REPORT NO. UMTA-MA-

A. F. Sugar Cong

ADVANCE COPY FOR REVIEW ONLY

SOAC

STATE-OF-THE-ART CAR

TRANSIT PROPERTY

ENGINEERING TESTS

FINAL TEST REPORT

VOLUME III. DATA REPORT MBTA, CTS, CTA, SEPTA, PATCO

R. OREN



DECEMBER 1975

FINAL REPORT

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

Prepared for

URBAN MASS TRANSPORTATION ADMINISTRATION

Office of Research and Development

Washington, D.C. 20590

Technical Report Documentation Page

1. Report No. UMTA-MA-	2. Government Acces	ssion No. 3. F	Recipient's Catalog N	10.
4. Title and Subtitle			Report Date cember 1975	
SOAC, State-of-the-Art Car Transit Property Engineering Final Test Report		·	Performing Organizati	on Code
Volume III Data Report – MBT	A, CTS, CTA, SEPT	A, PATCO		
7. Author's) Ray Oren		0. F	erforming Organizati 32-10007-3	on Report No.
9. Performing Organization Name and Addres	55	10.	Work Unit No. (TRAI	S)
Boeing Vertol Company* Phila., Pa. 19142			Contract or Grant No T-TSC-580).
		13.	Type of Report and F	Period Covered
12. Sponsoring Agency Name and Address			· /pe er kepert dita i	enda coveres
U.S. Department of Transportation Urban Mass Transportation Admi	nistration	Fin	al Report (April 19	974 to April 1975)
Office of Research and Developm Washington, D.C. 20590	ent	14.	Sponsoring Agency C	Code
15. Supplementary Notes *Under Contract		ent of Transportation on Systems Center IA 02141		
16. Abstract			n an	#1948/24-08-08-08-08-04-04-04-04-04-04-04-04-04-04-04-04-04-
This three-volume report presents the technical methodology, data samples, and results of tests conducted on the SOAC on six transit-authority properties, namely the New York City Transit Authority (NYCTA), Massachusetts Bay Area Transportation Authority (MBTA), Cleveland Transit System (CTS), Chicago Transit Authority (CTA), Southeastern Pennsylvania Transportation Authority (SEPTA), and the Port Authority Transit Corporation (PATCO). These tests were conducted during the course of the SOAC Operation and Demonstration Program which occurred between April 1974 and April 1975. The UMTA-sponsored Urban Rail Supporting Technology Program, for which TSC is Systems Manager, emphasizes three major development task areas: facilities, technology, and test programs. Test-program development comprises three subareas: vehicle testing, ways and structures testing, and track-geometry measurement. The objective of the SOAC program is to demonstrate the current state of the art in rail-rapid-transit vehicle technology, with passenger convenience and operating efficiency as primary goals. The initial phase of the SOAC Engineering Test Program provided a set of SOAC engineering data and provided some advancement to the methodology for providing transit-vehicle comparisons. The objective of this phase of the Test Program was to compare tests at the TTC with operations on the SOAC Demonstration Program Transit Authorities. This objective is met by the presentation of the test data and results in this report. Volume I contains a program description and summaries of the test sites and data results. Volume II contains the test data reports for the NYCTA tests. Volume III contains the test data reports for the NYCTA tests. Volume III contains the test data reports for the NYCTA tests. Volume III contains the test data reports for the tests at MBTA, CTS, CTA, SEPTA, and PATCO.			assachusetts ority (CTA), oration Program Technology es, technol- nd structures current ciency as neering The objec- Demonstra- ts in this	
17. Key Words		18. Distribution Statement		
Rail-Transit Vehicle Testin Rail-Transit Property Tests Rail-Transit Route Analysi			NTIS	
19. Security Classif. (of this report)	20. Security Class	sif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNC	LASSIFIED	310	
Form DOT F 1700.7 (8-72)	D 1			L

completed page authorized

TABLE OF CONTENTS

	Page
LIST OF ILLUSTRATIONS	iv
LIST OF TABLES	x
PREFACE	l
APPENDIX A, TESTING AT BOSTON	Al
APPENDIX B, TESTING AT CLEVELAND	В1
APPENDIX C, TESTING AT CHICAGO	Cl
APPENDIX D, TESTING AT PHILADELPHIA	Dl
APPENDIX E, TESTING AT LINDENWOLD, NEW JERSEY	El

ŗ

LIST OF ILLUSTRATIONS

Figure

1-1	Cmbridge-Dorchester Red Line of the MBTA	A3
3-1	SOAC Instrumentation System Block Diagram	A6
5-1	'P-Wire' Current Distribution	A20
5-2	Vehicle Speed Distribution	A21
5-3	Vehicle Acceleration Distribution	A22
5-4	Journal Box Vertical Acceleration	
	Distribution.	A23
5-5	Journal Box Lateral Acceleration	
	Distribution	A24
5-6	Truck Frame Strain Level Distribution	A25
5-7	Longitudinal Ride Roughness Distribution	A26
5-8	Forward Car Vertical Ride Roughness	
	Distribution	A27
5-9	Mid-Car Vertical Ride Roughness	
	Distribution	A28
5-10	Forward Car Lateral Ride Roughness	
	Distribution	A29
5-11	Mid-Car Lateral Ride Roughness Distribution	A30
5-12	Vehicle Pitch Distribution	A31
5-13	Vehicle Roll Distribution	A32
5-14	Vehicle Yaw Distribution	A33
5-15	Interior Noise Level Distribution	A34
5-16	Interior Noise Level Sample Time History	
	Chart	A35
5-17	Vehicle Acceleration and Speed Time History	
J 1/	Chart (H-A)	A37
5-18	Vehicle Acceleration and Speed Time History	1107
5 10	Chart (~)	A39
5-19	Mid-Car Acceleration Time History	1155
5 17	Chart (H-A)	A41
5-20	Mid-Car Acceleration Time History	114 L
5 20	Chart (~)	A43
5-21	Journals, Truck Frame, and Angular	1115
5 61	Acceleration Time History Chart (H-A)	A45
5-22	Journals, Truck Frame, and Angular	ATJ
5 44	Acceleration Time History Chart (~)	A47
5-23	Forward Car Acceleration Time History	MH/
5 25	Chart (H-A)	A49
5-24	Forward Car Acceleration Time History	M4)
J-24	Chart (~)	A51
5-25	Vehicle Acceleration and Speed Time	AJT
5 25		A53
5-26	History Chart (A-H) Mid-Car Acceleration Time History	AJJ
5-20	Chart (A-H)	A55
5-27	Journals, Truck Frame, and Angular	AJJ
5-21	Acceleration Time History Chart (A-H)	A57
	ACCELETACION ITHE HISCOLY CHAIL (A-U)	nJ/

<u>Figur</u>		Page
5-28	Forward Car Acceleration Time History	
5-29	Chart (A-H)	A59
5-29	Vehicle Acceleration and Speed Time History Chart (H-Q)	A61
5-30	Mid-Car Acceleration Time History	
F 01	Chart (H-Q)	A63
5-31	Journals, Truck Frame, and Angular Acceleration Time History Chart (H-Q)	A65
5-32	Forward Car Acceleration Time History	110.5
	Chart (H-Q)	A67
5-33	Vehicle Acceleration and Speed Time	760
5-34	History Chart (Q-H) Mid-Car Acceleration Time History	A69
	Chart (Q-H)	A71
5-35	Journals, Truck Frame, and Angular	
5-36	Acceleration Time History Chart (Q-H) Forward Car Acceleration Time History	A73
5 50	Chart (Q-H)	A75
1-1	Cleveland Rapid Transit System	B3
3-1	SOAC Instrumentation System Block Diagram	в6
5-1	'P-Wire' Distribution	B17
5-2	Vehicle Speed Distribution	B18
5-3	Vehicle Acceleration Distribution	B19
5-4	Journal Box Vertical Acceleration	
	Distribution	B20
5-5	Journal Box Lateral Acceleration	
	Distribution	B21
5-6	Truck Frame Strain Level Distribution	B22
5-7	Longitudinal Ride Roughness Distribution	B23
5-8	Forward Car Vertical Ride Roughness	
	Distribution	в24
5-9	Forward Car Lateral Ride Roughness	
	Distribution	B25
5-10	Mid-Car Vertical Ride Roughness	
	Distribution	B26
5-11	Mid-Car Lateral Ride Roughness	210
J 11	Distribution	в27
5-12	Vehicle Pitch Distribution	B28
5-12 5-13	Vehicle Roll Distribution	B28 B29
5-14	Vehicle Yaw Distribution	B30
5-15	Interior Noise Level Distribution	B31
5-16	SOAC Interior Noise Level Sample	в32
5-17	Vehicle Acceleration and Speed Time	
.	History Chart (WA)	в33
5-18	Journals, Truck Frame, and Angular	
	Acceleration Time History Chart (WA)	B37

Figure		Page	
5-19	Mid-Car Acceleration Time History		
F 00	Chart (WA)	В41	
5-20	Forward Car Acceleration Time History Chart (WA)	в45	
5-21	Vehicle Acceleration and Speed Time		
5-22	History Chart (AW)	в49	
5-22	Vehicle Acceleration and Speed Time History Chart (~)	в53	
5-23	Journals, Truck Frame, and Angular	•	
5-24	Acceleration Time History Chart (AW) Journals, Truck Frame, and Angular	B55	
J~24	Acceleration Time History Chart (~)	B59	
5-25	Mid-Car Acceleration Time History		
5-26	Chart (AW) Mid-Car Acceleration Time History	B61	
5 20	Chart (~)	B65	
5-27	Forward Car Acceleration Time		
5-28	History Chart (AW) Time	B67	
5 20	History Chart (~)	B71	
		a 2	
1-1 3-1	CTA Skokie Swift Line	C2 C5	
5-1	'P-Wire' Current Distribution	C15	
5-2	Vehicle Speed Distribution	C16	
5-3	Vehicle Acceleration Distribution	C17	
5-4	Journal Box Vertical Acceleration	CT /	
•	Distribution	C18	
5-5	Journal Box Lateral Acceleration		
	Distribution	C19	
5-6	Longitudinal Ride Roughness Distribution	C20	
5-7	Forward Car Vertical Ride Roughness		
- 0	Distribution	C21	
5-8	Forward Car Lateral Ride Roughness Distribution	C22	
5-9	Mid-Car Vertical Ride Roughness	C22	
5 5	Distribution	C23	
5-10	Mid-Car Lateral Ride Roughness		
	Distribution	C24	
5-11	Vehicle Pitch Distribution	C25	
5-12	Vehicle Roll Distribution	C26	
5-13	Vehicle Yaw Distribution	C27	
5-14	Interior Noise Level Distribution	C28	
5-15	SOAC Interior Noise Level Time History		
	Sample	C29	
5-16	Vehicle Acceleration and Speed Time		
	History Chart (H-D)	C31	

Figur		Page	
5-17 5-18	Journals, Truck Frame, and Angular Acceleration Time History Charts (H-D)	C33	
	Mid-Car Acceleration Time History Chart (H-D)	C35	
5-19	Forward Car Acceleration Time History Chart (H-D)	C37	
5-20	Vehicle Acceleration and Speed Time History Chart (D-H)	C39	
5-21	Journals, Truck Frame, and Angular Acceleration Time History Chart (D-H)	C41	
5-22		C41	
5-23	Mid-Car Acceleration Time History Chart (D-H) Forward Car Acceleration Time History		
	Chart (D-H)	C45	
1-1 3-1 5-1	The SEPTA Broad Street Subway System SOAC Instrumentation System Block Diagram 'P-Wire' Current Distribution	D2 D5 D16	
5-2	Vehicle Speed Distribution	D17	
5-3 5-4	Vehicle Acceleration Distribution Journal Box Lateral Acceleration	D18	
5-5 5-6	Distribution Longitudinal Ride Roughness Distribution Mid-Car Vertical Ride Roughness	D19 D20	
	Distribution	D21	
5-7	Mid-Car Lateral Ride Roughness Distribution	D22	
5-8	Forward Car Vertical Ride Roughness Distribution	D23	
5-9	Forward Car Lateral Ride Roughness Distribution	D24	
5-10	Vehicle Pitch Distribution	D24 D25	
5-11	Vehicle Roll Distribution	D26	
5-12	Vehicle Yaw Distribution	D27	
5-13	Interior Noise Level Distribution	D28	
5-14	SOAC Interior Noise Level Sample	D29	
5-15	Vehicle Acceleration and Speed Time History Chart (FP)	D31	
5-16	Vehicle Acceleration and Speed Time History Chart (P-F)	D33	
5-17	Vehicle Acceleration and Speed Time		
5-18	History Chart (~) Mid-Car Acceleration Time History	D35	
5-19	Chart (FP) Mid-Car Acceleration Time History	D37	
5-20	Chart (PF) Time History	D39	
5 20	Chart (~)	14ח	

Figure		Page
5-21	Forward Car Acceleration Time	
	History Chart (FP)	D43
5-22	Forward Car Acceleration Time	
	History Chart (PF)	D45
5-23	Forward Car Acceleration Time	
	History Chart (~)	D47
5-24	Journals, Truck Stress, and Angular	n 40
	Acceleration Time History Chart (FP)	D49
5-25	Journals, Truck Stress, and Angular	
F 96	Acceleration Time History Chart (PF)	D51
5-26	Journals, Truck Stress, and Angular	D53
	Acceleration Time History Chart (~)	222
1-1	The PATCO Lindenwold Line	E2
3-1	SOAC Instrumentation System Block Diagram	E5
5-1	'P-Wire' Current Distribution	E16
5-2	Vehicle Speed Distribution	E17
5-3	Vehicle Acceleration Distribution	E18
5-4	Journal Box Vertical Acceleration	
	Distribution	E19
5-5	Journal Box Lateral Acceleration	
×	Distribution	E20
5-6	Longitudinal Ride Roughness Distribution	E21
5-7	Mid-Car Vertical Ride Roughness	
- 0	Distribution	E22
5-8	Mid-Car Lateral Ride Roughness	E23
F 0	Distribution	EZO
5-9	Forward Car Vertical Ride Roughness	E24
5-10	Distribution	<u>с</u> 24
2-T0	Forward Car Lateral Ride Roughness Distribution	E25
5-11	Vehicle Pitch Distribution	E25
5-12	Vehicle Roll Distribution	E27
5-12	Vehicle Yaw Distribution	E28 [.]
5-14	Interior Noise Level Distribution	E29
5-15	SOAC Interior Noise Level Sample	E30
5-16	Vehicle Acceleration and Speed Time	
3 10	History Chart (L-15)	E31
5-17		
• = ·	History Chart (15-L)	E33
5-18	Vehicle Acceleration and Speed Time	
	History Chart (~)	E35
5-19	Mid-Car Acceleration Time History	
	Chart (L-15)	E37
5-20	Mid-Car Acceleration Time History	
	Chart (15-L)	E39
5-21	Mid-Car Acceleration Time History	_ 4 -
	Chart (~)	E41

Figur	e	Page
5-22		
	History Chart (L-15)	E43
5-23	Forward Car Acceleration Time	
	History Chart (15-L)	E45
5-24	Forward Car Acceleration Time	
	History Chart (~)	E47
5-25	Journals, Truck Frame, and Angular	
	Acceleration Time History Chart (L-15)	E49
5-26	Journals, Truck Frame, and Angular	
	Acceleration Time History Chart (15-L)	E51
5-27	Journals, Truck Frame, and Angular	
	Acceleration Time History Chart (~)	E53

1

LIST OF TABLES

Table		Page
4-1 4-2 5-1	SOAC Revenue Service Data List A SOAC Revenue Service Data List B Summary Values for SOAC Operating on the	A8 A9
5-2 5-3 5-4 5-5	MBTA Red Line Station Summary I Station Summary II Station Summary III Station Summary IV	A15 A16 A17 A18 A19
4-1 4-2 5-1	SOAC Revenue Service Data List A SOAC Revenue Service Data List B Summary Values for SOAC Operating on the	B8 B9
5-2 5-3	CTS Airport Line Station Summary I Station Summary II	B14 B15 B16
4-1 4-2 5-1	SOAC Revenue Service Data List A SOAC Revenue Service Data List B Summary Values for SOAC Operating on the	C7 C8
5-2 5-3	CTA Skokie Line Station Summary I Station Summary II	C12 C13 C14
4-1 4-2 5-1	SOAC Revenue Service Data List A SOAC Revenue Service Data List B Summary Values for SOAC Operating on the	D7 D8
5-2 5-3	SEPTA Line Station Summary I Station Summary II	D13 D14 D15
4-1 4-2 5-1	SOAC Revenue Service Data List A SOAC Revenue Service Data List B Summary Values for SOAC Operating on the	E7 E8
5-2 5-3	PATCO Line Station Summary I Station Summary II	E13 E14 E15

PREFACE

This test report, presenting the results of tests on the State-of-the-Art Cars, derives from the efforts of two agencies of the U.S. Department of Transportation: the Rail Programs Branch of the Urban Mass Transportation Administration's Office of Research and Development and the Transportation Systems Center.

UMTA's Rail Programs Branch is conducting programs to improve urban rail transportation systems. The Transportation Systems Center (TSC) is supporting UMTA by providing systems management for the Rail Programs Branch's Urban Rail Supporting Technology Program (URSTP) in the design, construction and operation of UMTA test facilities, the analysis and testing of vehicles and components, and the development of key technological data. This test report stems from the second of the four URSTP tasks: facility development, test and evaluation, technology development, and application engineering.

Boeing Vertol Company had previously been engaged by UMTA as systems manager for the Urban Rapid Rail Vehicle and Systems Program (Contract DOT-UT-10007). One phase of this vehicle and component development program is the design, development, and demonstration of two State-of-the-Art Cars (SOAC) whose primary objective is to demonstrate the best current technology in rail rapid transit car design.

Following selection by Boeing and UMTA, the St. Louis Car Division of General Steel Industries built and delivered two SOAC cars to USDOT's High Speed Ground Test Center (HSGTC), Pueblo, Colorado in September 1972 for developmental and acceptance testing. This test facility permits the use of known track and grade conditions for test operations (without interfering with revenue service); it also allows a largescale test plan to be completed in a relatively short period of time. (UMTA's Rail Transit Test Track at the HSGTC became available for rail rapid transit vehicle testing in August 1972.) In February 1973, TSC awarded Boeing Vertol Company the contract to perform engineering tests on the SOAC vehicles. The objective of this program was to provide engineering data on the SOAC and to develop further the General Vehicle Test Plan methodology for providing vehicle comparisons (defined in GSP-064). This methodology for controlling test variables by standardizing procedures and data requirements was developed in 1972 and was successfully checked by a series of tests using NYCTA R-42 type cars on the initial track section in March 1972.

