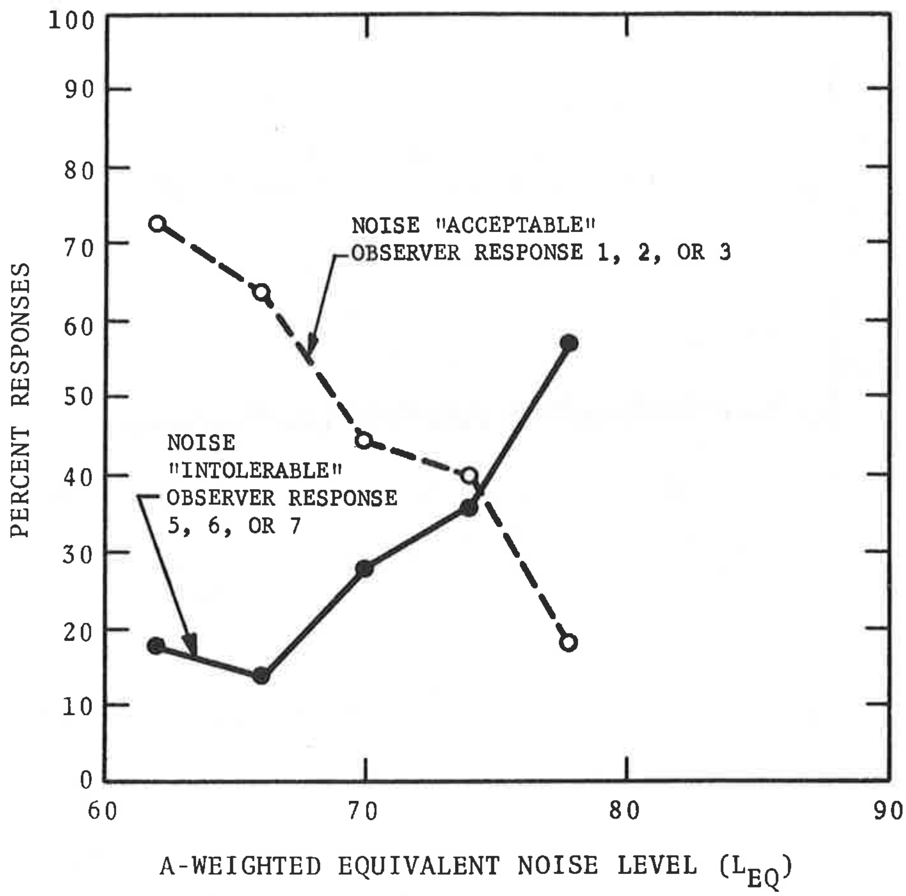


Figure 3-18 Major Elements of Wheel/Rail Noise and Vibration



Notes:

The dashed and solid lines are plots of the percentages of observer responses as to the acceptability of noise on an L_{EQ} scale. The dashed line plots responses that judged the noise "acceptable". The solid line plots responses that judged the noise "intolerable".

The observer response scale is a range of 1 thru 7 in which response 1, 2, or 3 is a subjective indication of an "acceptable" noise level and 5, 6, or 7 is a subjective indication of an "intolerable" noise level. Response 4 is "indeterminate".

Example:

43 percent of observer responses to an L_{EQ} of 70 were 1, 2, or 3 (dashed line = acceptable) while 28 percent were 5, 6, or 7 (solid line = intolerable) and the remaining 29 percent were indeterminate.

Figure 3-19 French Data on Wayside Annoyance Due to Train Noise

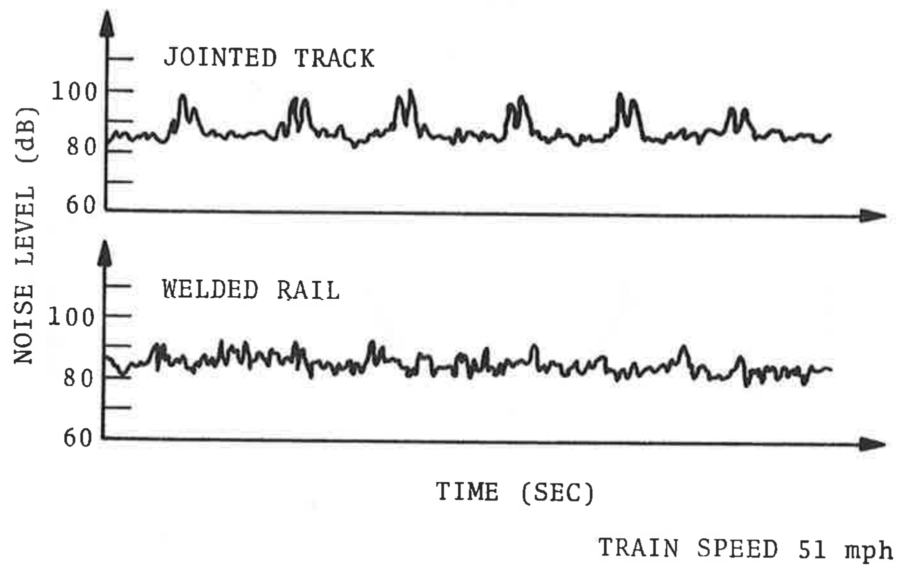


Figure 3-20 Car Interior Noise Levels on Welded and Jointed Rail

Transport "Noise Deadening Ring," which attaches to a steel wheel, was made and tested. The tentative conclusions of the contractor were that the ring does not produce useful damping for squeal prevention.

The final report, scheduled in mid-FY75, will contain the quantitative parametric relationships, various test and analytic results, and recommendations for innovative quieter wheel and rail designs based on knowledge gained from the tests.

Track and Elevated Structure Noise Control

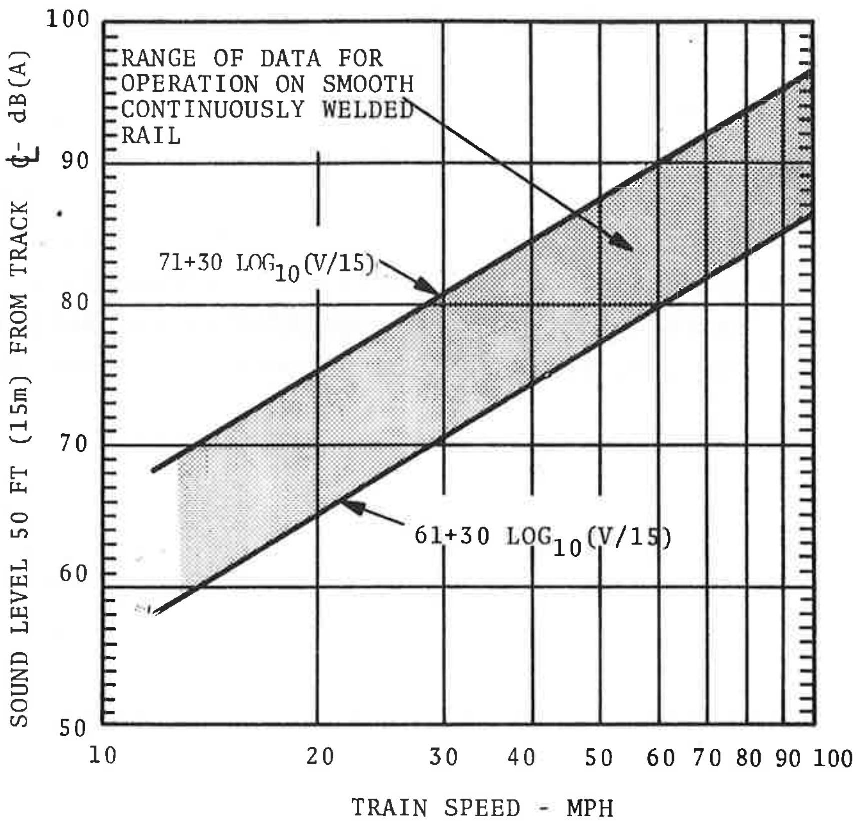
The Cambridge Collaborative, contract DOT-TSC-643, has been making a critical assessment of current technology on track and elevated structure noise control. Their interim report, UMTA-MA-06-0025-74-5, NTIS PB 233 363/AS (see Appendix C), presents a user-oriented method for predicting the range of expected noise levels for various system design options and operating speeds. One of these graphs for predicting noise is reproduced in Figure 3-21.

They have found that for the purpose of predicting noise radiation and control elevated structures can be classified into three types. An analytical model has been developed for each type which relates noise to parameters such as rail fastener stiffness and damping, structure mechanical impedance, surface area and geometry. Full scale experiments on the MBTA system have been used to refine the prediction models. Figure 3-22 shows the site and instrumentation used in one experiment to determine the contribution to wayside noise due to vibration of the supporting beam of one type of structure (concrete-slab on steel I-beam). The upper photo shows a guyed pole on top of which is mounted a microphone to pick up overall noise. The close-up in the lower photo shows accelerometers, which pick up beam vibration, and a "near field" microphone to pick up noise coming primarily from the beam. Determining the primary noise radiating surfaces by experiments such as this is an important step in developing design options which radiate less noise.

The analytic and experimental bases for floating slab and resiliant fastener technology were also extended. Quantitative measures of slab performance were developed and evaluated. Full scale tests have been performed on the NYCTA floating slab to determine slab effectiveness in reducing transmission of vibration from the rail to the tunnel structure and to assess the validity of the analytic model. A final report giving the results is being prepared.

3.5.2 Tunneling

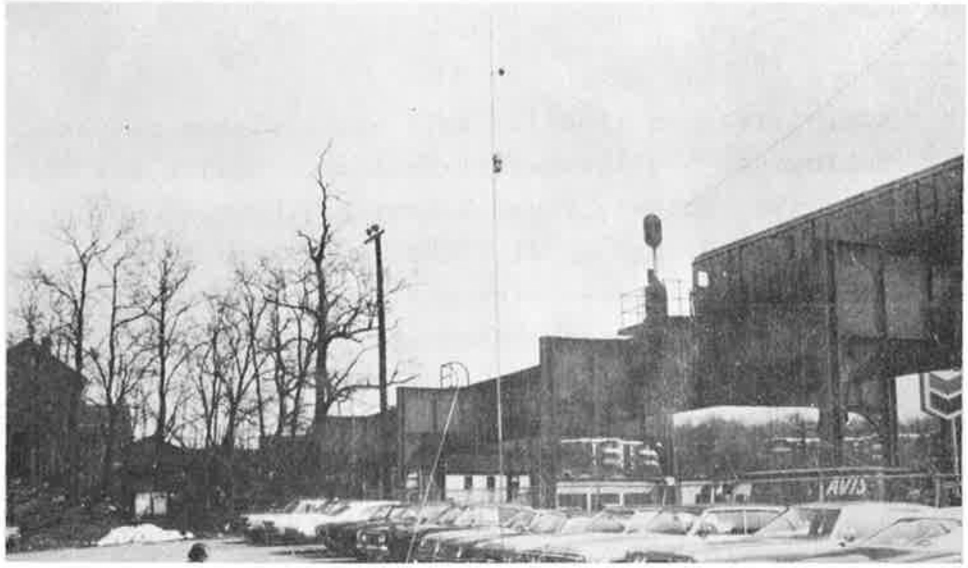
The end of this fiscal year marks two years of UMTA participation in the DOT Tunneling Program. In the second half of this fiscal year, the Office of the Secretary (OST) redirected the efforts of the participating administrations and assigned lead agency responsibility for research and development in various areas to the Federal Railroad Administration (FRA), UMTA, and Federal Highway



CORRECTION FACTORS*	
	ADD
JOINTED RAIL	8 TO 10 dBA
WHEEL FLATS	8 TO 10 dBA
NEW OR ROUGH RAILS	3 TO 6 dBA
ROUGH WHEELS	3 TO 6 dBA
CORRUGATIONS	UP TO 15 dBA

*ADD ONLY ONE CORRECTION FACTOR - THE LARGEST APPLICABLE

Figure 3-21 Wayside Noise for At-Grade Operations on Tie and Ballast Track



Upper: Far-Field Microphone on Guyed Pole.

Right: Near-field Microphone and Accelerometers on Web of Beam.

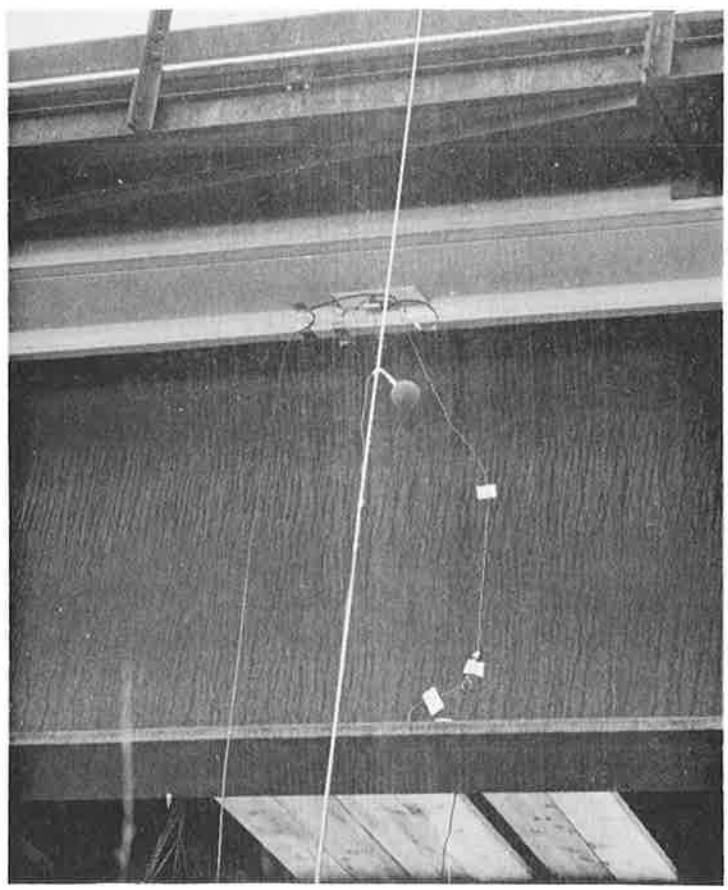


Figure 3-22 Wayside Instrumentation for Noise Measurements

Administration (FHWA). UMTA was assigned responsibility for the following: Environmental Factors: Health and Safety; Disruptions; Economic Factors; Legal Relations; Education and Evaluation; Maintenance; and Modal Problems related to mass transit tunneling in the urban areas. The assigned responsibilities in the DOT Tunneling Program are shown in Figure 3-23. This redirection has necessitated revision the UMTA TSC tunneling program plan. Ultimately, UMTA expects to use outputs from UMTA R&D, and from other sources including the FHWA and the FRA R&D to develop a series of guideline manuals on subjects of interest to UMTA. (See Figure 3-24 showing UMTA Tunneling Objectives.)