The results of this initial phase of the program was reported in a six volume report, SOAC State-of-the-Art Car Engineering Tests at Department of Transportation High Speed Ground Test Center Final Test Report, January 1975, UMTA-MA-06-0025-75.

The tests reported in this document are the result of the second phase of the SOAC Engineering test program. From April 1974 through May 1975 the SOACs were on a Demonstration Program through five different transit properties. An each of these properties a simulated revenue service test was performed. The data was analyzed and presented here as a method to compare the TTC with the transit properties and also to promote future comparisons of various vehicles and subsystems with SOAC.

APPENDIX A TESTING AT BOSTON

1.0 TEST DESCRIPTION

As part of the Operational Test and Evaluation Program, the State-of-the-Art Cars were in the Boston Area from July 25th to September 16, 1974. The period during vehicle setup and checkout was used to install the engineering instrumentation system and to perform the Simulated Revenue Service Tests.

1.1 Test Site

The SOACs were operated in revenue service on the Cambridge - Dorchester Red Line of the MBTA rail rapid transit system (Figure 1-1). This line runs through Cambridge underground from Harvard to Kendall stations. It crosses the Charles River via the Longfellow bridge to the Charles station. It returns to an underground run from Charles to Broadway stations. Beyond Broadway the line is at grade level to the end of the route. The route is split south of Andrew station with one run continuing to Ashmont and the other continuing to Quincy Center (formerly the South Shore Line). The service on the Harvard-Ashmont route is 9 miles long with 14 stations and has a scheduled run time of 22 minutes. The Harvard-Quincy Center route is 11.8 miles, 12 stations and has a scheduled run time of 23 minutes.

1.2 Test Operations

The test plan was to operate the SOACs in simulated revenue service over the test routes. For safety and operational reasons, vehicle operation was entirely under the control of MBTA personnel during the tests. The only requirement imposed by the test was to maintain the normal scheduled service as close as possible and to simulate the normal station stop by opening the car doors on the side opposite to the station platform.

The test runs were conducted late at night and early morning hours in order to have minimum interference with revenue service. The scheduling worked well during the MBTA tests for there were few work crews out on the tracks during the test period and no incidents occurred which would influence the test runs. A set of test runs was accomplished on the evening of August 9th. As the test progressed it became apparent that the vehicles had excessive wheel flats which induced a non-characteristic vibration in the car body ride quality.

The vehicles were subsequently scheduled through a wheel truing operation and the tests were repeated on August 13, 1975. No significant events occurred to detract from the validity of these tests runs and it is the August 13th data which is presented here.

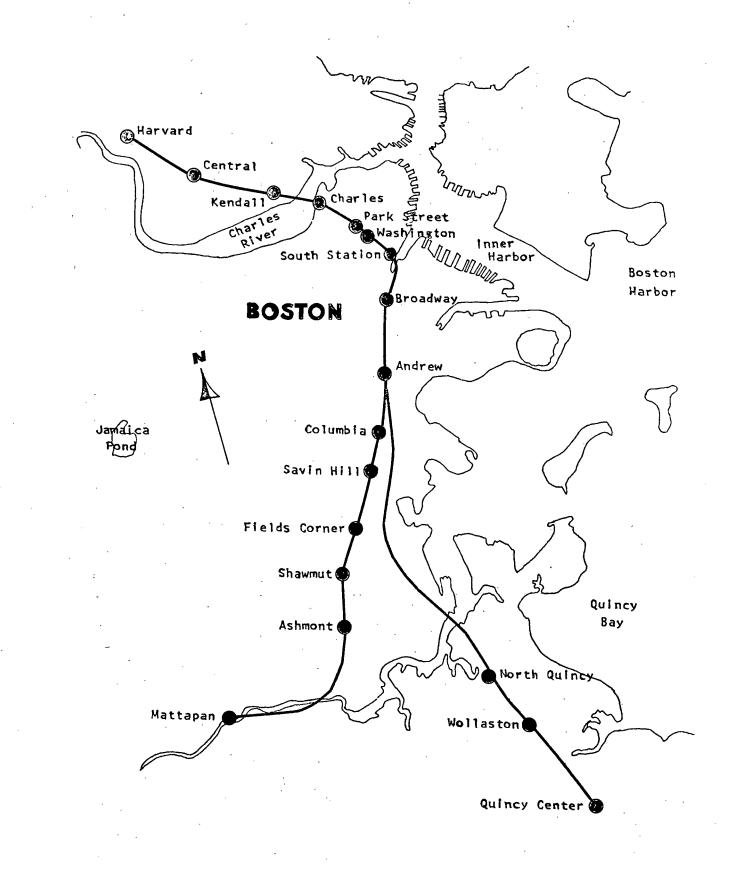


Figure 1–1. Cambridge-Dorchester Red Line of the MBTA

A-3

2.0 TEST PROCEDURES

Pretest

- 1. Mount all required sensors
- 2. Calibrate Instrumentation System
- 3. Brief Test Crew on Test Operations

NOTE:

One vehicle is instrumented for noise measurements, avoid other than normal conversation.

Test

- Operate the vehicles in a simulated revenue service,
 i.e. maintain the given schedule.
- Provide a nominal 10 second door opening at each scheduled stop.
- Provide voice commentary on instrumentation recording during progress of test.
- 4. Maintain a manual log of events during the test run, correlated to the instrumentation system records.
- 5. Monitor various preselected data channels to ascertain validity of test run.
- 6. The Test Controller will terminate the test if:
 - (a) An extended delay or train shutdown occurs
 - (b) One or more required data channels malfunction

(c) The test vehicle is not operating properlyAdvise Test Controller of any abnormal operationsor events that occur during the test run.

3.0 INSTRUMENTATION

The SOAC Instrumentation System was used for this series of tests. This system is described in detail in Volume VI of State-of-the-Art Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center, Final Test Report, UMTA-MA-06-0025-75-6, January 1975. A synopsis is included below.

3.1 Ride Qualities, Structural and Performance Tests

Electrical signals from the vehicle mounted transducers are conducted by cables to an interface panel which is connected to an instrumentation console containing two magnetic tape recorders, two light beam oscillographs, a time code generator, a temperature recorder and signal conditioners. Any 28 selected test parameters can be recorded on tape and displayed on the oscillographs. In addition, wheel speeds may be recorded directly on the oscillographs; total power is recorded on tape and displayed on a mechanical counter. The time code generator provides signals that are recorded on both tape and the oscillograph. The oscillographs provide quick-look data to evaluate test progress and results during testing (See Figure 3-1).

3.2 Noise Tests

The instrumentation used for noise measurement consisted of a 1" condenser microphone with battery operated cathode follower and a 1/4" single channel tape recorder.

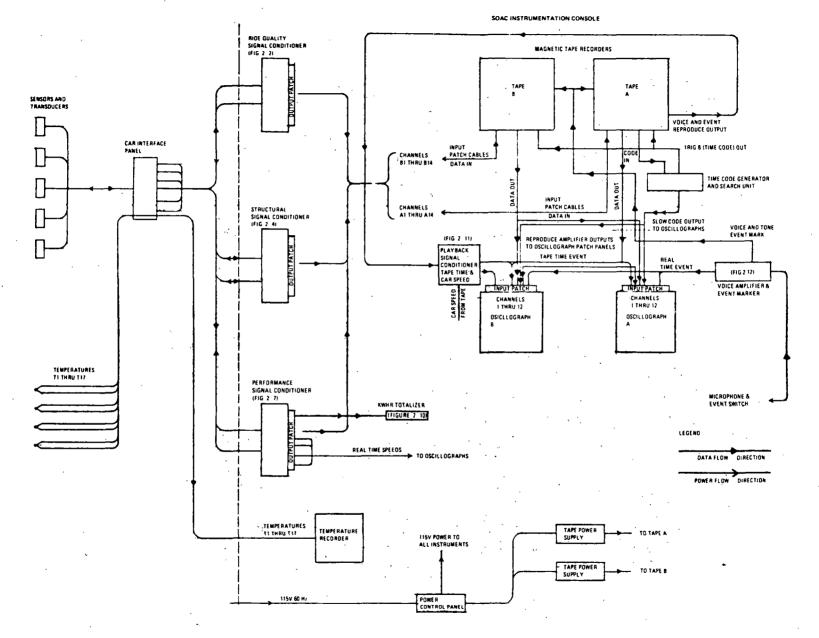


Figure 3–1. SOAC Instrumentation System Block Diagram

A--6

4.0 DATA

The parameters recorded during the property tests are described in Tables 4-1 and 4-2. The definition of the parameter measurements is contained in Appendix A, Standard Outputs for SOAC Property Tests.

Data was recorded for the roundtrip routes noted in the Test Description Section. All of the data was recorded on analog tapes and processed to provide three types of outputs.

Time History Charts Station Summary Tables Frequency Histograms

4.1 Time History Charts

A slow chart speed strip-out of certain parameters is included in this report. The purpose of these charts is to provide an indication of the maximum levels of parameters during various phases of the run. The complete run is described on the charts including station stops and any particularities that occurred. A series of time histories at a high chart speed is included to illustrate the cyclical nature of the data. These charts are a single time frame for all parameters and are representative of the worst case conditions exhibited for a particular test run.

Intermediate parameters, such as a weighted (filtered) car body acceleration are shown on some charts.

4.2 Station Summary

A summation or summary of specific parameters is made by each station stop. These include test running time and distance for comparison to the property's schedule. Power consumption, motor duty cycle parameters are also summarized by station to indicate the relative sizing of the SOAC propulsion with respect to operations on the property. Station stops and maximum speeds are also shown as another indicator of vehicle operation in a scheduled service environment.

Table 4–1. SOAC Revenue Service Data

PA	RAMETER	:
DESIGNATION NO.	DESCRIPTION	RANGE
301	Longitudinal Acceleration	<u>+</u> 0.25 g's
302	Line Voltage	0 to 1000 VDC
303	Line Current	0 to 2000 ADC
304	No. 1 Truck Armature Voltage	0 to 1200 VDC
305	No. 1 Truck Armature Current	0 to 1000 ADC
306	No. 1 Truck Field Current	<u>+</u> 50 ADC
307	No. 2 Truck Armature Voltage	0 to 1200 VDC
308	No. 2 Truck Armature Current	0 to 1000 ADC
309	No. 2 Truck Field Current	<u>+</u> 50 ADC
310	"P" Wire Current	0 to 1.00 ADC
317	Total Power Consumption	l Pulse/0.1 KWHR
315	Speed	0 to 80 MPH
318	Brake Cylinder Pressure	0 to 100 psig

A-8

List A

STANDARD	OUTPUTS	
RECORDED	PRESENTED	PRELIMINARY ANALYSIS
AP/A	Format(3)	Format(4)
LVD/A	None	-
LCD/A	None	-
MAVD/A	None	-
MACD/A	None	RMS-MAC/A
MFCD/A	None	RMS-MFC/A
MAVD/A	None	
MACD/A	None	-
MFCD/A	None	- .
CS/A	None	Format(3)
PCC/A	Format(2)	Format(2)
VS/A	Format(3)	Format(4)
BCP/A	None	_ `

Table 4–2. SOAC

PARAMETER

DESIGNATION NO.	DESCRIPTION
101	Front Truck, Forward Axle, Righthand Wheel Journal Box Vertical Acceleration
102	Front Track, Forward Axle, Righthand Wheel Journal Box Lateral Acceleration
103	Front Truck, Forward Axle Lefthand Wheel Journal Box Vertical Acceleration
115	Mid Car Centerline Vertical Acceleration
116	Mid Car Centerline Lateral Acceleration
120	Forward Car Centerline Vertical Acceleration
121	Forward Car Centerline Lateral Acceleration
219	Truck Frame Upper Strain Gage
220	Truck Frame Lower Strain Gage
221	Pitch Angular Acceleration
222	Roll, Angular Acceleration
223	Yaw, Angular Acceleration
-	Interior Sound Pressure

A−9

Revenue Service Data List B

	STANDARD	OUTPUTS .	· .
RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	-
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1)
<u>+</u> 6348 psi	STP	Format(3)	Fromat(4)
<u>+</u> 6348 psi	STP	Format(3)	-
+ 1.5 Rad/sec/sec.	ACA/A	Format(3)	Format(4)
<u>+</u> 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
<u>+</u> 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
40 to 120 dB(re 2 x SP/A	10-5 y M ²)	NL/A(1)	NL/A(2)

4.3 Frequency Histograms

 $\left\{\cdot\right\}$

These distributions are an indication of the ratio of time that a parameter is at a particular level with respect to the time to complete a roundtrip scheduled service run. These parameters may be used to describe how the vehicle was driven, the track conditions, and how the vehicle responded to these conditions.

5.0 DATA DISCUSSION

The vehicle operation was such that SOAC No. 2, the instrumented car, was leading and running in the forward direction for the Harvard to Ashmont and Harvard to Quincy Center runs. For these runs the vehicle longitudinal acceleration has a positive value for startup. During the Ashmont to Harvard and Quincy Center to Harvard runs, SOAC 2 was trailing and running in the reverse direction.

As defined in Section 4 there are three forms of data. These forms are discussed below with respect to three categories:

(1) Operation

How the vehicle is operated and maintained schedule.

(2) Environment

Track and truck conditions.

(3) Response

How the vehicle responded to operational environment.

Figures 5-1 through 5-15 present the frequency histograms for the MBTA Tests. Figure 5-16 is a sample of the interior noise level time history. The remaining time histories are shown in Figures 5-17 through 5-36. Table 5-1 is a summary of some of the test parameters and is taken from the histograms and time histories. Tables 5-2 through 5-5 are the Station Summaries with power consumption.

5.1 Operation

The Station Summary Tables show that SOAC maintained the MBTA schedule reasonably well for the Harvard-Ashmont run. However, the test time was somewhat longer than scheduled for the Harvard-Quincy Center runs. This time difference occurred mainly between the North Quincy and Andrew stations. The crossover between the Ashmont and Quincy center lines is between these two stations. The speed time-history charts reveal that SOAC was limited to low speed in this area. Apparently, there were special operating restrictions placed on the SOAC in this area.

The maximum vehicle acceleration is shown on the timehistories to be 2.73 mph/second, and the maximum braking is 3.80 mph/second. This braking rate is abnormally high for the SOAC, and could have contributed to the wheel flats described in the Test Operations section earlier.

The Station Summaries show that 14 percent of the total test time was spent in a station. The speed frequency histogram shows 18.7 percent of the time in the speed range of 0 to 5 mph. This speed frequency histogram also shows 17.5 percent of the time was spent in the 15 to mph band. An analysis of the SOAC performance and the MBTA schedules indicates that the most efficient vehicle operation occurs with the major proportion of time in the 35 to 40 mph speed band. This is based on average station spacing and block speeds.

The power consumption for the Harvard-Quincy Center run averaged 7.37 KWH/Mile for the station spacing of 1.19 miles, and a block speed of 25.9 mph. On the Harvard-Ashmont line, with a 23.3 mph block speed and a .69 mile distance between stations, the power consumption was 7.01 KWHR/Mile.

The RMS armature current indicates the relative sizing of the SOAC propulsion system with respect to the route described. The SOAC motors have a continuous rating of 175 hp (460 amps) and a one hour rating of 230 hp (600 The Harvard-Ashmont run drew 270 amperes (RMS) or amps). 59 percent of the rated value. The most severe cycle occurred between Ashmont and Shawmut stations. The easiest cycle was between Columbia and Andrew stations which reflects the special operating restrictions for SOAC mentioned above. Another light cycle occurred between Fields Corner and Savin Hill stations, where the timehistories show a definite 25 mph speed limit. On the Harvard-Quincy Center run the current drawn per motor was 290 amperes (RMS). This is 63 percent of their rated The most severe cycle occurred between North value. Quincy and Wollaston stations.

5.2 Environment

It is intended that the journal box accelerations and

A–12

the truck frame stress levels be used as indicators of track roughness. Summary values for these parameters are shown in Table 5-1. The 50th% value is a statistical quantity. For these tests it assumes a linear distribution of acceleration levels within a class interval (Example: 1 to 2 gs). The value is read as 50 percent of the time the journal box vertical acceleration is at + .75 gs or less. The 95th% is read similarly. The maximum values are from the time-history charts. The "nominal" value is an average, or 50th%, for the time that the vehicle is moving.

The time history charts show the journals receiving quite a few vertical shocks up to 20 gs. These shocks occurred most regularly between Harvard and Central stations. Also noted on the time histories is the failure of the lateral journal box accelerometer during the Harvard and Quincy Center runs.

It should be mentioned that the truck frame stress levels reflect dynamic loading only. Passenger load and car weight do not influence this parameter.

5.3 Response

The car body Ride Roughness and Noise Level parameters are the indicators of how the vehicle responded to the operation and environment. Ride Roughness is a vibration parameter which is weighted according to human response characteristics in riding comfort. This technique is similar to using the "A" weighing on sound pressure to yield Noise Levels. Noise Level and Ride Roughness are related to "human responses". Both of these parameters are described in the Standard Outputs section of this report.

Summary Ride Roughness values are shown in Table 5-1. The fast chart speed time histories show the mid-car vertical acceleration to have a substantial level during the Shawmut to Ashmont run. The value is + .069 gs at 8 Hz. The speed trace for this record shows the car was operating around 45 mph. Eight hertz is the wheel revolution frequency for the SOAC 30 inch wheels at 45 mph. In addition, the SOAC car body has a second body bending mode at 8 hz and is sensitive to this frequency. Wheel flats have been known to drive the SOAC car body into this vibration, but the wheels were "turned down" prior to this test run. Subsequent to the tests the wheels were measured and found to be out-of-round as a result of the "wheel turning" operation. Consequently the SOAC Ride Quality data for these MBTA tests must be reported as what the vehicle did, and should not be constricted as how the car is capable of riding.

From the same fast chart speed time histories another characteristic of the SOAC is evident; the 1.2 hertz lateral acceleration. At the mid car point the acceleration level is \pm .063 gs. This characteristic is more noticeable as vehicle roll where the angular acceleration level is \pm .46 radians per second per second.