Environmental Impact and Safety

Contract DOT-TSC-802 has been awarded to A.A. Mathews, Inc., of Rockville, Maryland, for the Environmental Impact and Safety study. The contract is made up to two phases. In phase A, the work will develop a series of guidelines to minimize the adverse environmental impacts of tunneling in the urban areas and also a series of guidelines to promote safety and reduce accidents. These recommendations will be developed through the investigations of several case histories and by interviewing contractors, designers, labor groups, insurance agents, and transit authorities. In phase B, the proposed guidelines will be evaluated through workshops in three cities to develop a final set of guidelines to be presented to the tunneling community for implementation.

Muck Utilization

Contract DOT-TSC-836 has been awarded to Haley and Aldrich, Inc., of Cambridge, Massachusetts, to explore potential uses for excavation waste materials. The contract, scheduled for completion in February 1975, will provide guidelines for muck utilization.

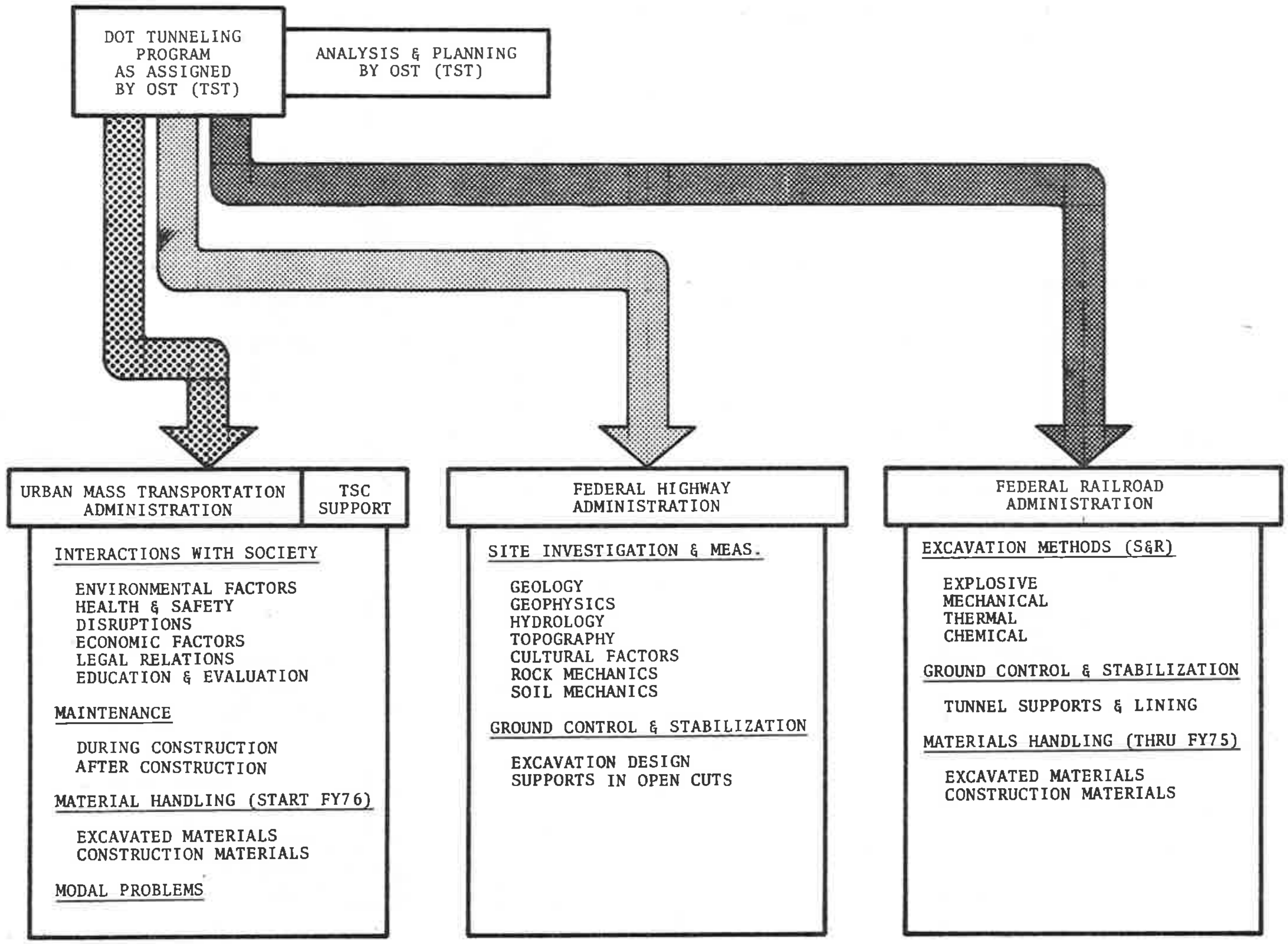


Figure 3-23 Assigned Responsibilities in DOT Tunneling Program

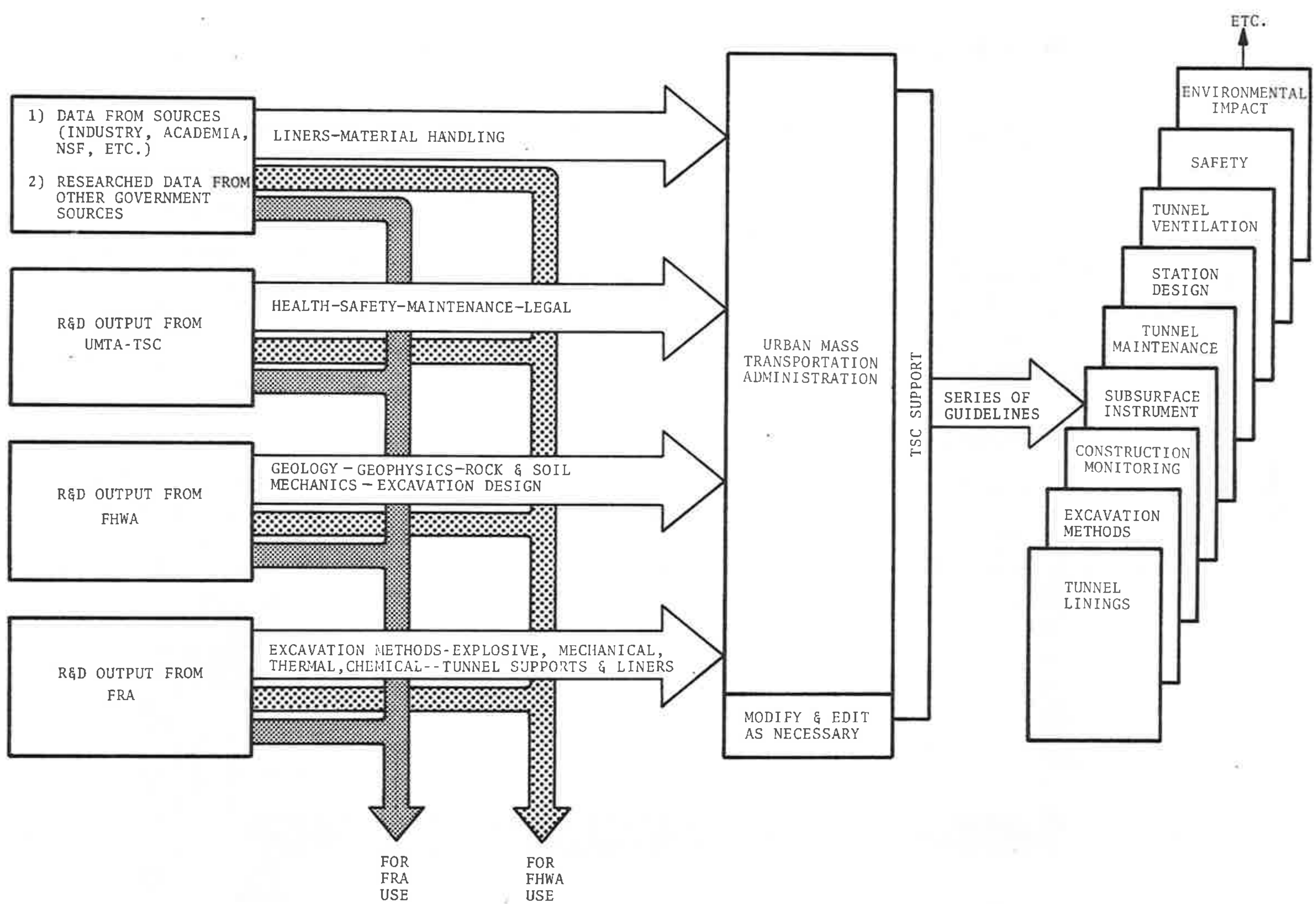


Figure 3-24 UMTA Tunneling Objectives

Subsurface Obstacle Detection

The final report (draft) on contract DOT-TSC-654 with Parsons, Brinckerhoff, Quade, and Douglas has been received. This report which will be available to the public through NTIS reviews available instrumentation and the use in tunneling for detection of obstacles and better identification of subsurface soil conditions. The report suggests areas for research and development efforts and also identifies equipment which, with minor repackaging, can be put to use almost immediately.

Construction Monitoring

A draft of the final report on construction monitoring of soft ground rapid transit tunnels was received from Parsons, Brinckerhoff, Quade, and Douglas, contract DOT-TSC-661. The report contains considerable technical data on monitoring instrumentation and considers the effects of pore pressures, soil movements, and forces on temporary and permanent supporting structures for future improvement of monitoring practice and instrumentation development. It will be available from the NTIS.

Systems Modeling and Optimization

Work on systems analysis and optimization in rapid transit tunneling has been completed (contract DOT-TSC-601, Bechtel Inc.).

The final report, being made available to the public through NTIS formulates an analysis for determination of systems sensitivities and optimization of rapid transit tunneling processes. This analysis includes a modeling framework structured to estimate the sensitivities of several construction and design techniques and the impact upon the construction cost-time schedule. The report outlines the type of data necessary to develop accurate cost-time models. Models are developed through case analyses.

UMTA Tunneling R&D Plan

The UMTA tunneling R&D plan was revised and forwarded to UMTA in mid-June. The plan reflects efforts proposed for accomplishment over a five year period.

NAS Contractual Relations Effort

An interagency transfer of funds to the National Science Foundation was completed in June to support the National Academy of Sciences (NAS) effort in assessing those changes in contractual relations for underground construction having potential for reducing construction costs. A final report is due the end of August 1974.

U.S. National Committee on Tunneling Technology

An interagency transfer of funds to the National Science Foundation was completed in June for support of the U.S. National Committee on Tunneling Technology (USNC/TT). The procurement request represents the UMTA share of the annual operating cost. Membership includes representatives from government, contracting, engineering, manufacturing, academic, research and professional organizations. The organization stimulates advancement in tunneling technology and effective use of subsurface regions.

3.6 HSGTC FIELD SUPPORT

TSC provided technical and planning field support at the DOT High Speed Ground Test Center, Pueblo, Colorado, to all of the urban transit vehicle test projects conducted there on the UMTA programs. Such support is available for non-UMTA testing programs on an arranged basis.

A most important objective of the urban Rail Supporting Technology Program is the development of a test and evaluation capability to provide data to the transit properties, related agencies and trades, and the scientific and technical community. These data must be timely, germane, unbiased, and in a form that is readily useable.

Test capability on the UMTA Rail Transit Test Track, has been acquired, at both the system and subsystem levels, in the testing of the State-of-the-Art Cars (SOAC), the NYCTA R-42 cars, and, more recently, the Energy Storage Cars (ESC) modified NYCTA R-32's. Activities are well in progress to further expand this experience to include the Gas-Turbine/Electric (GT/E) cars (Garrett and Pullman), and the Standard Light Rail Vehicle (SLRV) (Boeing Vertol).

The SOAC vehicles were shipped to New York in April 1974 after successfully completing an extensive test program including both the General Vehicle Test Plan (GVTP) (TSC GSP 064) Engineering Tests and a 3000-mile reliability test. The reliability endurance test consisted of 1500 miles of 80-mile-per-hour high speed running and 1500 miles of simulated revenue service which involved some 3000 station stops and an average running speed of 35- to 50-miles-per-hour.

The ESC vehicles arrived at the HSGTC in April 1974 and the GTE vehicles arrived in June 1974.

The number of test operation days for fiscal year 1974 was:

SOAC	66
ESC	55
R-42	3
Total	124

APPENDIX A

URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM PROJECTS

URST PROJECTS IN FISCAL YEAR 1974

ADVANCED CONCEPT TRAIN (ACT)

1. Program review and technology support given to the ACT program by TSC personnel throughout fiscal year 1974.

TRANSIT SYSTEM COSTS

2. Rail Rapid System Cost Study - A comprehensive study of urban rail transit system costs by Thomas K. Dyer, Inc., under Contract No. DOT-TSC-808. TSC Monitor: Frederick J. Rutyna

VEHICLE CRASHWORTHINESS

3. Engineering Program Assessment of the Crashworthiness of Existing Urban Rail Vehicles - Program development work was performed by Calspan, Inc., providing methodology and assessment criteria, under Contract No. DOT-TSC-681. TSC Monitor: Dr. A.R.Raab.

4. SOAC Crashworthiness Study - Crashworthiness evaluation and test study of the State-of-the-Art Car by engineering assessment performed by Boeing Vertol, under Contract No. DOT-TSC-791. TSC Monitor: Frederick Rutyna.

TRACK GEOMETRY MEASUREMENT SYSTEMS

5. Track Geometry Sensor Systems - Two sensor systems were engineered by MB Associates, to TSC specifications, under Contract No. DOT-TSC-616. TSC Monitor: Frederick Rutyna.

FACILITIES DEVELOPMENT

6. Development of Design Tools and Criteria for Urban Rail Structures - A study of design elements for urban rail structures by Battelle Columbus Laboratories, under Contract No. DOT-TSC-563. Two-volume final report issued in April 1974. TSC Monitor: Dr. Leonard Kurzweil.

7. Tight Turn Loop and Train Dynamics Track for the Rail Transit Test Track (RTTT) at the High Speed Ground Test Center (HSGTC). Drawings and specifications prepared by TSC personnel, earthwork completed. TSC Monitor: R. Ebacher.

8. Electrical Equipment and Drawings and Specifications for UMTA Substations Providing Power to RTTT - Specification No. DOT/LBP-71421 developed by Laramore, Douglas & Popham, Consultants, under Contract No. DOT-FR-30033 Wismer & Becker, Inc., under contract for rectifier substation equipment; Contract No. DOT-TSC-847. TSC Monitor: L. Zorio.

9. Catenary Power System - Planning and design work prior to the selection of a contractor for the construction of the Rail Transit Test Track catenary structure. All materials GFM. TSC Monitor: L. Zorio.

10. Development of RTTT Laboratory and Maintenance Facilities. Prepared specifications and initiated procurement for:

    a. Underfloor Wheel Truing Machine, DOT-TSC-876
    b. Track Scale, DOT-TSC-829
    c. Railroad Car Jacks, DOT-TSC-825
    d. Air Compressor (large unit), DOT-TSC-806

    TSC Monitor: R. Ebacher.

11. Power Conditioning Systems - Engineered by the Avtel Corporation, Contract No. DOT-TSC-671, for use in conjunction with Data Acquisition System (DAS) equipment. TSC Monitor: R. Wilmarth.