Interior Noise Level data was taken in the middle of the non-instrumented vehicle, at a seated passenger ear level. The Engineering Tests at the Transit Test Center indicate this is the quietest point in the car. The table below reports the statistical quantities calculated from the combined runs on the MBTA:

L(99)	L(90)	L(50)	L(10)	L(1)	L(EQ)
65.0	66.5	68.8	76.0	81.5	72.7

Table 5–1. Summary Values for SOAC Operating on

50TH %

Journal Box Vertical Acceleration (G) .75 Journal Box Lateral Acceleration (G) + 1.50Truck Frame Stress (PSI) 160 + Forward Car Vertical Acceleration (G) .017 Mid Car Vertical Acceleration (G) + .023 Forward Car Lateral Acceleration (G) + .018 Mid Car Lateral Acceleration (G) + .016 Longitudinal Ride Roughness (GRMS) .006 Forward Car Vertical Ride Roughness (GRMS) .015 Mid Car Vertical Ride Roughness (GRMS) .011 Forward Car Lateral Ride Roughness (GRMS) .009 Mid Car Lateral Ride Roughness (GRMS) .006 Pitch (RAD/Sec-Sec) .054 (RAD/Sec-Sec) .055 Roll (RAD/Sec-Sec) Yaw + .050

the MBTA Red Line

"NOMINAL"	95TH %	MAXIMUM
<u>+</u> .88	<u>+</u> 5.5	<u>+</u> 20.
<u>+</u> 1.88	<u>+</u> 8.5	<u>+</u> 17.5
<u>+</u> 182	<u>+</u> 680	-
.020	.075	<u>+</u> .250
<u>+</u> .027	<u>+</u> .091	<u>+</u> .250
<u>+</u> .021	<u>+</u> .071	<u>+</u> .125
<u>+</u> .018	<u>+</u> .058	<u>+</u> .088
.007	.017	.050
.019	.060	.150
.014	.054	.120
.011	.030	.075
.007	.019	.035
<u>+</u> .060	<u>+</u> .098	<u>+</u> .239
<u>+</u> .062	<u>+</u> .160	<u>+</u> .420
<u>+</u> .058	<u>+</u> .095	<u>+</u> .100

Table 5–2. Station Summary	mary I	Sumi	Station	5–2.	Table
----------------------------	--------	------	---------	------	-------

	STATION		SCHEDULE	TE	ST	POWER CO	NSUMPTION			amon	MD W
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)
1	Harvard Street	0	0	0	0	0	0	0	0	0	0
2	Central Street	.95	1.65	1.09	2.32	6.44	5.91	293.7	24.2	18.0	48
3	Kendall Street	.96	1.95	1.07	2.58	6.08	5.68	257.7	19.9	42.0	49
4	Charles Street	.72	1.78	.81	2.36	6.87	8.48	239.8	30.8	18.0	34
5	Park Street	.56	1.40	.60	1.92	4.57	7.62	291.1	25.8	16.8	42
6	Washington Street	.21	1.17	.24	1.14	1.79	7.46	268.7	24.1	15.6	24
7	South Station	.27	1.15	.31	1.30	2.31	7.46	280.2	23.1	14.4	30
8	Broadway Street	.83	2.08	.92	2.36	6.02	6.54	261.1	20.1	26.4	49
9	Andrew Street	.83	1.87	.94	1.96	6.87	7.31	317.8	29.0	19.2	50
10	Columbia Street	.74	1.97	.84	2.34	6.18	7.36	230.4	31.1	19.2	37
11	Savin Hill	.70	1.56	.76	2.02	6.06	7.97	313.1	29.0	18.0	44
12	Fields Corner	1.00	2.30	1.05	3.16	6.96	6.63	191.0	31.9	18.0	26
13	Shawmut Street	. 53	1.90	.65	1.70	4.95	7.61	302.3	24.4	18.0	44
14	Ashmont Street	.62	1.22	.71	1.84	5.53	7.79	310.0	26.5	18.0	48
					TOTAL	70.64	7.07	271.0	25.0		

TEST RUN SUMMARY

	SCHEDULE	TEST
Distance	8.97	9.99
Time	22.00	27.00
Block Speed	24.5	22.4
Station Dwell	30.	20.1
Station Spacing	.69	.77

A-16

	STATION		SCHEDULE	т	EST	POWER CONSUMPTION				STOP	MD V
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP~RMS)	TIME SECONDS	MAX. SPEED (MPH)
1	Ashmont Street	Ö	0 "	0	0	0	· 0	0	0	0	0
2	Shawmut Street	.62	1.20	.69	1.60	5.68	8.24	345.7	28.3	20.4	48
3	Fields Corner	.58	1.45	.66	1.76	4.46	6.76	281.3	25,9	10.8	40
4	Savin Hill	1.00	2.32	1.13	2.94	5.57	4.93	182.9	29.4	15.6	26
5	Columbia Street	.70	1.58	.79	2.56	5.64	7.14	232.8	19.7	57.6	42
6	Andrew Street	.74	2.03	.83	2.70	4.81	5.80	175.9	24.5	19.2	26
7	Broadway Street	.83	1.89	.94	1.88	6.66	7.09	303.1	23.1	Í5.6	50
8	South Station	.84	1.98	.92	1.92	5.67	6.17	278.9	21.4	15.6	50
9	Washington	.27	1.13	.31	1.26	3.36	10.84	271.3	28.3	15.6	30
10	Park Street	.21	1.10	.24	1.04	2.80	11.68	296.8	26.5	18.0	26
11	Charles Street	.56	1.72	.60	1.62	5.85	9.75	321.6	24.4	21.6	46
12	Kendall Street	.74	1.60	.81	1.88	4.53	5,59	280.3	21.2	15.6	40
13	Central Street .	.96	1.95	1.07	2.02	7.11	6,65	299.5	22.9	16.8	50
14	Harvard	.97	2.05	1.09	2.14	7.79	7.15	299.9	22.4	16.8	50
					TOTAL	69.95	6.94	270.0	24.5		

Table 5–3. Station Summary II

TEST RUN SUMMARY

2

SCHEDULE	TEST
9.02	10.08
22.00	25.32
24.6	23.9
30.0	19.9
.69	. 78 [.]
	9.02 22.00 24.6 30.0

ςP	66D LIM	11	STATION	. 50	CHEDULE	TI	EST	POWER CO	NSUMPTION			STOP	MAX.	,
		NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	TIME SECONDS	SPEED (MPH)	
		¥_1	Harvard Street	. 0	0	0	· 0	0	. 0	0	0	0	0	
		5 0 2	Central Street	.96	2.17	. 1.09	2.18	7.10	6.51	289.4	25.1	14.4	49	
		ົ 3	Kendall Street	:95 1.91	2.33	1.07	2.80	6.62	6.19	233.7	18.9	57.6	49	
·		40 4	Charles Street	.72 2.(3	2.10	.81	2.28	6.46	7.97	243.9	26.7	16.8	37	
		ن ن 25 25	Park	. 56 3.19	1.65	.61	2.26	4.78	7.83	251.5	22.1	15.6	38	
		25	Washington Street	.21 3.46	1.17	.23	1.12	2.00	8.71	271.9	26.2	16.8	24	
	⊳	50 50	South Street	.27 3.67	1.08	.32	1.30	2.36	7.39	268.1	22.2	15.6	26	
	1	8	Broadway Street	.83 4.50	2.42	.91	2.00	6.21	6.83	286.3	20.4	24.0	49	
	18	<u>د</u> و	Andrew Street	.83 5.33	2.25	.95	2.00	7.12	7.49	295.6	22.9	18.0	50	
		10	North Quincy St.	4.43 9.76	5.00	4.75	8.50	30.90	6.51	296.6	25.6	32.4	64	
		11	Wollaston Street	.76 10.57	1.08	.93	2.64	9 .9 6	10.71	352.5	29.9	19.2	52	
		10 10 11 12	Quincy Center	1.27 11.79	1.90	1.42	3.20	10.02	7.05	327.1	23.8	16.8	56	
_							тотаь	93.53	7.15	290.0	24.5			
.15			TEST RUN SUMMARY											
630		· _		SCHEDULE	ED TH	ST								
ن می کو (ز. می کو			Distance Time Block Speed Station Dwell Station Spacing	11.79 23.15 30.6 18.8 1.07	13. 30. 25. 22. 1.	28 9		23.1						

Table 5–4. Station Summary III

23.15 Ul³⁶

30.30

1.33

	STATION	1	SCHEDULE	TE	ST	POWER CO	NSUMPTION					
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	SECONDS	MAX. SPEED (MPH)	
· 1	Quincy Center	0	0	0	0	0	. 0	0.	0	0	0	
2 2	Wollaston Street	1.27 /3	k.°(1.57	1.42	2.92	9.88	6.95	295.0	26.8	21.6	62	
60 ² 60 ³	North Quincy St.	.76 /3	. 82 1.33	.91	2.46	7.59	8.34	298.0	24.2	20.4	57	
	Andrew Street	4.43/8	-25 4.75	4.75	9.72	35.92	7.56	320.7	27.6	24.0	63	
50 50 50	Broadway Street	.83 19	08 2.33	.94	2,22	7.41	7.88	277.0	26.4	18.0	49	
6	South Street	.83 19	91 2.34	.91	2,30	6,90	7.58	244.1	25.1	18.0	50	
257	Washington Street	. 27 20	./& 1.00	.32	1.40	3.33	10.42	202.6	28.8	19.2	26	
8	Park	.2120	.39 1.08	.23	1.14	2.96	12.87	263.2	27.6	18.0	26	
20	Charles	. 56 20	.951.90	.61	1.60	5.58	9.14	307.1	24.9	15.6	4 5 [·]	
10 مح	Kendall Street	.72 2/	67 2.07	.81	1.86	5.59	6.90	308.6	24.0	15.6	49	
11	Central Street	.95 22	.62 2.28	1.07	2.32	6.84	6.39	264.5	24.3	16.8	49	
5012	Harvard Street	.96 23	3.582.50	1.09	2.44	7.14	6.55	261.2	22.5	21.6	49	
					TOTAL	99.14	7.59	291.0	26.1			

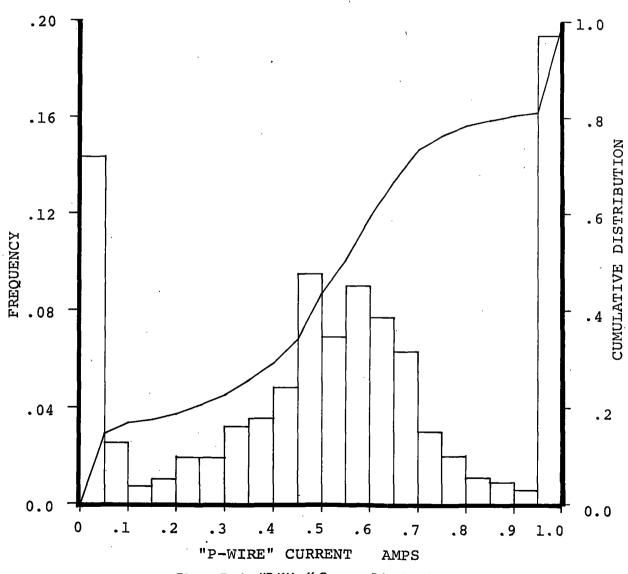
Table 5–5. Station Summary IV

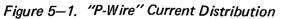
TEST RÚN SUMMARY

	SCHEDULED	TEST
Distance	11.79	13.06
Time	23.15	30.38
Block Speed	30.6	25.8
Station Dwell	17	19.0
Station Spacing	1.07	1.19

A--19

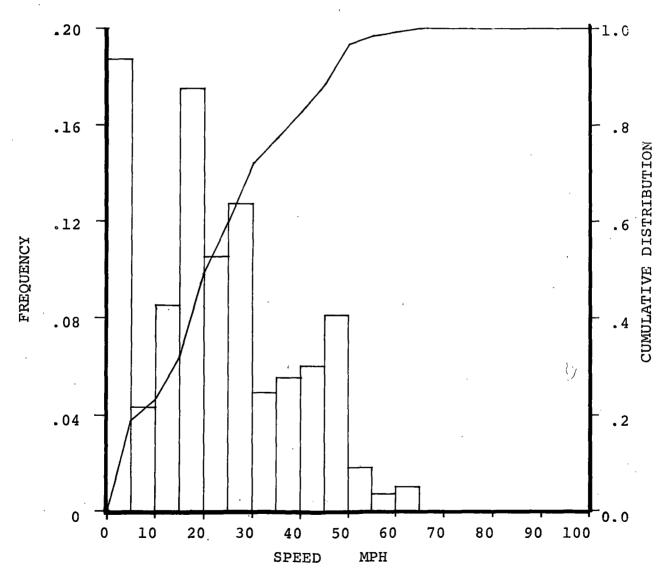
State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line "P-Wire" Current Distribution

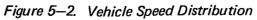




A-20

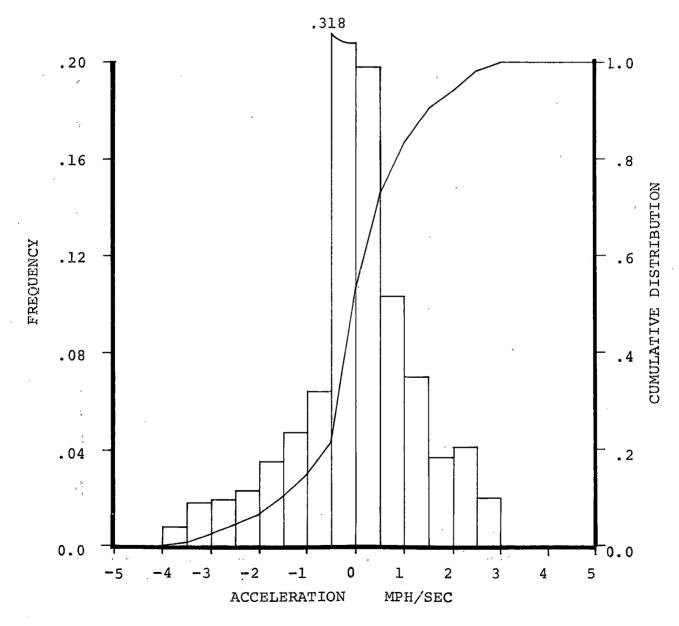
State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line Vehicle Speed Distribution

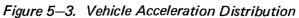




A--21

State-of-the-Art Car Revenue Service Round Trip On MBTA Red Line Vehicle Acceleration Distribution





State-Of-The Art Car Revenue Service Round Trip On MBTA Red Line Journal Box Vertical Acceleration Distribution

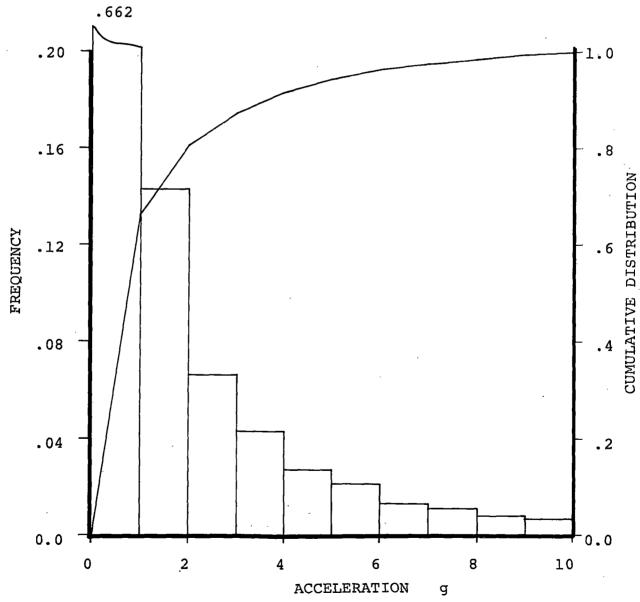
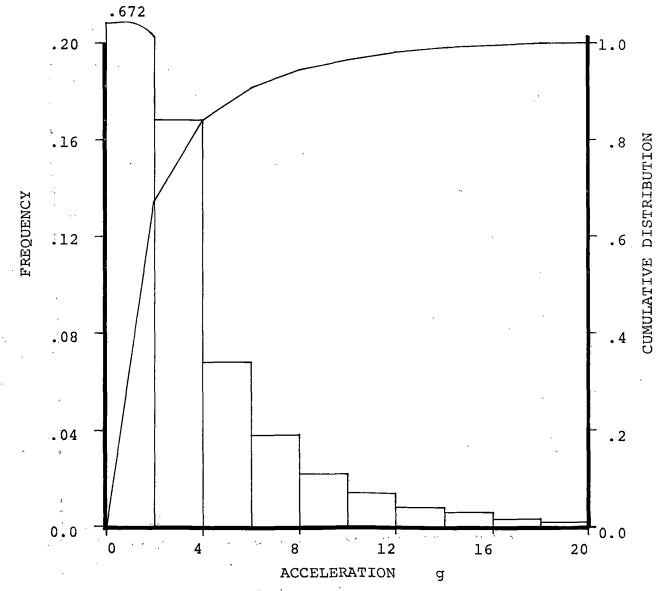
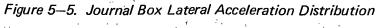


Figure 5-4. Journal Box Vertical Acceleration Distribution

State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line Journal Box Lateral Acceleration Distribution





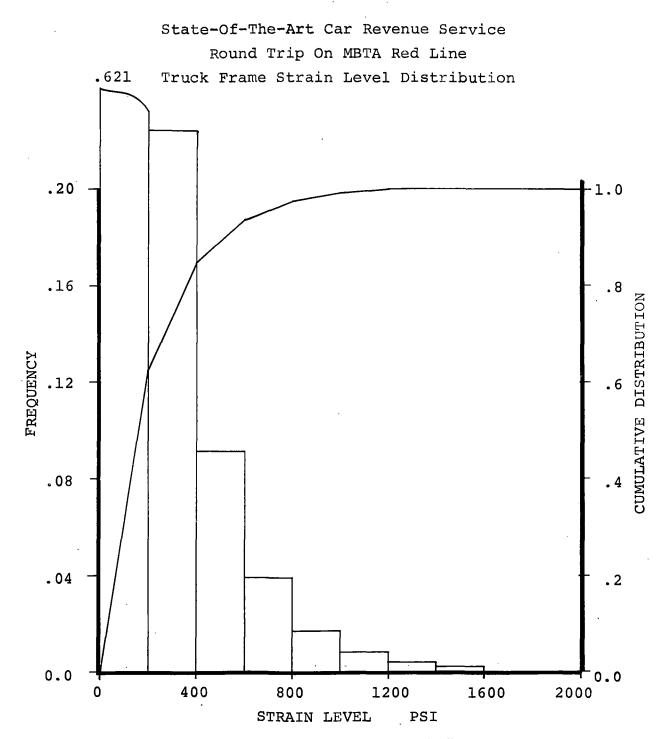
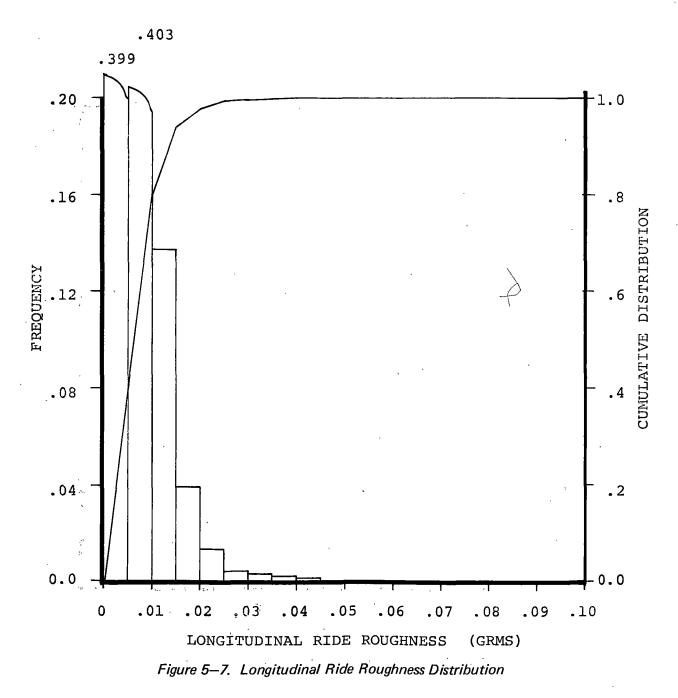
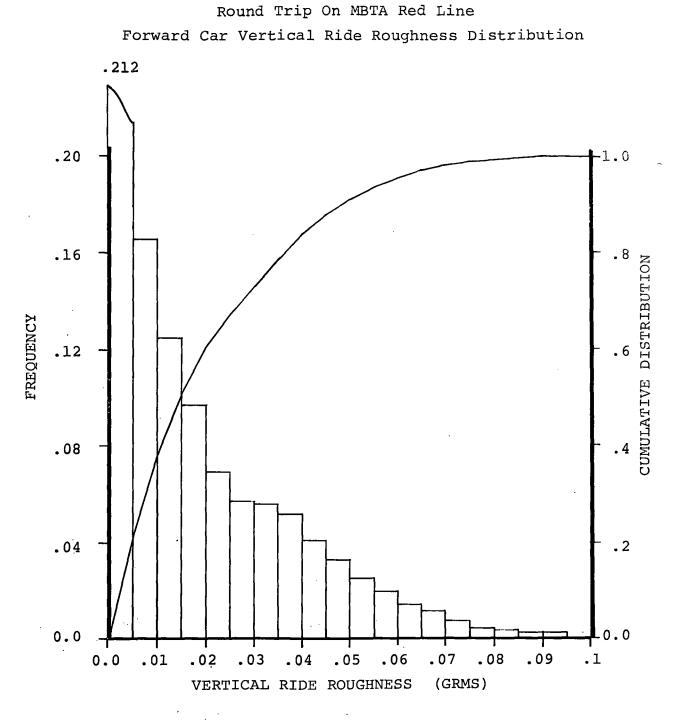