TEST AND EVALUATION

12. Energy Storage Car (ESC) Engineering Tests at HSGTC - TSC generated test plans and procedures. Tests were conducted by AiResearch Mfg. under Contract No. DOT-TSC-838. TSC Monitor: George Neat.

13. State-of-the-Art Car (SOAC) Engineering Tests at HSGTC - TSC generated test plans and procedures.

    a. Extensive testing performed by Boeing Vertol, under Contract No. DOT-TSC-580.

    b. SOAC post-repair engineering tests- special test work performed by Boeing Vertol, under Contract No. DOT-TSC-580, to verify data taken prior to accident.

    c. SOAC engineering tests on NYCTA demonstration run. Revenue-line demonstration runs (4 separate lines) constituting the first phase in the scheduled five-property test plan for the SOAC.

    TSC Monitor: George Neat.

14. General Vehicle Test Plan for Urban Rapid Transit Cars (GSP 064 - Rev. 1) - Expansion of tests and procedures, based on evaluation data acquired during the SOAC engineering tests. TSC Monitor: George Neat.

15. AC Propulsion Ride Roughness Tests, Cleveland Transit System, September 1973 - AC and DC propulsion comparison tests as to ride roughness, in cooperation with the Cleveland Transit System. TSC Monitor: Lowell Babb.

16. Study of Techniques for the Evaluation of Dynamic Characteristics of Rail Vehicles - Study and evaluation work by General Electric under Contract No. DOT-TSC-652. TSC Monitor: Dr. Herbert Weinstock.

17. Gas-Turbine/Electric Car Tests at HSGTC - TSC provided technical support at the HSGTC for testing the UMTA sponsored Gas-Turbine/Electric Cars built by the Garrett Corporation for the New York Metropolitan Transportation Authority.

18. R-42 Transit Car Test Participation - The New York City Transit Authority R-42 cars were used by TSC to check out test equipment and test procedures at HSGTC and for trainline tests with the Energy Storage Cars.

19. Digital Data Acquisition - Three Data Acquisition Systems (DAS) were developed for TSC by Sperry Univac under Contract No. DOT-TSC-561. TSC Monitor: Paul Poirier.

20. Software development and process evaluation for the DAS application in the Track Geometry Measurement System, General Vehicle Testing, and Wayside Data Acquisition and Processing.

21. Integrated accelerometer data processing test and evaluation, to provide true rail profile data.

22. Algorithm development to compute true track alignment data from capacitance probe and lateral acceleration measurements.

NOISE ABATEMENT

23. The Procurement of Engineering Data on Wheel/Rail Noise and Vibration Control Technology - Project work was performed by Bolt, Beranek & Newman, under Contract No. DOT-TSC-644. TSC Monitor: Dr. Robert Lotz.

24. Development of an Acoustic Rating Scale for Assessing Annoyance Caused by Wheel/Rail Noise in Urban Mass Transit - The work was performed by Bolt, Beranek & Newman, under Contract No. DOT-TSC-644. TSC Monitor: Dr. Robert Lotz.

25. Noise Assessment and Abatement in Rapid Transit Systems - Complete analysis of wheel/rail noise data by Bolt, Beranek & Newman, under Contract No. DOT-TSC-644. TSC Monitor: Dr. Robert Lotz.

26. A State-of-the-Art Assessment of the Prediction and Control of Rail Transit Noise and Vibration - Project

work performed by Cambridge Collaborative, under Contract No. DOT-TSC-643. TSC Monitor: Dr. Leonard Kurzweil.

27. Noise and Vibration Assessment of the Chicago Rail Rapid Transit System - A study performed by the University of Illinois, under Research Grant No. US-DOT-IL-0007. TSC Monitor: Frederick Rutyna.

28. Data Management System for Rail Rapid Transit Noise Measurements - Development study work performed by the University of Illinois, under Research Grant No. US-DOT-IL-0007. TSC Monitor: Frederick Rutyna.

29. Noise and Vibration Assessment of New York City Rapid Transit System - A study performed by the Polytechnical Institute of New York, under Research Grant No. US-DOT-NY-11-0010. TSC Monitor: Frederick Rutyna.

TUNNELING

30. System Analysis, Modeling and Optimization of Rapid Transit Tunneling Process - Development study by Bechtel, Inc., under Contract No. DOT-TSC-601. TSC Monitor: Dr. George Kovatch.

31. Requirement Study Investigating Instrumentation Development for Rapid Transit Tunneling - Investigation by Parsons, Brinckerhoff, Quade & Douglas, under Contract No. DOT-TSC-661. TSC Monitor: Dr. George Kovatch.

32. Specifications and Design for Monitoring Instruments for Rapid Transit Soft Ground Tunneling - Design work by Parsons, Brinckerhoff, Quade & Douglas, under Contract No. DOT-TSC-661. TSC Monitor: Dr. George Kovatch.

33. Two Studies on Tunneling Technology - initiated by the FRA; Reimbursable Agreements RA-7439 and RA-7444 to the National Science Foundation. TSC Monitor: Santo Gozzo.

34. Environmental Impact and Safety Guidelines for Improved Rapid Transit Tunneling - A study by A.A. Mathews, Inc., under Contract No. DOT-TSC-802. TSC Monitor: Santo Gozzo.

35. Muck Utilization in Urban Rapid Transit Tunneling Process. A study by Haley and Aldrich, Inc., under Contract No. DOT-TSC-836. TSC Monitor: Gerald R. Saulnier.

APPENDIX B

URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM CONTRACTS AND GRANTS

Contracts

Contract No.	Contractor	Purpose	TSC Monitor
DOT-TSC-561 UM304	Sperry Univac	Data Acquisition System for Rapid Rail Vehicle	P. Poirier
DOT-TSC-563 UM304	Battelle Columbus Laboratories	Development of Design Tools and Criteria for Urban Rail Structures	L. Kurzweil
DOT-TSC-580 UM404	Boeing Vertol	Engineering Tests of the State-of-the-Art Car	G. Neat
DOT-TSC-601 UM304	Bechtel, Inc.	System Analysis, Modeling and Optimization of Rapid Transit Tunneling Process	G. Kovatch
DOT-TSC-616 UM304	MB Associates	Track Geometry Sensor System	F. Futyna
DOT-TSC-643 UM304	Cambirdge Colaborative	Engineering Data on Track and Elevated Structure Noise and Vibration Control	L. Kurzweil
DOT-TSC-644 UM304	Bolt, Beranek & Newman	Engineering Data on Wheel/Rail Noise and Vibration Control Technology	R. Lotz
DOT-TSC-652 UM304	General Electric	Study and Evaluation of Dynamic Characteristics of Rail Vehicles	H. Weinstock
DOT-TSC-654 UM304	Parsons, Brinckerhoff, Quade & Douglas	Requirement Study Investigating Instrumentation Development for Rapid Transit Tunneling	G. Kovatch