Figure 5–6. Truck Frame Strain Level Distribution

State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line Longitudinal Ride Roughness Distribution



A--26

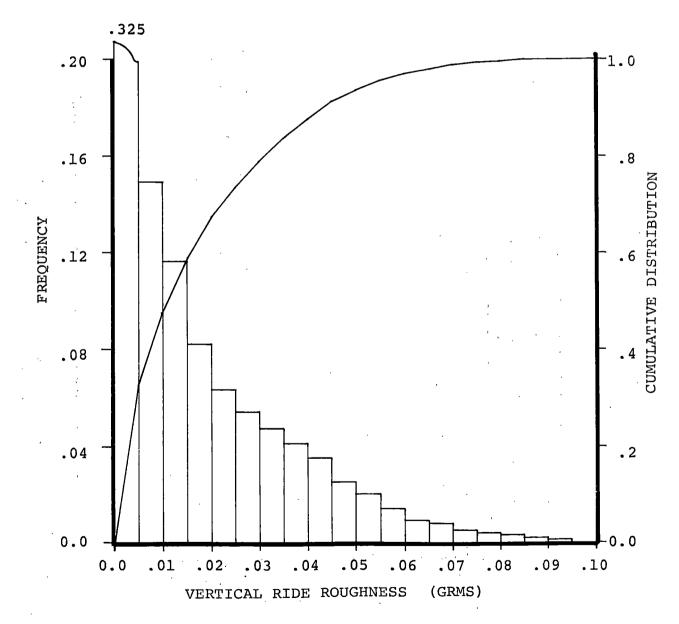


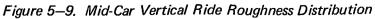
State-Of-The-Art Car Revenue Service

Figure 5–8. Forward Car Vertical Ride Roughness Distribution

A--27

State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line Mid Car Vertical Ride Roughness Distribution





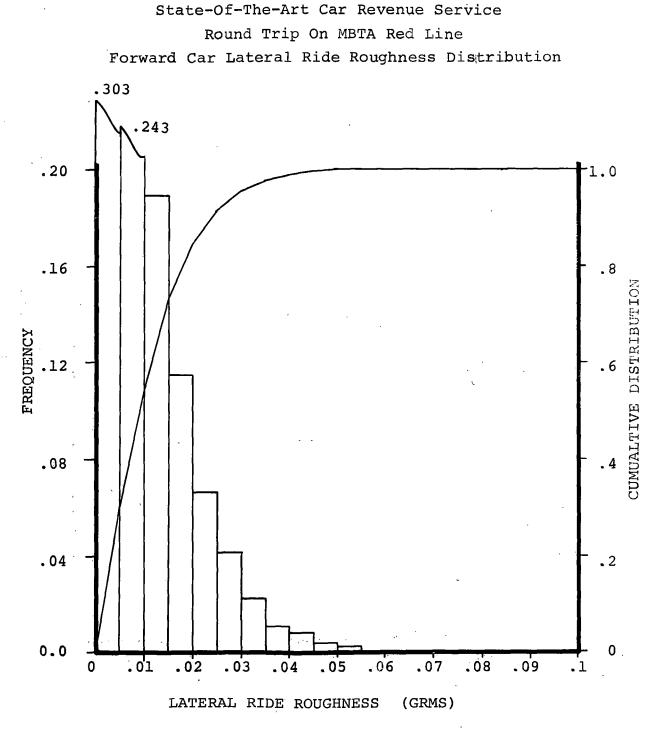
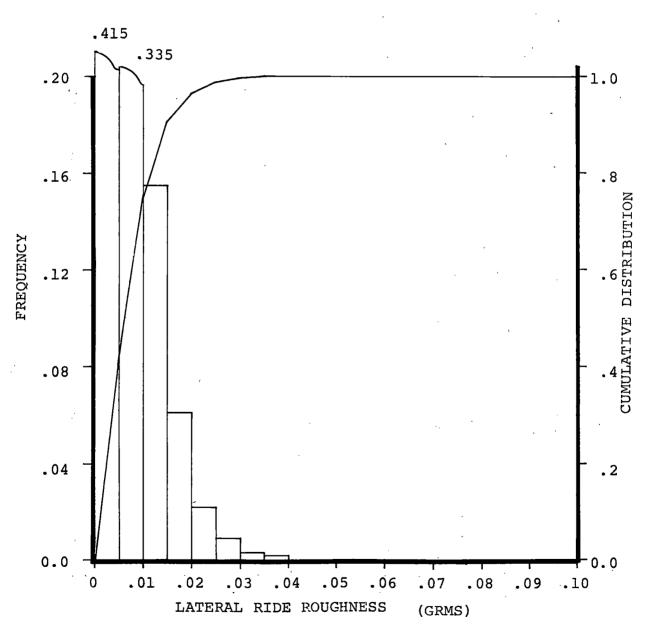
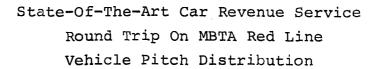


Figure 5–10. Forward Car Lateral Ride Roughness Distribution



State-Of-The-Art Car Revenue Service Round Trip On MBTA Red Line Mid Car Lateral Ride Roughness Distribution

Figure 5–11. Mid-Car Lateral Ride Roughness Distribution



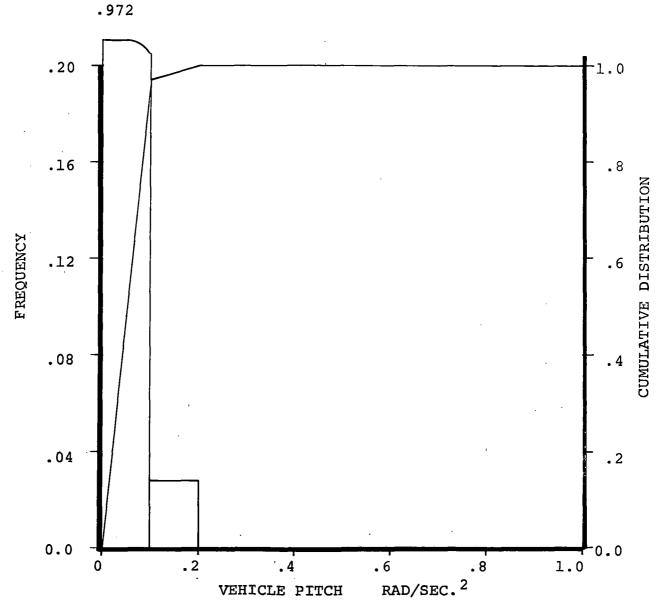
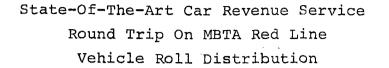
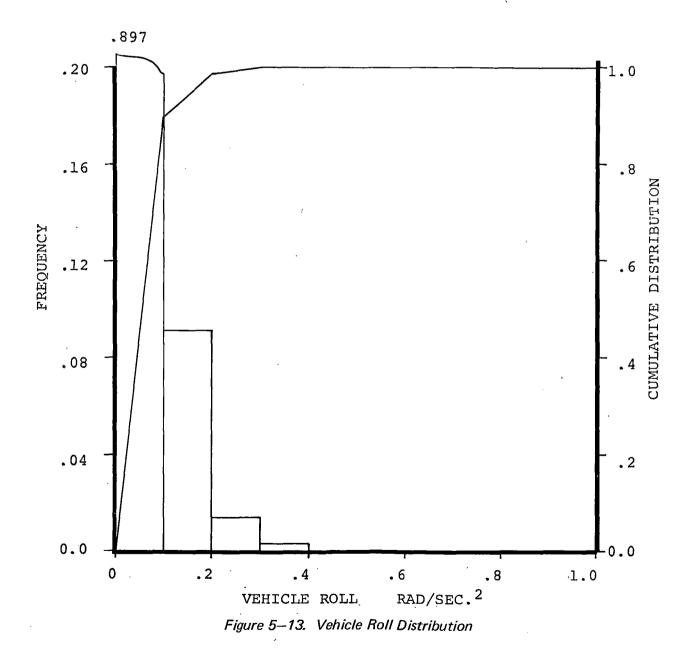
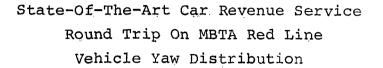


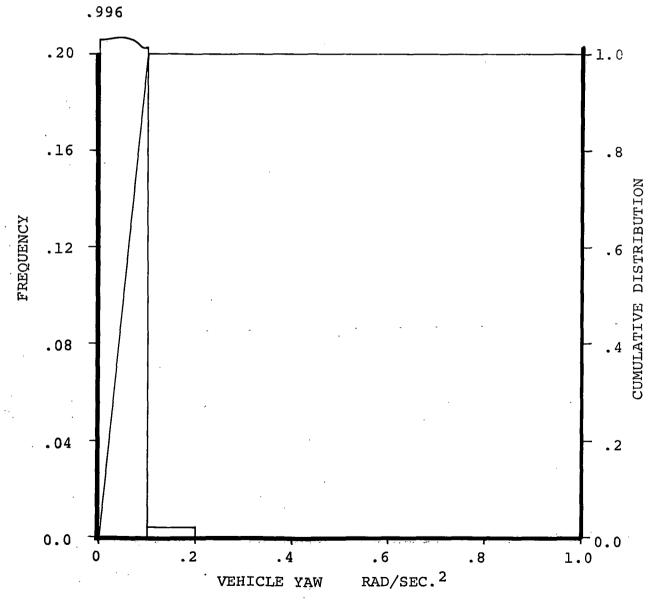
Figure 5–12. Vehicle Pitch Distribution

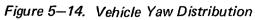


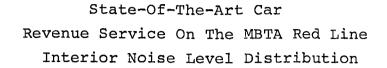


A--32









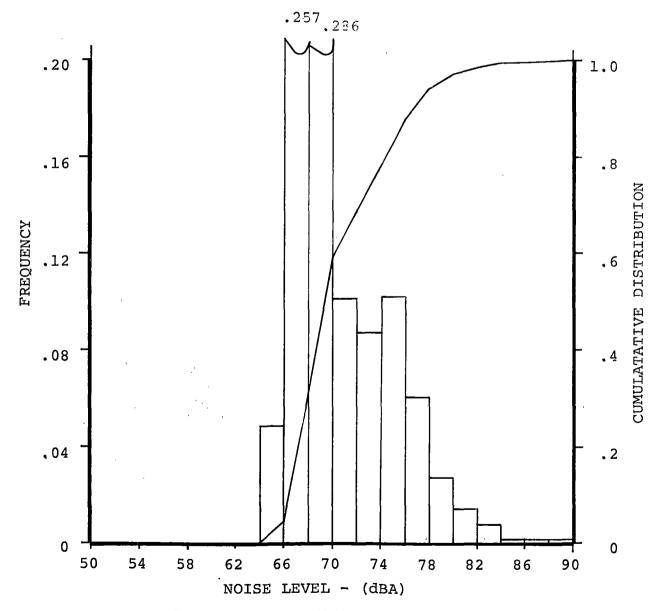
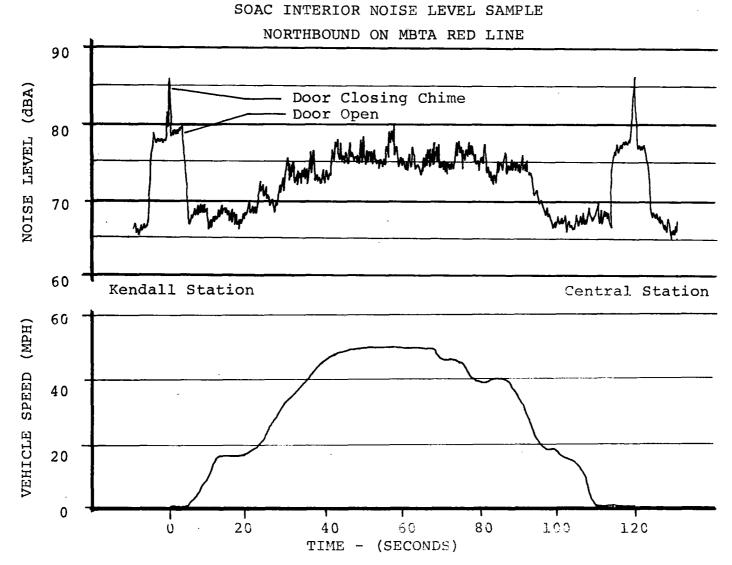
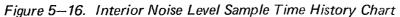


Figure 5–15. Interior Noise Level Distribution





A--35

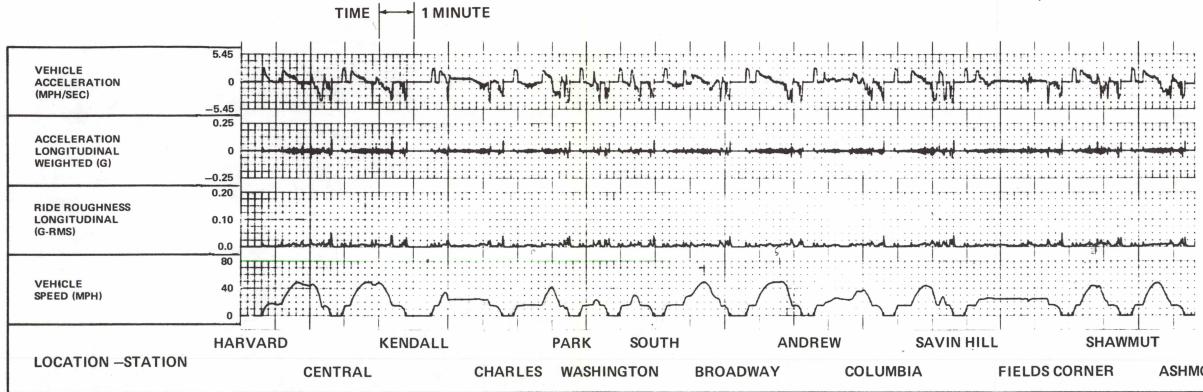
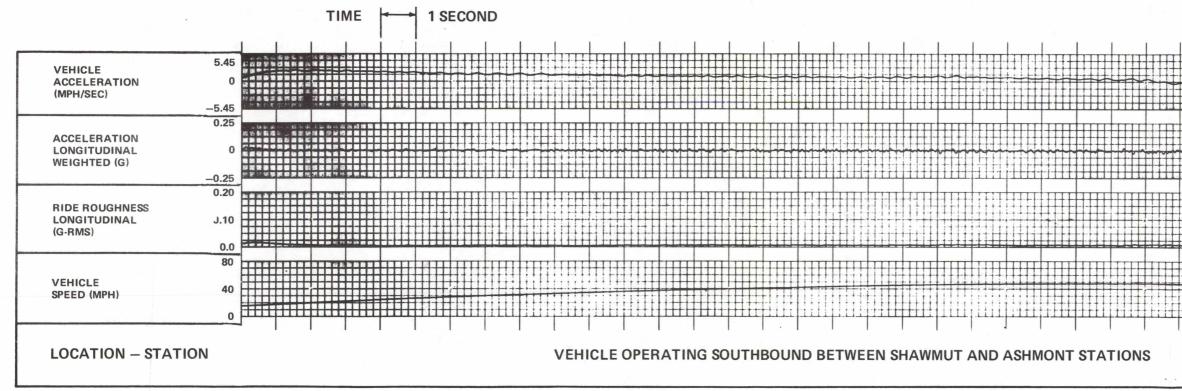
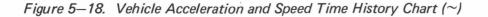


Figure 5–17. Vehicle Acceleration and Speed Time History Chart (H–A)

ASHMONT





					TIT		TIT	TT

	+		. + + +-		++++	+++++	+++++	+++
	╡╡┿╎┽╿┽╿┼							封
							TT 115 117 117 117	-
					TIT			
┥┿┿╆┽╂╴	┼┼┽┽╞╁╎┥┽	┝╶┨╶╀╺╄╶╄╺╋╺ ╸	+++++	++++	++++	++++		+++
		-		hhh			delate	
++++++	+++++++++++++++++++++++++++++++++++++++				+++++		H	+++
HHH	++++++++++		TTT					H
						17 W. 17 17 18	17 107 WA WAT 115 1	التشط
+		++++++		+	11111	1111	+	
					1111			
	<u>; + + + + + + + + -</u>			+++++	+++++	++++	+++++	
						1111		
++++++	• • • • • • • • • • • • • • •	└┽┢╄┢╅╍	++++	+++++	+++++	++++	+++++	
+++++++	· · · · · · · · · · · · ·							TT I
					+++++	1111		111
					++++	+++++	+++++	
			1111			1111		
				++++				

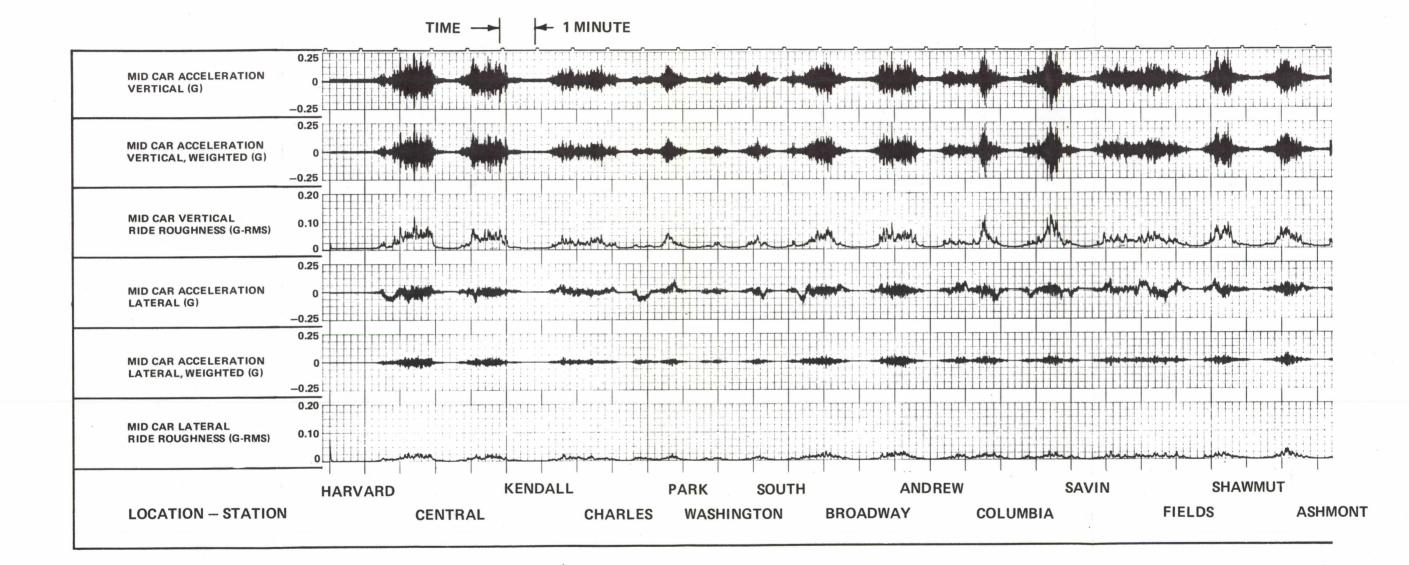
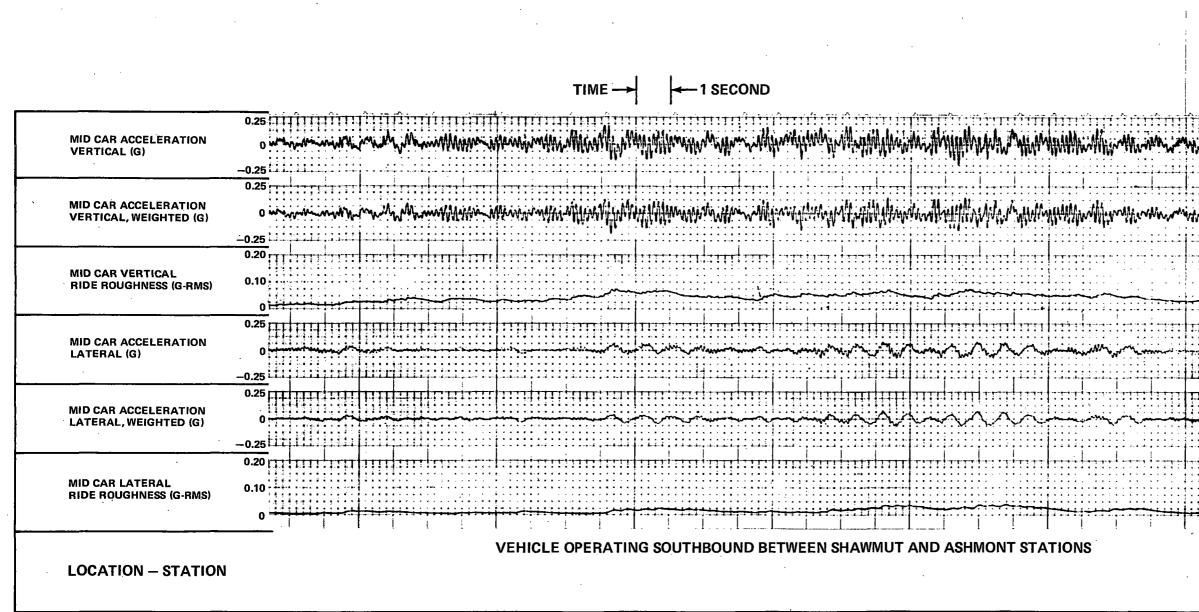


Figure 5–19. Mid-Car Acceleration Time History Chart (H–A)





]					Ĥ			Ĩ	T				1						Ŧ		Ţ												ļ
11	W	M		ιγ I			,		¥ 1				1	1		¥1	1									ÌÌ							
		m!		, il	14	1	-1		1	M	-	- -	ļ		2	M	AA									H		-	H	Ļ	ų		
							1	1	1	11											1									Ŧ	H		Ŧ
• •				•					•																								
++ 		÷		1		1			i. T		ł					1			1	Ы П			1			Ē				Ŧ			Ī
	<u>.</u>		1	T		1	-1	4			-		and a state of the second	5	See See		-																
				-		1	L		j. F		1 T		1					F1		H			± T	H F	+ -		H	t T					
	-	Ŵ	~	, ,	M		-					.,,			Ţ,						المناسبة المناسبة											Ę	
		Ţ		T		1			1				1			1	T					F	1										T
		-									4		-																				
	1							T				ļ			1				l			I							Ī				_

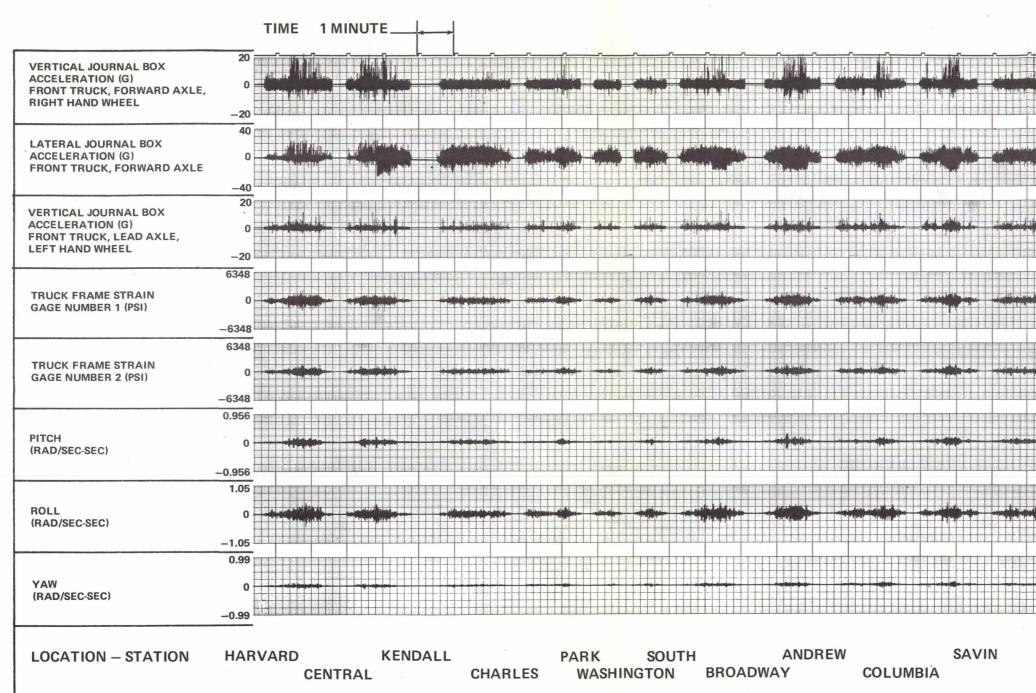


Figure 5–21. Journals, Truck Frame, and Angular Acceleration Time History Chart (H–A)

FIELDS

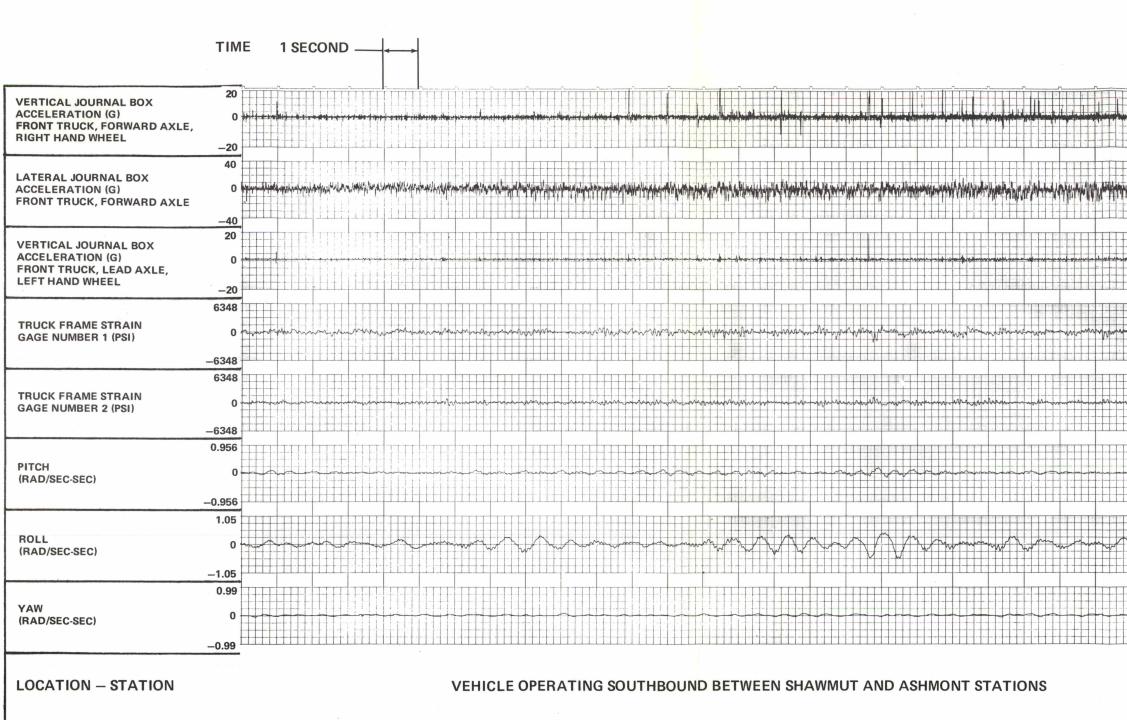
ASHMONT

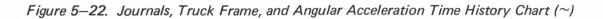
SHAWMUT

		1.4		11	1					1	1		1.1	1.					1		11	-	r.,			
				Ľ																1						
		1.1																					1.5			
	*****			1			*****		-	*****	 *****		-	*****			-	-	-				1			hana
				1																						
														1					1.11							
																			1				-	-		r
													-										1	-		F
	-							111						-		1	1	1		-	-	-	1-	-		h
-	-		-			-						-	-	-		-	-	-	-				1			F
	1	1	-					1					-	-		1		1	-			-	1-			F
													-	1				-		1.1					-	ŀ
													-											-	-	\vdash
	1.1.1	1111	1111	1111			1.111	1111		1111	 	1111			1.1.2.8	1115		1111			1111			1111	1000	

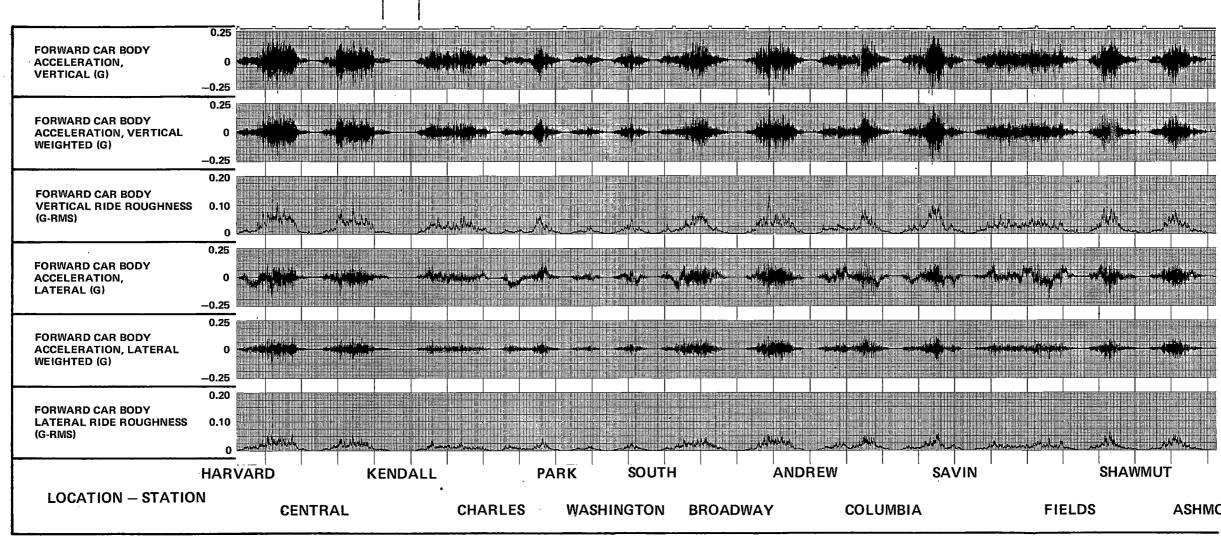
													L										
						1.11	1111		 					1				 					
1111			111	1	1	111	111	1	111	111	1112		÷	1		1		 	 1141	1111	 1		
			194	10		1.1.1						-			1.11								
	Ċ.	1					1111	1									1.11	 1.1	 1111			111	
				1.1.1			1111	111					1.11					 	 		 	1.1	
															111		****		 	1	 1		
																				_			

								L					1										
																	1111				 1113		
														1111		1.12							 1
					1	 		1			1.11		1111			1.11		111					
Į	 		щ			 		1	1.64		6	11							цā	-			
Ì	in:								112	1	1		1.1.1.1		1111		1111			11		1111	1
		1.112	1111	1.111			1111	1			1100	1.13		1		1.1.1	1015	1.11		1111	 	1.1.1	1.5
													11.1	1		1111	111				 	111	111
								1.11															





	r	_	_	_		~				_	_				_	_				_	_									<u> </u>									~~
-	+	+		+	-	-	-	-	-	-	-												-	-			-												
	Ŧ			1				t.			_	-				-								-	-				-						-	-	-		-
ľ	ľ	1	1			-	-				1		-	1	1		Ċ	1			1	1	-		1	1	1		1	1	Ì	1		-	1	1	1	1	T
-	-	+		+	-	-	-					-	-						-	-	-	-			+	-	+	+	+	-	-			-	-		-+	+	+
t	t	t	1	t	t																÷.						1												
	L																																						
F	t	T	T	T	1		_	_		_	-	1			-	_						-				_	-	-			1		×					_	
t	╈	÷		+	┝	-	-						-	-	-	-		-	-		-	-	-	-		-	+	+	-						-	-	-		-
h	W	4	1	-	Ill	4	4	W		4	1	4	N		-	4	U.		4	-	1	1				H		ł					4			-	-	H	4
H	F	1	1	7	1	H	۲	H	Щ.	-		1	-	1.	-	-				-			-			I		ľ	1					-	1.			-	1
ŀ	1	-	4.	Į.						-				_		_		-	-					-	-		+	-	-	-							-	-	-
1.	t		_	1		+		احتدا		-	-				-	-		111			-22.								it lass	T	1.124								
r	+	Т		Т	T	-	-				-			1						198																			
t	t	1	1	1	t				-										-	-	-		-	1			1	1	T					-				-	
-	1	-		-	+-	-	-	-		-	-	-	-	-		-				-			-	-	_	-	-	+	+	-	-	-			-				-
1	T	T		ľ	1	1		-					-					-		-					1			T	T	F			_	-	-	1		1	-
+	+	+	-	+		-		-		-	-	-	-			-		-						-		+	+	-	-	-									
t	t		1	T	1	in																														-113			-
															2																								
F																																							
1	t	+		+		-													1.1				-	-									•						
-	-N	-	-	h	h	20	-	4	A	-	~	5	~	02	5	Y	~	0	50	64	2	200	~	-	-	-	7	4	4	A	-		24	~	Į	-	4	4	-
ŀ	f	+		1								111									-	-					1												
F		-																				_	-	-			-												
	t					1	222					1111						1.11	11.1			11.1	e i e							1	1	1999	2444			1111		mur	
T	╀		-		1	-										11/1	HII															H							
t	t	1		1	t	1																		-															
┝	t	+	+	-	÷			-	-													-	-	-															
ľ	1	Υ	-		1	yo.	~	~	m	5	~	-	-	~	-01	54	m		1		1		~	~	-			T	1	T	2							90	1
┝	+	+	+	+-	+-	-	-	-	-	-	-	-	-	-	-				-				-	-				+											-
t	1	İ		t	t	1							-																										
Į.	T	Ŧ	Ŧ	Ŧ	L	-	-		_	-											-			_															
ŀ	t	+	+	+	t	1							-			-			-								-			1									
-	+	4	+	-	+	-	-	-	-	-	5	-	-	-	-	-	2	-	-	-	-	-	-	-	-	+	-	+	+	+	h	-	-	-	-	-	-	-	-
t	t		1	1		t																			_		1	1		t	1	-			-	-			1
ŀ	+	+		+	+	+			-	-		-	-	-	-		-		-	-		-			-		+	+	+	+	-		-				-		-
-	t	-		-		t			11.00	-	1				-	-		Ú).			-						aist.		i della	T	1			mi		1.11			
Г	+	Т	-	T	T	+								111										1		1	Т	T											
t	1	1	1	1	1	1			_							_		_		_		_		_	_	-	-	-	-	-		-							
+	1	+	to	4	+	+	m		-		-	-		N	5			-	N	5		-	~	3	-	-+	-	+	+	1	-	-	-		1	-		~	2
ţ.	N	4	1	T	5	r.	_	1	3	1		-	w			-	w	2	_	4	n	2			3	~	1	-	-	-	1			-	-	_		-	1
ŀ	t	+	-	+	+	+	-	-			-	-		-	-				-			-			-	+	+	+	+	+			-	-	-	1	-	+	-
	1	1	T	t	1	F					-	Ľ.	•		Ľ	-	[]								_	1	1	1	1	F									
Ľ																																							
Ľ				T	T	-													_			-		-	-		-	T	-	-	-	-							
L T		Ţ	T	+	1					1	1.1	1	. 1	1			.											1		1	1.1	1	1						-
				1	-	+									-								_						-	1									
										-					-							-		-		-	4		-				-	-			-		-
														-	-		-						-	-			-						-				-	-	-
																										-											-		