Contracts

Contract No.	Contractor	Purpose	TSC Monitor
DOT-TSC-661	Parsons, Brinckerhoff, Quade & Douglas	Specifications and Design for Monitoring Instruments for Rapid Transit Tunneling	G. Kovatch
DOT-TSC-671 UM304	Avtel Corporation	Power Conditioning Systems	R. Wilmarth
DOT-TSC-681 UM304	Calspan Corp.	Assessment of the Crashworthiness of Urban Rail Vehicles	A. Raab
DOT-TSC-791 UM404	Boeing Vertol	Engineering Assessment of SOAC Crashworthiness	F. Rutyna
DOT-TSC-802 UM404	A.A. Mathews, Inc.	Environmental Impact and Safety Guidelines for Improved Rapid Transit Tunneling	S. Gozzo
DOT-TSC-806 UM404	Lincoln Controls Co.	Air Compressor	E. McCarthy
DOT-TSC-808 UM404	Thomas K. Dyer	Rail Rapid Transit System Cost Study	F. Rutyna
DOT-TSC-825 UM404	Whiting Corp.	Portable Jacks	J. Paolini
DOT-TSC-829 UM304	Murphy Scale and Equipment Co.	Railway Track Scale	R. Ebacher
DOT-TSC-831 UM404	American Aerospace Controls	Sensors	L. Babb
DOT-TSC-836 UM404	Haley & Aldrich	Muck Utilization in Urban Rapid Transit Tunneling Process	G. Saulnier

Contracts

Contract No.	Contractor	Purpose	TSC Monitor
DOT-TSC-838 UM404	AiResearch Mfg.	Tests on Energy Storage Cars	G. Neat
DOT-TSC-847 UM404	Wismer & Becker	Rectifier Substation Equipment	L. Zorio
DOT-TSC-876 UM404	Hegenscheidt Corp. of America	Underfloor Wheel Truing Machine	R. Ebacher
DOT-TSC-882 UM404	Endevco	Mode Cards	P. Silvia
DOT-TS-7147 UM304	Ithaco, Inc.	Electronic Filter Modules	J. Nickles
DOT-RA-7429 UM404	Federal Highway Administration	Transfer of UMTA Funds for Construction of Track at HSGTC	R. Ebacher
DOT-RA-7439 UM404	National Science Foundation	Study of Tunneling Technology	S. Gozzo
DOT-RA-7444 UM404	National Science Foundation	Study of Tunneling Technology	S. Gozzo

Grants

Grant No.	Grantee	Purpose
US-DOT-IL-0007 DOT/UMTA	University of Illinois	Data Management System for Rail Rapid Transit Noise Measurements
US-DOT-IL-0007 DOT/UMTA	University of Illinois	Noise Assessment of the Chicago Rail Rapid Transit System
US-DOT-NY-11-0010 DOT/UMTA	Polytechnic Institute of New York	Noise Assessment of New York City Rapid Transit System

APPENDIX C

URBAN RAIL SUPPORTING TECHNOLOGY PROGRAM
DOCUMENT LIST

Appendix C lists documents related to the Urban Rail Supporting Technology Program, including:

- Interim Reports and Final Reports
- Papers
- Newsletters
- Preliminary Memoranda (PM) Documents
- Ground Systems Programs (GSP) Documents

Documents bearing a DOT or UMTA number may, if appropriate, be available through the National Technical Information Service (NTIS) Springfield, Virginia 22161. Other documents are, generally, internal to the Department of Transportation and, generally, are not available. The listing includes documents that are in preparation and documents that are forthcoming, some of which will be available through the NTIS when they are published.

Interim Reports and Final Reports are arranged primarily by DOT-TSC numbers. A document having more than one number assigned to it is listed with all numbers and an asterisk (*) is placed beside the number that appears on the cover of the document. The NTIS number, if assigned, is listed preceding the name of the TSC contract monitor or author, as the case may be. Reports in preparation and reports forthcoming are listed by contract number or no number.

Reports in preparation reflect current research, planning, and evaluation work, the reports of which are expected within the year, depending on the progress made by the related program or project.

Reports forthcoming are documents expected to be generated under contract provisions or as a result of DOT grants for study and research purposes. The issue of forthcoming reports will be in accordance with the related contract or grant schedule.

Reports produced by a contractor are identified by the letters CR and the contractor name appears after the title.

The date listed is the date of publication and the type of document, if not stated, is indicated by the following abbreviations:

CR Contractor Report
FR Final Report
IR Interim Report
PM Preliminary Memorandum
TM Technical Memorandum
TR Technical Report

Papers are arranged in groups according to the location of the initial presentation.

Newsletters are listed in order of the date of publication.

Preliminary Memoranda (PM) Documents are designated as internal working documents. They are listed according to the assigned PM number and the author, title, and date are listed in the same manner as described for reports.

Ground Systems Programs (GSP) Documents are listed in GSP number sequence with the title and date of issue. The GSP documents generally pertain to equipment specifications and requirements, or to operating procedures or plans for the implementation of test and evaluation, or to related information developed under the Urban Rail Supporting Technology Program within the DOT Transportation Systems Center, Ground Systems Programs Division.

Interim Reports and Final Reports

Report No.(s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-UMTA-71-2 DOT-UMTA-71-2* Joseph E. Picardi	Analysis of Electro Hydraulic Servo Equation for WRDRF Prototype Control System	10/71	PM
DOT-TSC-UMTA-72-2 Dr. Herbert Weinstock John E. Nickles	Preliminary Vibration Measurements on Mark I Vehicle	10/71	TM
DOT-TSC-UMTA-72-3 E.J. Rickley R.W. Quinn G.E. Byron	Noise Level Measurements on the UMTA Mark I Diagnostic Car (R-42 Model)	10/71	TR
DOT-TSC-UMTA-72-4 Dr. E.G. Apgar	Rapid Transit System Noise Abatement Program	1/72	Program Plan
DOT-TSC-UMTA-72-5 William Van Dyke	Report on Subway Tunneling Needs of 13 Selected U.S. Cities, 1971-1975	6/72	TR
DOT-TSC-UMTA-72-10 MA-06-0025-73* NTIS PB 222654 Dr. Herbert Weinstock	Analyses of Rail Vehicle Dynamics in Support of Development of the Wheel/Rail Dynamics Research Facility (WRDRF)	6/73	IR
DOT-TSC-UMTA-73-5 George W. Neat	MBTA Green Line Tests-Riverside Line, December 1972	6/73	PM
DOT-TSC-UMTA-73-6 Dr. A.C. Malliaris Dr. E.G. Apgar Dr. L.G. Kurzweil Dr. R. Lotz	Rapid Transit Noise Abatement and Cost Requirements (MBTA Pilot Study)	6/73	PM

Interim Reports and Final Reports (Cont'd)

Report No.(s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-UMTA-73-14 UMTA-06-MA-0025-74-6* NTIS PB 233394 Frederick Rutyna	Track Geometry Development, UMTA Urban Rail Supporting Technology Program	4/74	FR
DOT-TSC-UMTA-74-1-I* DOT-TSC-UMTA-73-9-I NTIS PB 225093 George Neat	MBTA Green Line Test-Riverside Line, December 1972, Vol. I, Test Description	9/73	FR
DOT-TSC-UMTA-74-1-II* DOT-TSC-UMTA-73-9-II NTIS PB 225093 George Neat	MBTA Green Line Tests-Riverside Line, December 1972, Vol. II, Track Geometry Data Plots	10/73	FR
DOT-TSC-UMTA-74-1-III* DOT-TSG-UMTA-73-9-III NTIS PB 225093 George Neat	MBTA Green Line Tests-Riverside Line, December 1972. Vol. III, Eastbound Traffic Profile	10/73	FR
DOT-TSC-UMTA-74-1-IV* DOT-TSC-UMTA-73-9-IV NTIS PB 225093 George Neat	MBTA Green Line Tests-Riverside Line, December 1972, Vol. IV, Westbound Traffic Profile	10/73	FR
DOT-TSC-UMTA-74-1-V* DOT-TSC-UMTA-73-9-V NTIS PB 225093 George Neat	MBTA Green Line Tests-Riverside Line, December 1972, Vol. V, Gage Computer Printout	10/73	FR

Interim Reports and Final Reports (Cont'd)