TIME 🛏 🛏 1 MINUTE

Figure 5–23. Forward Car Acceleration Time History Chart (H–A)

ASHMONT

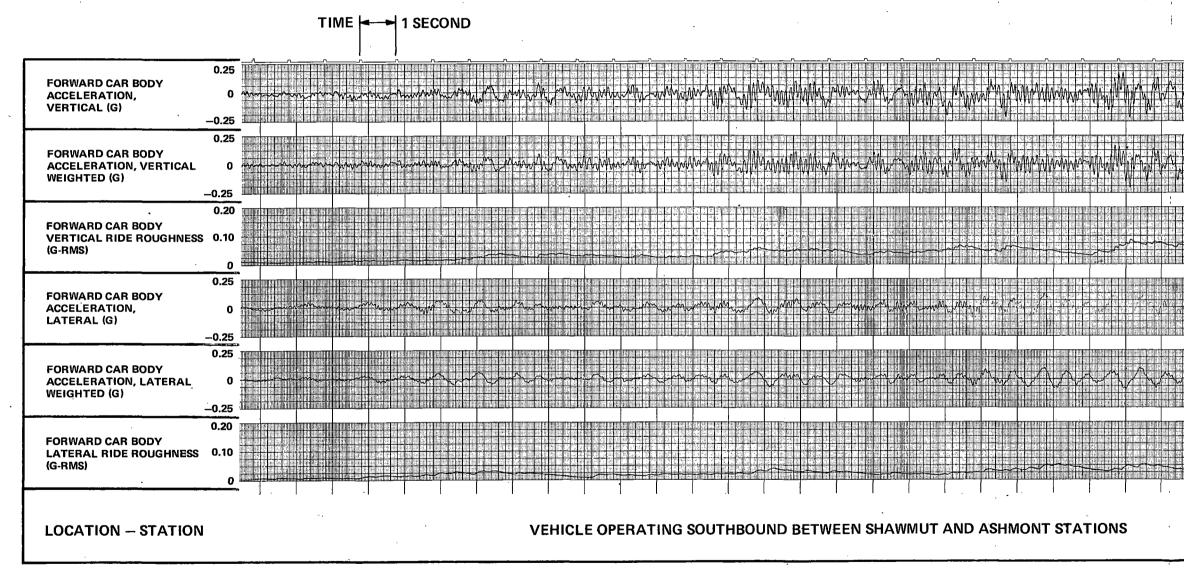


Figure 5–24. Forward Car Acceleration Time History Chart (~)

A–51

_	л	_	-	_			~	-	_		_	٦				_		_	_	-	_	٦	_		_	_	1	_	_	_	<u>ہ</u>	_	_	_	~		_		_^_	_		
Г		10	ll II	11	1	Г					19	90								9		10	11	20					10												ТП	
	1			-	-												10	÷										-	-	-	-	11.1			i.		1				+++	
	1	1.1								10	1			÷.			- 1	1	·			127		L.,	11			M	<u>.</u>		104		-				1111		111		1	
1.	á.	1	11	1.0	123	V		÷.,			43		V		19		15			Ŀ. 1		·	1	1			11		ШĽ.	VZ		1.4	AL.	1	۱.,		4			10		7
Т	撋	Ħ	1	h :	1	67			11	LA.			ħΛ			Λ	111	71	V				5			τN	11	11	1	UN A	10	M	111		ΠA					10	4	
-	1	ч	A.	ц.	LA-	₩.	14	h	ΩU.	٧N	n I	4	44	fΨ	6		in.	-	-14		HP.	P	-		LA.	44		-##	4	- 14	44	<u> </u>	-44	-HA	ця ;	- 44	144	- 1	₩V		h	- AF
A	11	1	IY		KI L	κ.	ΓII	hЛ			¥	UL.	11.	1.1	P	rи	U N		- 1	A١	N.	Ľ.,		24			1.1	IΥ		1	η١.			ħ,	1.00		1	WA			I V	7
Π	LT.	1	1		P		1.4	U S				11					•		1	7					1.1						1	F. 1	-q "	П.	1			::. [: 10		
t i							· · · ·								1.1		-	-		- 1			÷	***	-		-		-	-				-		****	÷:,-	-	1.1			
				1.1	r: 1	E.,	÷: :	÷.,	1.11	- h		۰.		a		<u> </u>	6.72	1	_		· .								<u>ال</u>		1.1	1.1	1.	1.14	12		12					
		÷		1.11										100		1.11	÷:	1	11	1	i,	1							ai i			111					110				1.6	
			1.10		1000	1.21	200	****	21.1														<u>- </u>							1.1.0.2	1.10	1.1.1								-		
::	1		1111		E	110	6.00	100	in the	100	10	1			1.1.1	101	::::	100	e 1		:		100	****		11	::::		11			20				22.0	111					312 22
			-14		1.1	1.1.1	1.1	1.11	i				1.1		Ľ.,	1	-	÷	- 11																							<u> </u>
1	4									1.1	÷.	100	5	11	F			÷ .	÷	Ξ.,	6.3		1.1	1.0	1.13	199	111						1.8						41			111
Г	Π.		111		117		1111			. 1	2.0	17	1		1				10	1		L			1			-					3.0				100					
ł.	HH	1				n A			Α.	1.1	÷.,	ł#	A-A	harri	L			n.		-	Ţ	-					A				1.1	l a f	-	-	Α.		-	-	-			
h	11	11		н.	lΛ	IM.	141		917	I۸.	41	11	RШ	И.	1.0	l A I	1		5		ЬĽ	'n	n.		١Δ.	613	111		1	144	11	MAR	ΔL,	10	Нſ		ĭΑi		ΛM	nn		
Г	П	U	Ш	٢Y	ш	14.	71	П		•	C U	П	Π	r v	N	Ą	U I		V	Λ			1 77	Ŵ		V.	۰.	m	7	¥٨	ПP		V GJ	IN.	Π.	1.4	UT	VΤ		T	ΠŊ	Y
÷	-	-			14.1	4	1-11	÷.	÷	÷	- ¥	H٩		-			•		- 2	44		1.0	1	• •		÷.,	- i -	ЩĘ	+		47-		-	H	1		-			-	-	
						181			÷.	1	÷.,	P		<u> </u>	1			į.	- 22	_				÷.,	:		-	•	_		1	1.1	÷.,	T	L		18					111.11
1			88	19	e.	127	0	1	5	2	. i	ΡĒ	111	Πī	12		- 1		. 3	••••	. I	1.11	k.ā	6.	b.ľ	83	11	L I	ΥĽ		1.3	1.1	ъP	N	РŪ		184. T	20			1.0	Ŷ
t	1	-	m	m	1÷	1	t:r					t÷		<u>F</u>	1			-	-	- 1	11.	-	1	-	-		-		: i :	-1-	T	11			1-1		i.		T			
1	ш	Ш	ш	LU.	1	1.00	1	لللله			÷.,	ы.,	1.5	[lui-	1	ii	сi.,		11		pi.i	lati i	H.,	ЪÚ	ati.	100	шŀ		110	96	шĿ,	abii	litti	Шi	1111	41	u liii	u ui	10	usiti.
								1					Ľ				1						1													1				1		
													1										Ŀ									1				1				1		
T	a.	-11			1			L					l	lan i									!									haa	m									
1		11												Ľ	L#		-	1	11	ΞŤ	ΗŤ	Ľ	E	186	1		Hi i			<u>.</u> 10	10	186		10	18		100					
		Π			1~~	Γ.	11		1	11		1			1.2		5						I.		1			1 1	T	7	197	THE			T II							
		-	-		-						-	-	t i i		1		<u>+</u>	- 1	-		÷	-	1	1	ŧ-		8-		-1-	-			-	+								
					2.5							Ŀ.	لنهط	Ε.	غسا				1	ш.	1.	La	L	-	19		1.11	Ŀ	1]											1	
ſ	3	3			1.1					10			177		(111		-		1	E.	Г	1	1			ΞĪ	Л	T	1		ा				96					
t		-			1		t in	H		ŀ÷	1	t i	+	-	1	⊧⇒i	÷		-	-	-	i	t	1-1				the state	-†		1	1	-+-	+	t i						1	
		-	.11		1	н.	1	<u> </u>		1	12	ŀ	1	t in	15	-1	1	1	<u> </u>			ف ا	I	1	L			1					-	40	1							
	7	1	-		Ľ	Ш	Е.			1		E		ЕĽ	1.1	L J	i di la	h., İ	\mathbb{T}^{1}	E I	e -	17	L.C	·- :	13				1.					ЧŪ	L I						PH.	
t		111		P	1.16			-			-	~	1	· · ·	-			-		~	÷		1.1	1.3				2	-			100	-	7	-	21.12						
						1.1				112	111								-	-	-				-													-				
L		19	ΗĤ							111				199				20		4171		12.5		144											Π		20					
		-																		_		_										I	_							Т	-	
													ſ				- 1						ſ									ſ				ſ				ſ		
																	_																									
		U.	-	111									12		1111								1.11					5.5							111	111	114		ΠÜ			
									100				1																													
				1112										£1.	103					10			110	111				111		1. 11			1.1							1		
	11.									1				1.5					-	8								5.0						10					<u>7</u>			
	Ţ	ш	1		f	n,		7				5			11.1	~			11	10.1	1000							7 ^			1.61	1	-	in a						: n	ħħ.	Ŵ
ł,	1	1				4.	14	1	<u>م</u>	111	11	2.			1.1	24	н.	. 44	÷.	1		<u>н</u> .,	<u> </u>	1	- 1	1			Ψ.	. IĂ	1.1	n . 1	- 14	• Hi 1	14.		ΨŲ				1.1	
ľ	H.		::5	ι, I	P.	51			[#P	-/,	2.11	÷.,	ť .	11	li i i		١Ň	A' I	1	4	1.	ГC,	Ľ.,	ыż		11.1		347	Þ	W.		11 + 1	M.	: T.	14			- IQ	fN i	104		k∩#/
		11						1.										-				•••	. ···	1	÷.,			100	111			17.0			10			11:		1.00		
-									1.11					1		-10	25				1.	1	÷.,			14			-		1				1							
			П											1.5				8.3		122		÷,		113			2.1		÷1								111					
		ш	##F									11	1111	1				1999				11):																16		2		
			1111	:::::			1:02	uu.		1000												****							7111-1			to the second	111 11	121021	uu:	899						
																																I .										
													1				- 1															1								1		
T	П	:0	(FIT	110	T:TI	T I	1 00	Π					1120	un.			w.	1111		ю	1111		800	107		999	101	1111	ЩH	00,00	999	had	m	i na i		900	1990	in n		den		THE O
			111											:111					111	:::::		2112		: #	- 0		:*!	- 1		-	1.11			-								
1				Шú	E.														11	1	0	.5			Ш÷.											10						
			111																							1111			1	17				1								
	ł	÷		÷	t	÷												-	-					-	1		1	~		-1-	ام	1-1	÷.	4		11	-	-			+	- H
ν	1					ha.	ŀć'	Ľ۵				ž	\sim			\sim	ال	لى.	لد	4		۵۵	١ċ,	-1-	۸.		1		ي ال	يذات	d'i		1	Ŀb.		1				3	15	
1	-1	1	κ.	5		Li C	2		гv	-5				100	2		Ň	3	- 1	ζ	66	مد	1	1.5	۳1	Š			. Т	11				19	Ņ			1	۲T	1.11	1.5	1 A P
T	πt		í.	ń.										v					- 1	10					H-1		-		1	1	1	6	-1-			ιü			Υ.		17	The second second second second second second second second second second second second second second second s
1	4	44	24											1.11	1911	1.1				11	100				12			1.1			1.11			5	31.1				10 10		14	111
																	10							T	11	-		dil i	24						LH)					100		X
Ŀ	11	III	П	111	1.00	11			111			111		80		99										2.5	1211		7		T			al di						1T		100
	ш	ы	ili.	44	1951	ŧiiii	Шų	-111	i iii	68		uiii	μii!	111	61	611	122	191	-61	466	utti.	1	Ыü	10	601	48	-11	التثب	ii lii	CHE:	a. Bi	للنشا	шu.	a Lati	61	111		ШŰ	uuuu	للتتهد	ulti	ulili
							- 1										1															1								1		
																	1										1					1								1		
Ŀ.	нF	ш	вн	101	lar.	ERE	1997		e e e		11-1			e.	1214	010			10.0			: ter	1111	1117	1110		201		un-			1000			1999	10.1	Terre	no P		dan	11110	
Ŀ			111	11				HH.	191	11		88			88	111	111		10	H.	ΠĮ.			111	Шİ		ш				L				ш					1.1		
	ШĒ		Ĩ		80									1		100	38	::I		1				670	1	1		-11	ा	315	16			ч т 5		1214		14				
			iii					t the	-															÷	-	1	-		-		15				10			-				
									39	122							1		64	12	h			· •	1.1	1		1			<u> </u>		-1-	ند ال								
L	аſ			111	ВŰ										133		- I		۰I	, id	1			1	n,	1		1 F	۰f		£5	4	Чľ	T.		11	:51				15.1	T
t.	÷		T	1.11								ti i		1111			-9			İ.	tt		1		÷			1	-1-	11	T	<u>⊧ -</u> †	-+-	+++	14	1		1				
													1		111			-				11 L	<u> </u>		i.			-	ł	44		أربيه		- i -	أتتبا			-1		4	12.	
E					-10								1	311						1	-	in,	e, i		÷Ĩ.			i in	÷.			1	ЧĽ	11			3.9		u Pi	T		연물
۰.	8	155												N	L							÷.,	-	1						18	T	17	-+-	+						1	1.11	
£			-	-	-	÷.,	1			-			1		-			-	-	11		-			-	_			-			r l	÷	-	1			-	-	1	100	÷++
l	-	11					811		la d				6.0	11		28				111	Шİ						11				÷.,		. I.	1 i i i i i i i i i i i i i i i i i i i		1	11		T	T	120	-
		-	-		-																		· · · ·										-				_			1		
		-1					- 1										1										٠ſ					[1					Ĺ		
		1															1						L				1								1					L		
																																										- 4
																																										1
																																										1



Figure 5–25. Vehicle Acceleration and Speed Time History Chart (A–H)

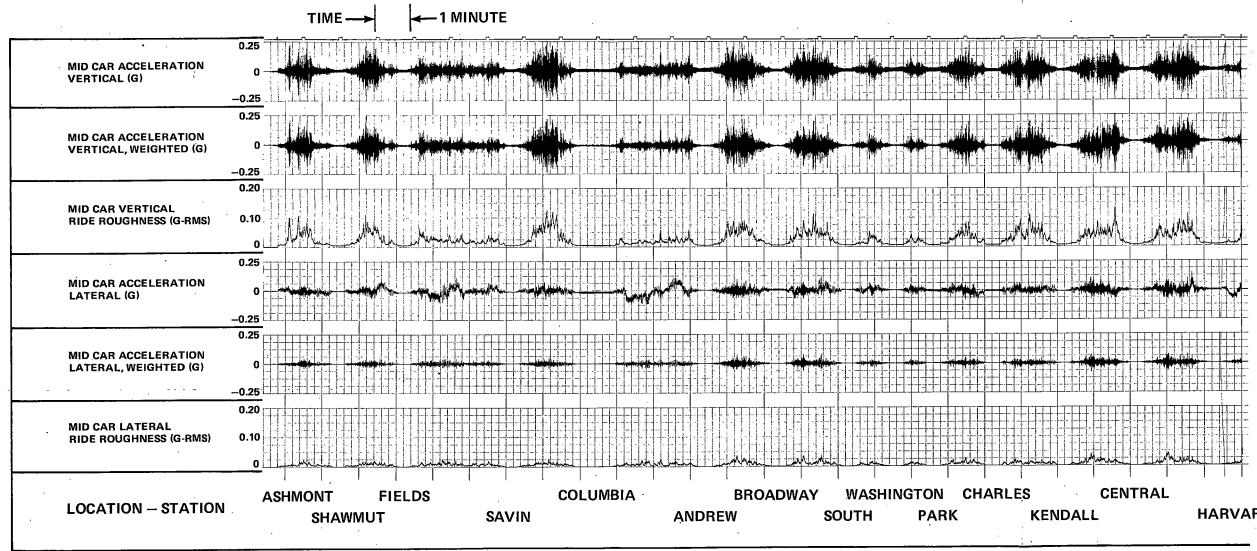


Figure 5–26. Mid-Car Acceleration Time History Chart (A–H)

A-55

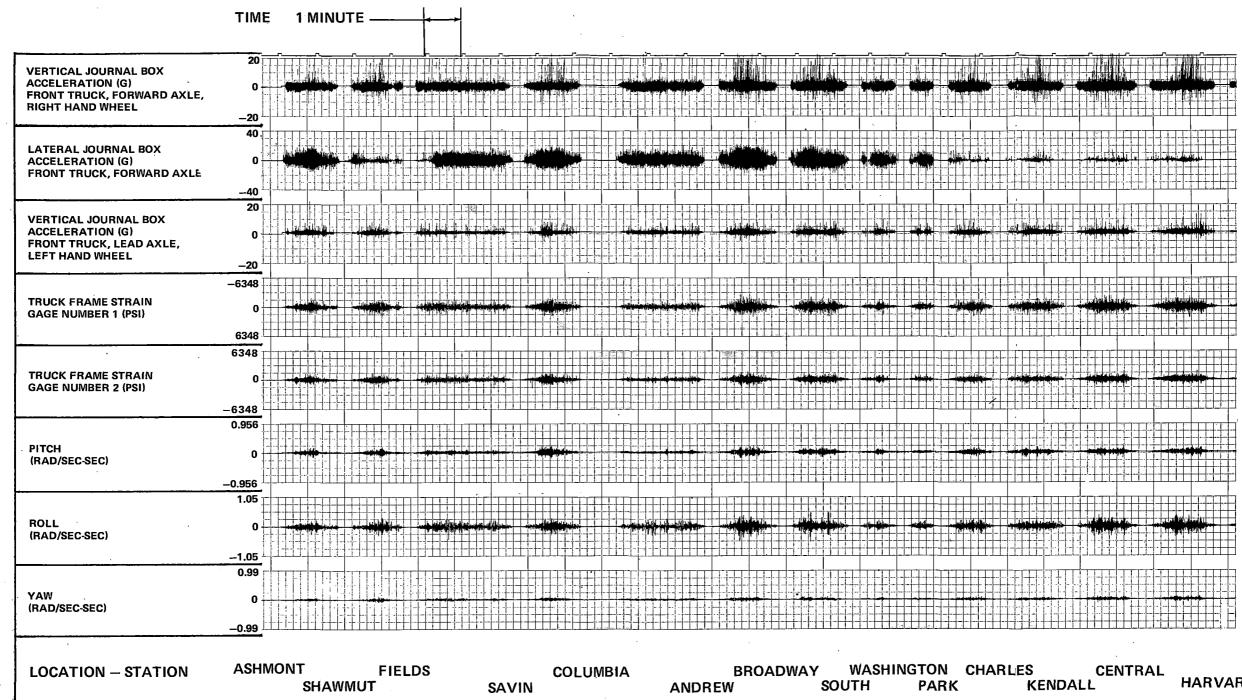


Figure 5–27. Journals, Truck Frame, and Angular Acceleration Time History Chart (A–H)

A-57

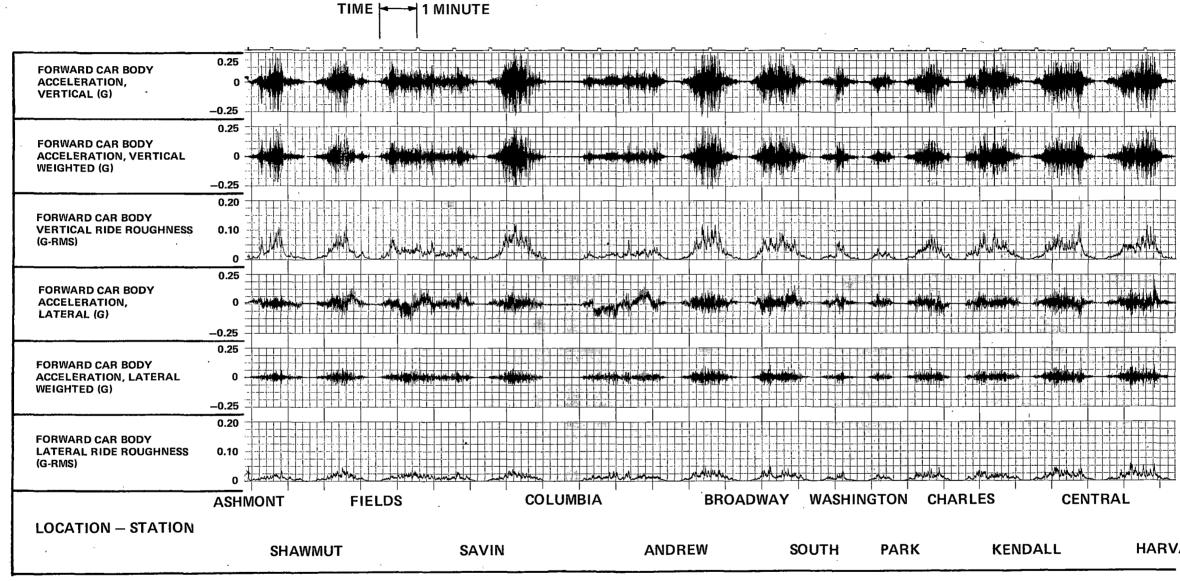


Figure 5–28. Forward Car Acceleration Time History Chart (A–H)

A--59

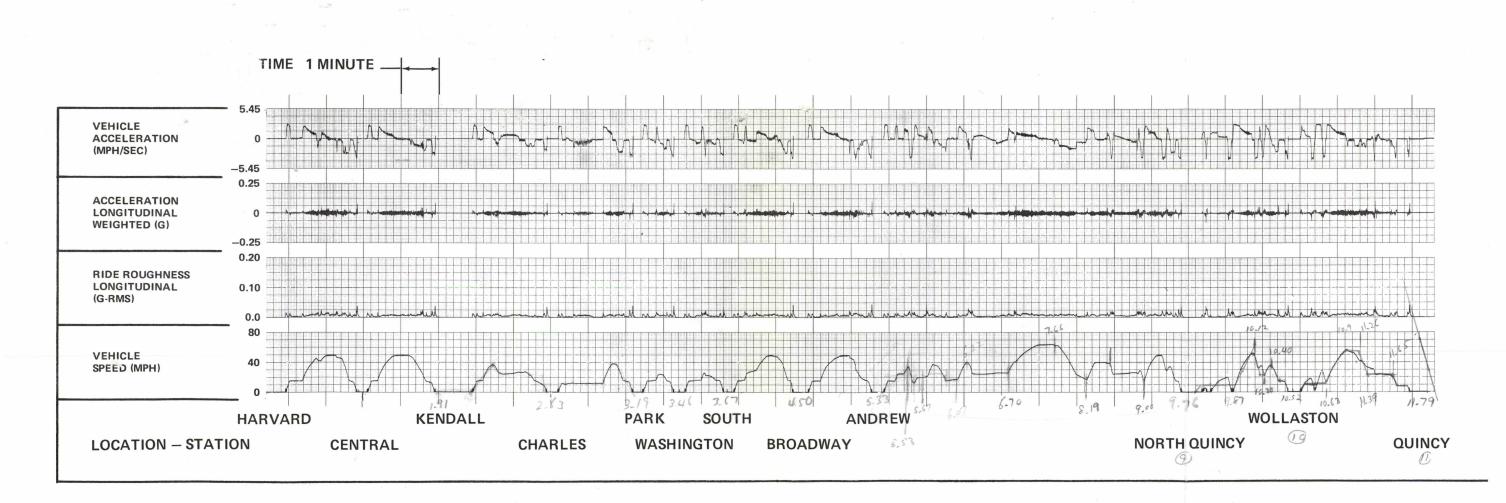


Figure 5–29. Vehicle Acceleration and Speed Time History Chart (H-Q)

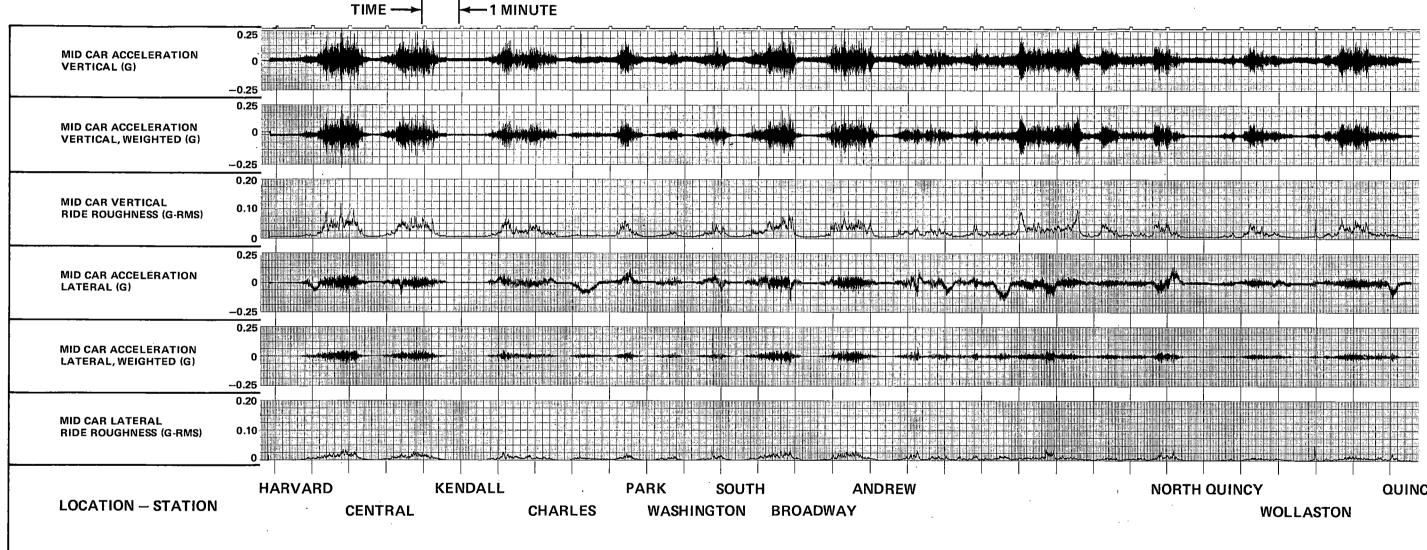


Figure 5–30. Mid-Car Acceleration Time History Chart (H–Q)

A--63

QUINCY

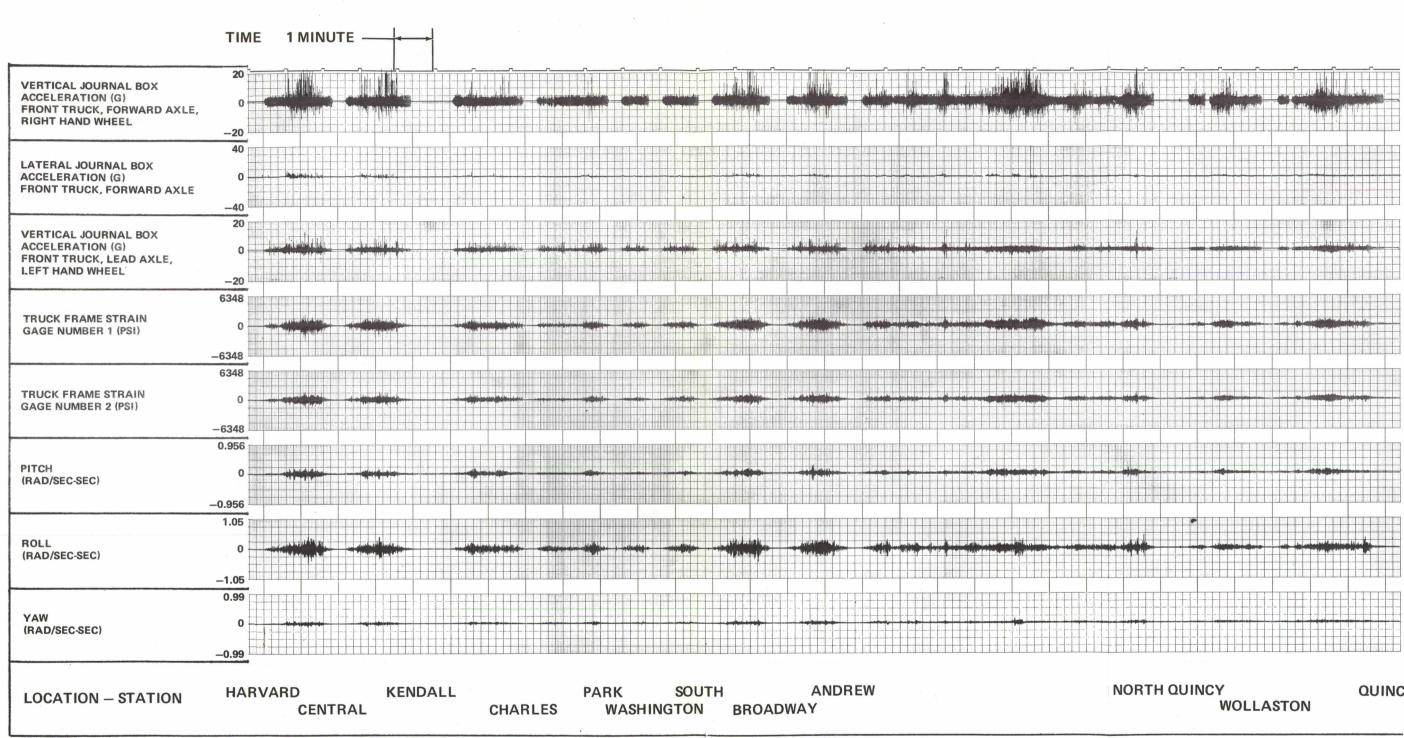


Figure 5–31. Journals, Truck Frame, and Angular Acceleration Time History Chart (H–Q)

QUINCY

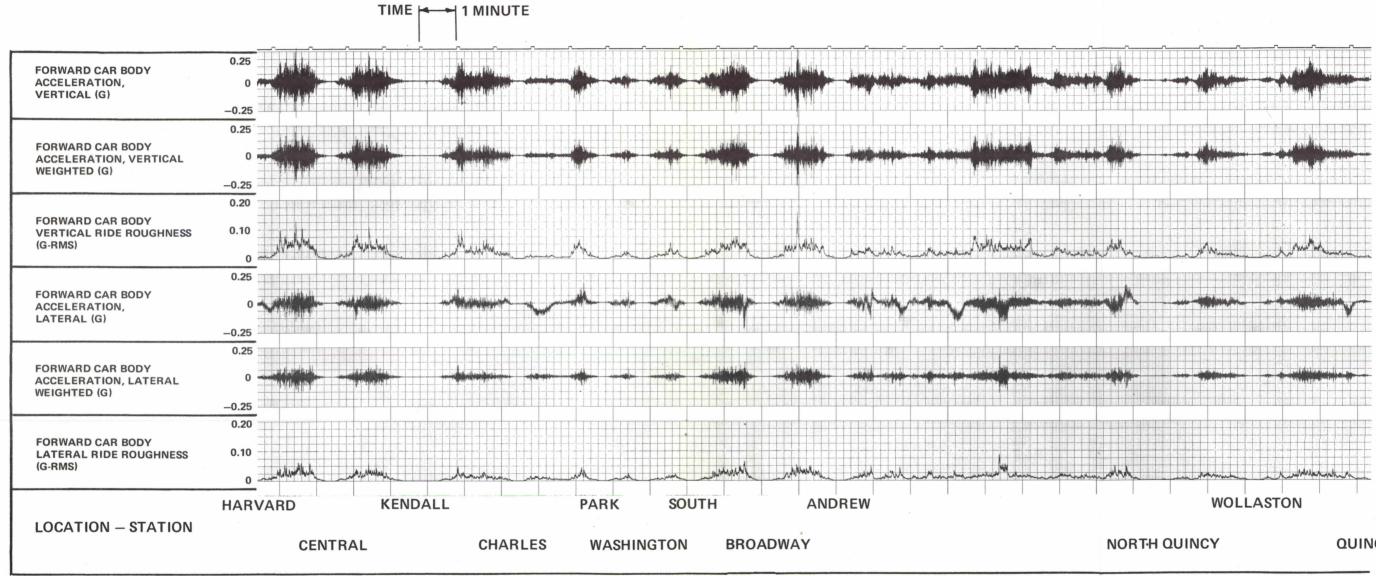


Figure 5–32. Forward Car Acceleration Time History Chart (H-Q)

QUINCY

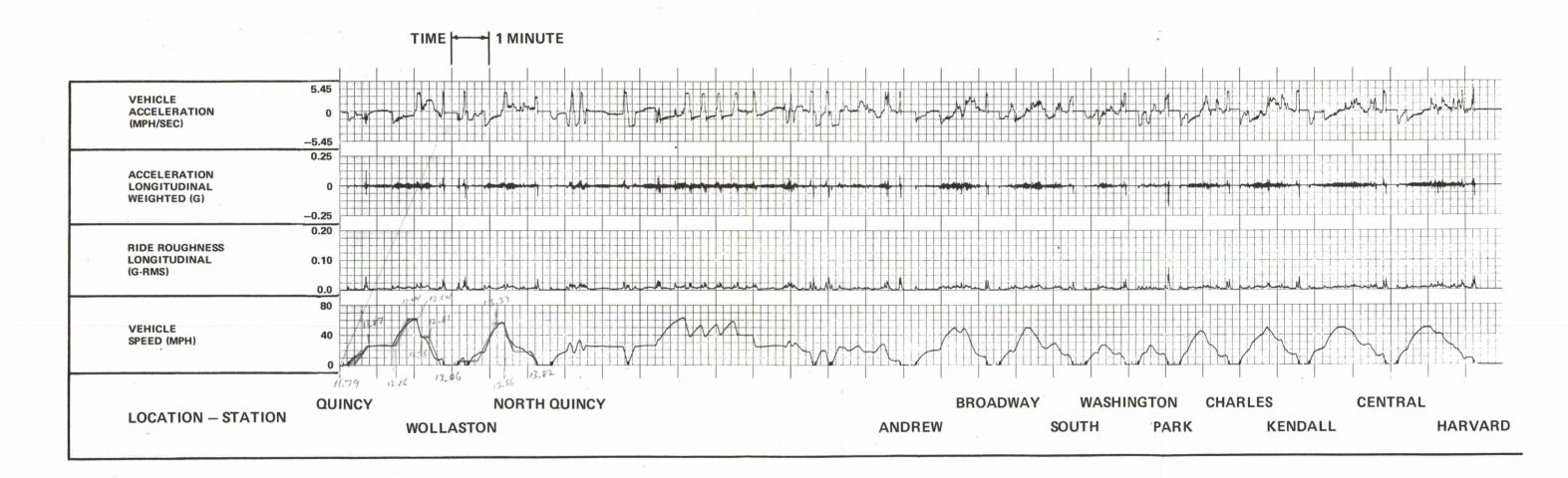


Figure 5–33. Vehicle Acceleration and Speed Time History Chart (Q-H)

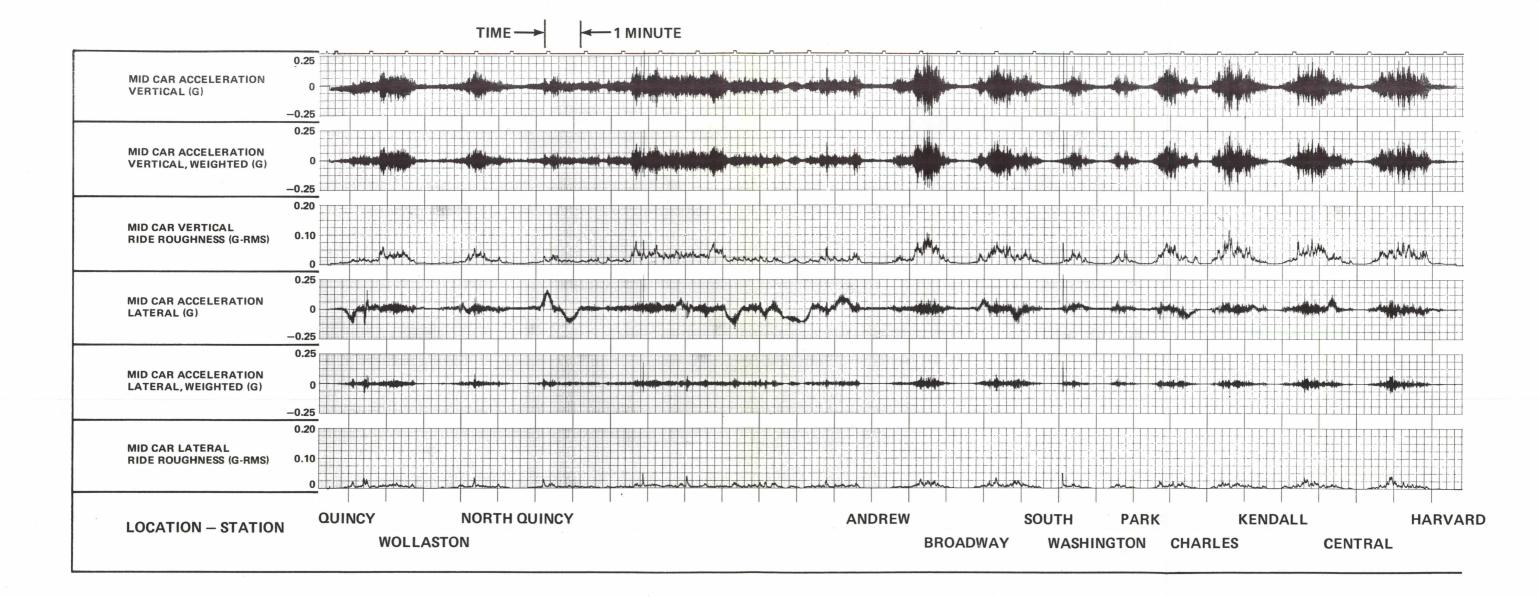


Figure 5–34. Mid-Car Acceleration Time History Chart (Q–H)