Report No.(s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-UMTA-74-3 UMTA-MA-06-0025-74-2* NTIS PB 231363/AS Dr. Robert Lotz, CR	Development of an Acoustic Rating Scale for Assessing Annoyance Caused by Wheel/Rail Noise in Urban Mass Transit by Schultz of Bolt, Beranek and Newman, Inc.	2/74	IR
DOT-TSC-UMTA-74-5 UMTA-MA-06-0025-74-3*& UMTA-MA-06-0025-74-4* (Vol. I NTIS PB233-016/AS) (Vol. II NTIS PB233-017/AS) Dr. Leonard G. Kurzweil, CR	Volume I, At-Grade Tie-Ballast Track & Volume II, At-Grade Slab Track. Both Volumes Together Make DOT-TSC-UMTA-74-5, Entitled: Assessment of Design Tools and Criteria for Urban Rail Structures by Prause, Meacham, et al of Battelle-Columbus Laboratories.	4/74	FR
DOT-TSC-UMTA-74-6 UMTA-MA-06-0025-74-5* NTIS PB 233 363/AS Dr. Leonard G. Kurzweil, CR	Prediction and Control of Rail Transit Noise and Vibration--A State-of-the-Art Assessment by Manning, Cann and Fredberg of Cambridge Collaborative, Inc.	4/74	IR
DOT-TSC-UMTA-74-7 UMTA-MA-06-0025-73-15* NTIS PB237012/AS Dr. Robert Lotz, CR	Wheel/Rail Noise and Vibration Control by Remington, et al of Bolt, Beranek and Newman, Inc.	5/74	IR
DOT-TSC-UMTA-74-11 UMTA-MA-06-0025-74-7* NTIS 238127/4S Dr. Leonard G. Kurzweil, CR	A Bibliography on the Design and Performance of Rail Track Structures, by Prause, Pestel and Melvin of Battelle-Columbus Laboratories	9/74	FR
DOT-TSC-UMTA-74-13 UMTA-MA-06-0025-74-8* NTIS 238113/AS Dr. L.G. Kurzweil Dr. R. Lotz Dr. E.G. Apgar	Noise Assessment and Abatement in Rapid Transit Systems Report on the MBTA Pilot Study	9/74	FR

Interim Reports and Final Reports (Cont'd)

Report No. (s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-UMTA-74-15 UMTA-MA-06-0025-74-9* NTIS 238602/AS Ronald J. Madigan	Urban Rail Supporting Technology Program Fiscal Year 1973 Year End Summary (UM-304)	1/74 In Preparation 6/74	PM FR
UMTA-MA-06-0025-73-1 NTIS PB 220846 Ronald J. Madigan	Urban Rail Supproting Technology Program (UM-204) Fiscal Year 1972, Year End Summary	4/73	FR
DOT-TSC-OST-74-4 ** R.J. Pawlak Dr. A.M. Colella Dr. N. Knable R.H. Robichaud Dr. E. Donald Sussman	Safety and Automatic Train Control for Rail Rapid Transit Systems	In Preparation	FR
DOT-TSC-310-1 NTIS PB 213447 G. Ameral	Light Rail Transit Systems--A Definition and Evaluation, by Vukan Vuchic	10/72	FR
DOT-TSC-319-1 NTIS-PB 213448	Fifteen-Oh-One to Sixteen-Thirty-Technical and Managerial Lessons from One Experience in Introducing New Technology to Improve Urban Mass Transportation, by C.R. Price & D.S. Scheele of Social Engineering Technology	11/72	FR
DOT-TSC-681 Frederick Rutyna	Engineering Program for Assessment of Crashworthiness of Existing Urban Rail Vehicles, by Calspan Corp.	10/73	TD
DOT-TSC-601 Santo J. Gozzo, CR	Systems Analysis, Modeling and Optimization of Rapid Transit Tunneling/; Bechtel Inc.	In Preparation	FR

* * Funded from the Office of the Secretary

Interim Reports and Final Reports (Cont'd)

Report No.(s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-580 George Neat	Urban Rail Rapid Transit State-of-the-Art-Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center	In Preparation	FR
DOT-TSC-580 George Neat	State-of-the-Art-Car (SOAC) Post-Repair Engineering Tests at Department of Transportation High Speed Ground Test Center	In Preparation	FR
DOT-TSC-580 George Neat	General Vehicle Test Plan for Urban Rail Transit Cars (TSC GSP-064 - Revised)	In Preparation	FR
DOT-TSC-652 Dr. Herbert Weinstock, CR	Study of Techniques for the Evaluation of Dynamic Characteristics of Rail Vehicles/General Electric Company, Transportation Systems Business Division	In Preparation	IR
DOT-TSC-654 Santo J. Gozzo, CR	Subsurface Obstacle Detection Report/Parsons, Brinckerhoff, Quade and Douglas	In Preparation	TR
DOT-TSC-661 Santo J. Gozzo, CR	Construction Monitoring of Soft Ground Rapid Transit Tunneling/Parsons, Brinckerhoff, Quade and Douglas	In Preparation	TR
DOT-TSC-791 F. Rutyna, CR	SOAC Crashworthiness Report/Boeing Vertol	In Preparation	IR
DOT-TSC-802 Santo J. Gozzo, CR	Safety and Environmental Impact in the urban Rapid Transit Tunneling Process/A.A. Mathews, Inc.	Forthcoming	FR

Interim Reports and Final Reports (Cont'd)

Report No. (s) TSC Monitor or Author	Title/Contractor (if any)	Date	Type
DOT-TSC-808 F. Rutyna, CR	Rail Rapid Transit System Cost Study T.K. Dyer, Inc.	In Preparation	FR
DOT-TSC-836 Gerald Saulnier, CR	Muck Utilization in the Urban Rapid Transit Tunneling Process/Haley and Aldrich, Inc.	Forthcoming	FR
UMTA-MA-06-0025-74-12 R. Madigan	Five Year Program-Urban Mass Transportation Administration Tunneling Research and Development Elements of Department of Transportation Tunneling Program for Fiscal Years 1975 to 1979	In Preparation	Plan

Papers

Title of Paper	Given by:	At
Noise Exposure Study of the Massachusetts Bay Transportation Authority, Rapid Transit System	Dr. E. Apgar & Dr. T.J. Trella	NOISECON 73 Washington, D.C.
A Methodology for Determining Minimum Cost in Rapid Transit Noise Control	Dr. R. Lotz & Dr. L.G. Kurzweil	NOISECON 73 Washington, D.C.
Wheel - Rail Noise: A Progress Report	Dr. R. Lotz	INTERNOISE 74 Washington, D.C.
Prediction of Wayside Noise from Rail Transit Vehciles	Dr. J. Manning Dr. L.G. Kurzweil	INTERNOISE 74 Washington, D.C.
UMTA Urban Rail Test and Evaluation Program	G. Neat	ATA Rail Transit Conference San Francisco
Test and Evaluation Capability development; The Program Philosophy	R. Madigan	ATA Rail Transit Conference San Francisco
UMTA Rail Facilities at the DOT High Speed Ground Test Center	H. Decker	ATA Rail Transit Conference San Francisco
Flexibility of the UMTA Rail Power System At HSGTC	H. Decker	ATA Rail Transit Conference San Francisco
Track Structures Research and Development	H. Decker	ATA Rail Transit Conference San Francisco

Papers (Cont'd)

Title of Paper	Given by:	At
On the Bechtel Model for Optimization of the Rapid Transit Tunneling Process	Dr. G. Kovatch	ATA Rail Transit Conference San Francisco
Safety and Automatic Train Control for Rail Rapid Transit Systems **	G. Pastor & R. Pawlak	ATA Rail Transit Conference San Francisco
Urban Rail Supporting Technology Applied Research	F. Rutyna	ATA Rail Transit Conference San Francisco
Urban Tunneling R&D	F. Rutyna	ATA Rail Transit Conference San Francisco
UMTA Noise Abatement Program	F. Rutyna	IRT Conference Los Angeles

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Newsletter

74-1	The Urban Rail Supporting Technology Program	6/74

Preliminary Memoranda

Report No.	Author	Title	Date
PM-P-1	Dr. H. Weinstock	Preliminary Instrumentation Development Tests, August 1971	8/73
PM-P-2	Lowell Babb	Urban Rail Technology Instrumentation Tests, June 1972	9/73
PM-P-3	George Neat	Checkout of General Vehicle Test Procedures, March 1972	8/73
PM-P-4	George Neat	Track Geometry Systems Development Test, November 1971	10/73
PM-P-5	Lowell Babb	Ride Roughness Tests, Cleveland Transit System, September 1973	11/73
PM-P-6	Ronald J. Madigan	Urban Rail Supporting Technology Program Fiscal Year 1973, Year End Summary (Reprinted as DOT-TSC-UMTA-74-15/UMTA-MA-06-0025-74-9)	1/74
PM-T-28	Dr. Leonard G. Kurzweil	Standard Methodology for Measurement of Noise Due to Urban Rapid Transit Operations (Working Paper-Limited Distribution)	9/74

Ground Systems Programs

Number	Title	Date
GSP-007	Requirements for Design of Balance of UMTA Rapid Transit Test Track	11/71
GSP-007A	Construction Specification for 150' Radius Screech Loop Track	6/73
GSP-008	Technical Development Plan, Urban Rail Supporting Technology Program	10/71
GSP-010	Rail Technology Test Plan	10/71
GSP-011	Requirements for Service Building for DOT High Speed Ground Test Center	10/71
GSP-016	Event Flow Chart	11/71
GSP-023	Electrification Specification for Balance of UMTA Rapid Transit Test Track	1/72
GSP-024	Specification for 150 lb. Contact Rail	12/71
GSP-025	Specification for End Approach Rail	12/71
GSP-026	Specification for Covering, Protective Board	12/71
GSP-027	Specification for Track Anchors	12/71
GSP-028	Specification for Welded Strings of Steel Rail 119# RE	1/72
GSP-029	Specification for Cross Ties, Contact Rail Ties, and Switch Timbers	1/72
GSP-030	Specification for No. 15 Railroad Turnouts	1/72
GSP-031	Specification for Welding Package	1/72
GSP-032	Specification for Welded Strings of Steel Rail 100# RE Section 1440' and Steel Rail 100# RE Section 39'	1/72
GSP-033	Specification for Standard Monitor Oscilloscope, 7 Channel	1/72

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Number	Title	Date
GSP-034	Specification for Portable Instrumentation Magnetic Tape Recording System	1/72
GSP-035	Specification for MD Constant Bandwidth System	1/72
GSP-036	Specification for General Purpose Oscillographic Recorder, Portable	1/72
GSP-037	Specification for Soil Strain Gage Consoles, Sensor, Cables, Calibration Mount and Extensiometers	1/72
GSP-038	Specification for Nuclear Moisture-Density Inst.	1/72
GSP-039	Specification for Embankment Accelerometers	1/72
GSP-040	Specification for Earth Pressure Cells (PE 0046)	1/72
GSP-041	Specification for Earth Pressure Cell (PE-0049)	1/72
GSP-042	Embedded Instrumentation Requirements for UMTA Rapid Transit Test Track	1/72
GSP-043	Track Construction Specifications for Balance of UMTA Rapid Transit Test Track	1/72
GSP-044	Specification for Prestressed Concrete Ties	1/72
GSP-046	Specification for Cable, Electrical	1/72
GSP-047	Specification for Rail Fasteners	1/72
GSP-048	Specification for Rail Bearing Pads	1/72
GSP-049	Specification for Tie Plates	1/72
GSP-050	Specification for Rail Joint Bars	1/72
GSP-051	Specification for Rail Track Spikes	1/72
GSP-052	Specification for Rail Anchors	1/72
GSP-053	Specification for Contact Rail Expansion Joints	2/72

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Number	Title	Date
GSP-054	Specification for Electric Generating Set	1/72
GSP-056	Specification for Wave Analyzer System	N/A
GSP-058	Specification for Insulator Assembly and Support	2/72
GSP-059	Specification for Portable Laboratory and Conveyance Vehicle	9/73
GSP-060	Specification for Concrete Tie/Rail Fastener System	3/72
GSP-062	Wheel/Rail Laboratory Foundation Vibration Analysis (Report)	3/72
GSP-064	General Vehicle Test Plans for Urban Rapid Transit Cars (Report) (Being revised for reissue)	4/72
GSP-065	Requirements for the Design and Construction of the Power System for Energizing the UMTA Rapid Transit Test Track at HSGTC	5/72
GSP-066	Description of Data Acquisition Systems for the Rail Technology Test Program	5/72
GSP-066A	Specification for Data Acquisition Systems for the Urban Rail Supporting Technology Program	5/72
GSP-067	Dynamic Track Compliance (Report)	4/72
GSP-068	UMTA-Temporary Service Building and Service Track	5/72
GSP-069	Specification for Portable Electric Jack	6/72
GSP-070	Modifications to the DOT 001 Locomotive for Additional Power Output	6/72
GSP-072	A Plan for UMTA Tunneling R&D (Report)	1/74
GSP-074	Requirements for Installation of Protective Fencing and Safety Signs for the UMTA Test Track at HSGTC	8/72

Number	Title	Date
GSP-075	Specifications for Track Geometry Sensor System	8/72
GSP-079	UMTA Related Requirements Wheel/Rail Simulator	8/72
GSP-087	Work Statement Systems Analysis Modeling and Optimization of Rapid Transit Tunneling	12/72
GSP-088	Work Statement Monitoring Instrumentation Development for Rapid Transit Tunneling	12/72
GSP-089	Work Statement Subsurface Investigation Instrumentation for Rapid Transit Tunneling	12/72
GSP-094	Specifications for Power Conditioning System	2/73
GSP-097	Specifications for UMTA Rectifier Substations and Associated Equipment	6/73
GSP-098	Statement of Work Noise and Vibration Assessment of the Chicago Transit Authority by the University of Illinois	8/73
GSP-099	Statement of Work Noise and Vibration Assessment of the New York City Transit Authority by the Brooklyn Polytechnical Institute	8/73
GSP-100	Specifications for Variable Electronic Filter System	9/73
GSP-101	Specifications for Modular Universal Signal Conditioning System (Amplifiers & Preamplifiers, Signal Conditioning)	N/A
GSP-102	Specification for Engineering Assessment of the Crashworthiness of the UMTA State-of-the-Art-Car (SOAC)	11/73
GSP-107	Specifications for PE 0106 Transit Systems Requirements Study (Ref: UMTA Five-Year RD&T Plan)	12/73
GSP-108	Operational Procedures, Rail Transit Test Track Operations	1/74

Ground Systems Programs (Cont'd)

Number	Title	Date
GSP-109	R-42 Operating Procedures	1/74
GSP-111	Specification for Railroad Gage and Cross-level measurement Instrumentation	6/74
GSP-112	Statement of Work for General Vehicle Tests on the Energy Storage Cars	5/74
GSP-114	Data Acquisition Specification for UMTA Signal Processing Software	5/74
GSP-116	Specifications for Custom-Designed Mode Card	6/74
GSP-117	Specifications for Differential Voltage Divider Model DVD-1	6/74