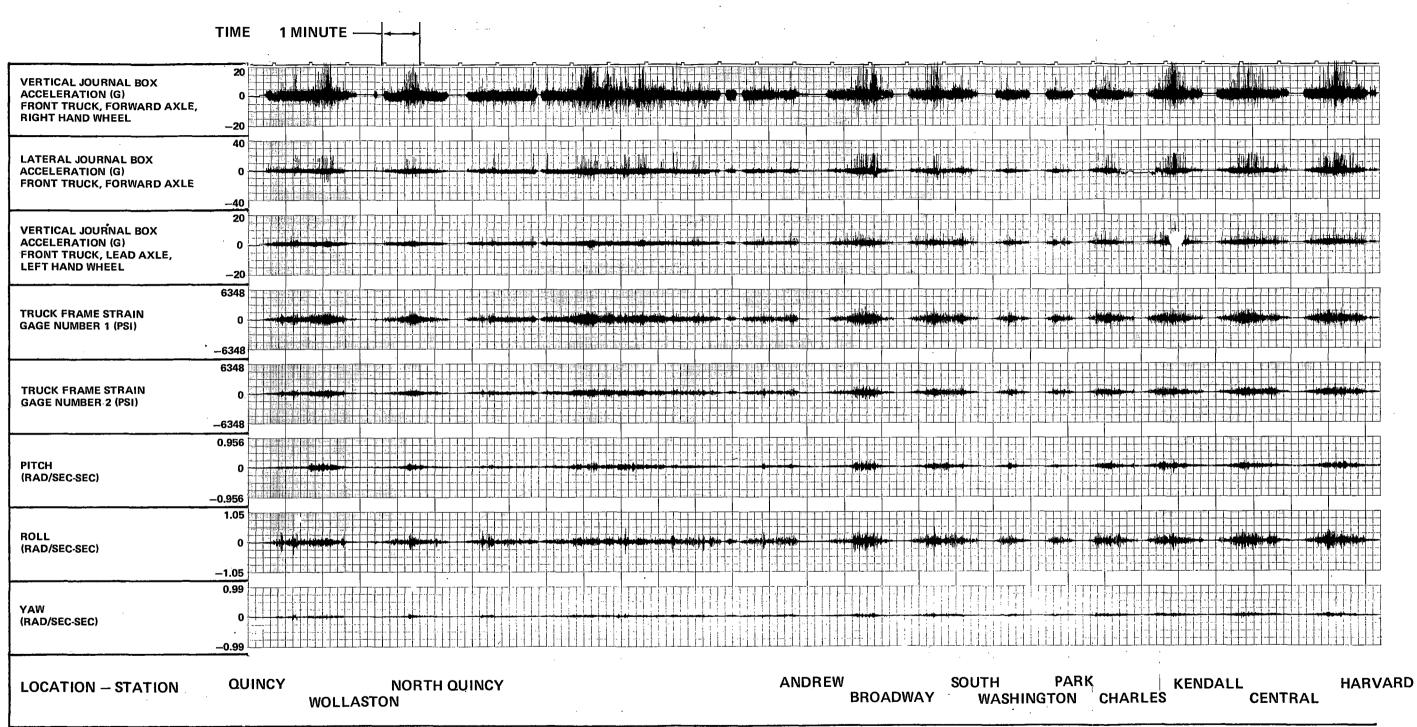


Figure 5–35. Journals, Truck Frame, and Angular Acceleration Time History Chart (Q–H)

A--73

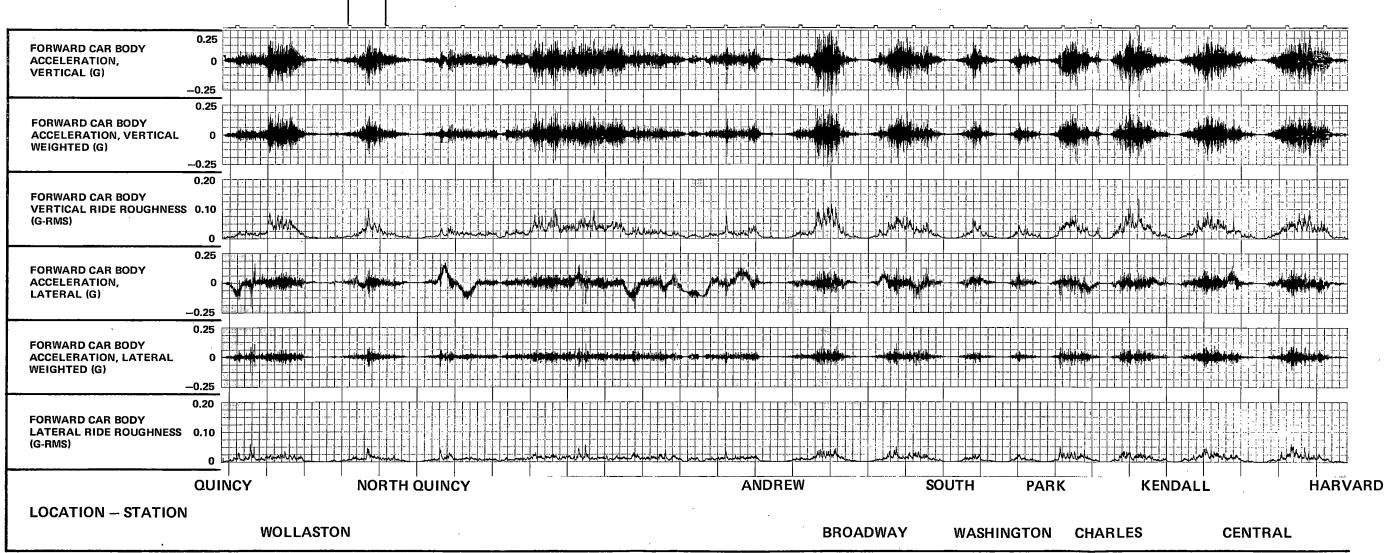


Figure 5–36. Forward Car Acceleration Time History Chart (Q–H)

• TIME

· 1

APPENDIX B TESTING AT CLEVELAND

1.0 TEST DESCRIPTION

As part of the Operational Test and Evaluation Program, the State-of-the-Art Cars were in the Cleveland Area from September 23rd to December 16th, 1974. The period during vehicle set-up and checkout was used to install the engineering instrumentation system and to perform the Simulated Revenue Service Tests.

1.1 Test Site

The SOACs were operated in revenue service on the CTS rapid transit system which runs from the Cleveland Hopkins Airport, runs northeast through downtown Cleveland and terminates at Windermere Station in East Cleveland. The route is 19.5 miles long, has 18 stations with a scheduled service time of 36 minutes. The line runs at surface level for most of the route. The Public Square Station is underground, being located beneath the Cleveland Union Terminal, and the Airport Terminal is also underground.

1.2 Test Operations

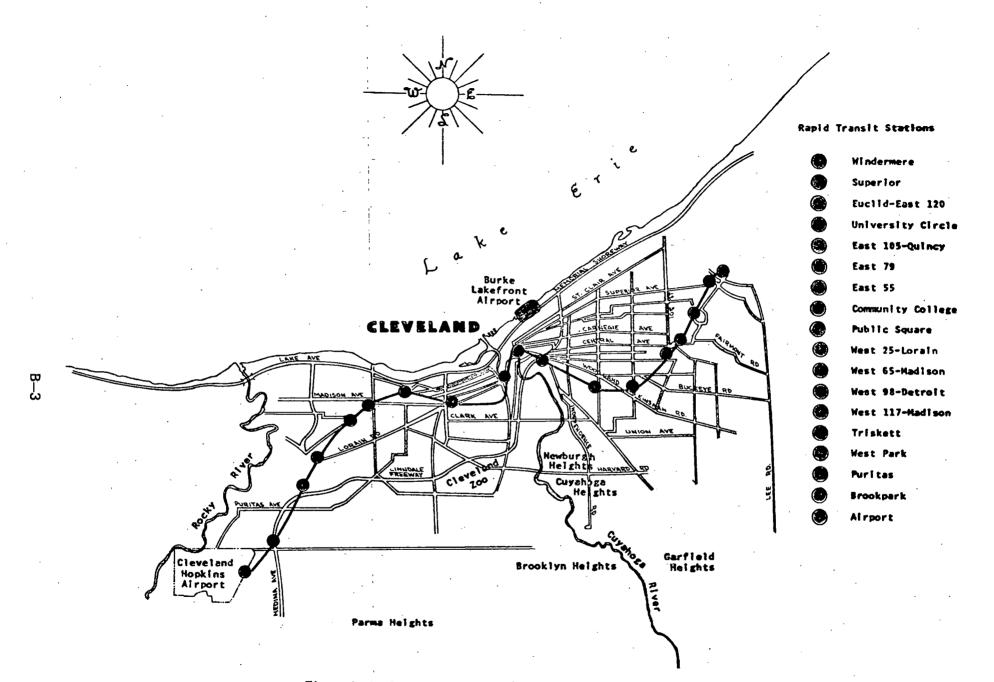
The test plan was to operate the SOACs in a simulated revenue service over the test route. For safety and operational reasons, vehicle operation was entirely under the control of CTS personnel during the tests. The only requirement imposed by the test was to maintain the normal scheduled service as close as possible and to simulate the normal station stops by opening the car doors on the side opposite to the Station platforms.

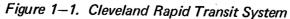
The test runs were scheduled for and accomplished on the evening of October 16, 1975. Two complete roundtrips were recorded, each with different lateral shock absorber settings. This was accomplished because a stiff setting was used on Boston, and a request was made to compare the settings for the subsequent Cleveland Service. Data analysis showed that the shock absorber setting had no effect on the SOAC ride comfort for the Cleveland Service. Either set of data could have been used for this report. In fact, the journal box accelerometer was a problem during this test, the

B--1

vertical failing during the second run. Therefore the data shown here is from the second run, except for the vertical journal box acceleration distribution which is taken from the first runs. The test times and other parameters indicate that the two tests were essentially the same.

There were no scheduled trains or work crews on the tracks during the tests. There were no incidents which would have an influence on the validity of the test data.





2.0 TEST PROCEDURES

Pretest

- 1. Mount all required sensors
- 2. Calibrate Instrumentation System
- 3. Brief Test Crew on Test Operations

NOTE:

One vehicle is instrumented for noise measurements, avoid other than normal conversation.

Test

- Operate the vehicles in a simulated revenue service,
 i.e. maintain the given schedule.
- Provide a nominal 10 second door opening at each scheduled stop.
- Provide voice commentary on instrumentation recording during progress of test.
- 4. Maintain a manual log of events during the test run, correlated to the instrumentation system records.
- 5. Monitor various preselected data channels to ascertain validity of test run.
- 6. The Test Controller will terminate the test if:
 - (a) An extended delay or train shutdown occurs
 - (b) One or more required data channels malfunction

(c) The test vehicle is not operating properly Advise Test Controller of any abnormal operations or events that occur during the test run.

3.0 INSTRUMENTATION

The SOAC Instrumentation System was used for this series of tests. This system is described in detail in Volume VI of State-of-the-Art Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center, Final Test Report, UMTA-MA-06-0025-75-6, January 1975. A synopsis is included below.

3.1 Ride Qualities, Structural and Performance Tests

Electrical signals from the vehicle mounted transducers are conducted by cables to an interface panel which is connected to an instrumentation console containing two magnetic tape recorders, two light beam oscillographs, a time code generator, a temperature recorder and signal conditioners. Any 28 selected test parameters can be recorded on tape and displayed on the oscillographs. In addition, wheel speeds may be recorded directly on the oscillographs; total power is recorded on tape and displayed on a mechanical counter. The time code generator provides signals that are recorded on both tape and the oscillograph. The oscillographs provide quick-look data to evaluate test progress and results during testing (See Figure 3-1).

3.2 Noise Tests

The instrumentation used for noise measurement consisted of a 1" condenser microphone with battery operated cathode follower and a 1/4" single channel tape recorder.

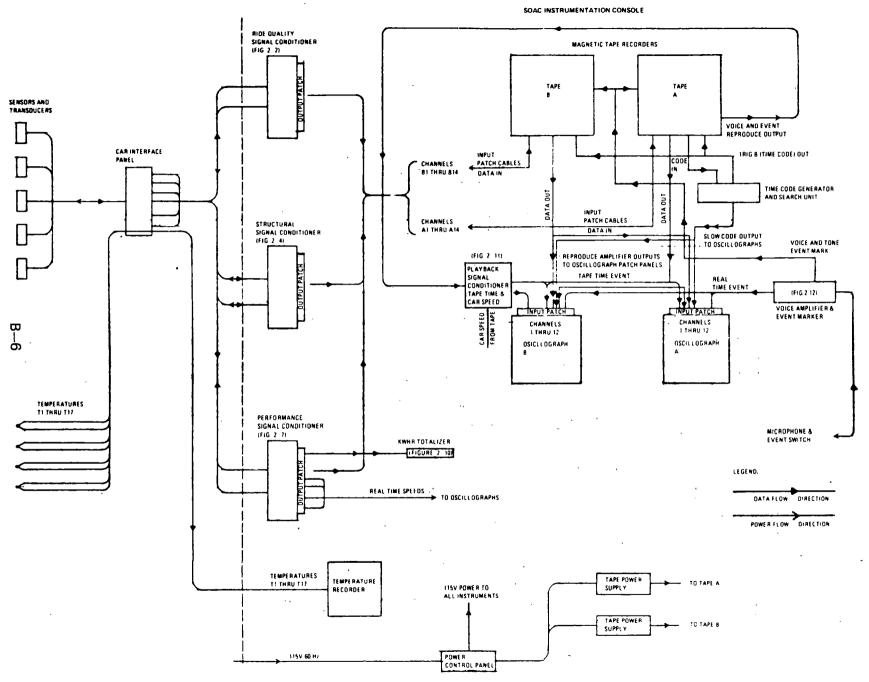


Figure 3–1. SOAC Instrumentation System Block Diagram

4.0 DATA

The parameters recorded during the property tests are described in Tables 4-1 and 4-2. The definition of the parameter measurements is contained in Appendix A, Standard Outputs for SOAC Property Tests.

Data was recorded for the roundtrip routes noted in the Test Description Section. All of the data was recorded on analog tapes and processed to provide three types of outputs.

Time History Charts Station Summary Tables Frequency Histograms

4.1 Time History Charts

A slow chart speed strip-out of certain parameters is included in this report. The purpose of these charts is to provide an indication of the maximum levels of parameters during various phases of the run. The complete run is described on the charts including station stops and any particularities that occurred. A series of time histories at a high chart speed is included to illustrate the cyclical nature of the data. These charts are a single time frame for all parameters and are representative of the worst case conditions exhibited for a particular test run.

Intermediate parameters, such as a weighted (filtered) car body acceleration are shown on some charts.

4.2 Station Summary

A summation or summary of specific parameters is made by each station stop. These include test running time and distance for comparison to the property's schedule. Power consumption, motor duty cycle parameters are also summarized by station to indicate the relative sizing of the SOAC propulsion with respect to operations on the property. Station stops and maximum speeds are also shown as another indicator of vehicle operation in a scheduled service environment.

PZ	ARAMETER		STANDARD OUTPUTS									
DESIGNATION NO.	DESCRIPTION	RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS							
301	Longitudinal Acceleration	<u>+</u> 0.25 g's	AP/A	Format(3)	Format(4)							
302	Line Voltage	0 to 1000 VDC	LVD/A	None								
303	Line Current	0 to 2000 ADC	LCD/A	None	-							
304	No. 1 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	_							
305	No. 1 Truck Armature Current	0 to 1000 ADC	MACD/A	None	RMS-MAC/A							
306	No. 1 Truck Field Current	<u>+</u> 50 ADC	MFCD/A	None	RMS-MFC/A							
307	No. 2 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	-							
308	No. 2 Truck Armature Current	0 to 1000 ADC	MACD/A	None	-							
309	No. 2 Truck Field Current	+ 50 ADC	MFCD/A	None	_ ·							
310	"P" Wire Current	0 to 1.00 ADC	CS/A	None	Format(3)							
317	Total Power Consumption	l Pulse/0.1 KWHR	PCC/A	Format(2)	Format(2)							
315	Speed	0 to 80 MPH	VS/A	Format(3)	Format(4)							
318	Brake Cylinder Pressure	0 to 100 psig	BCP/A	None	-							

Table 4-1. SOAC Revenue Service Data List A

Table 4-2. SOAC

Ì

PARAMETER

DESIGNATION NO.	DESCRIPTION
101	Front Truck, Forward Axle, Righthand Wheel Journal Box Vertical Acceleration
102	Front Track, Forward Axle, Righthand Wheel Journal Box Lateral Acceleration
103	Front Truck, Forward Axle Lefthand Wheel Journal Box Vertical Acceleration
115	Mid Car Centerline Vertical Acceleration
116	Mid Car Centerline Lateral Acceleration
120	Forward Car Centerline Vertical Acceleration
121	Forward Car Centerline Lateral Acceleration
219	Truck Frame Upper Strain Gage
220	Truck Frame Lower Strain Gage
221	Pitch Angular Acceleration
222	Roll, Angular Acceleration
223	Yaw, Angular Acceleration
-	Interior Sound Pressure

Revenue Service Data List B

	STANDARD	OUTPUTS	
RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	····
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1), (3
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1), (3
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(l)
<u>+</u> 6348 psi	STP	Format(3)	Fromat(4)
<u>+</u> 6348 psi	STP	Format(3)	-
+ 1.5 Rad/sec/sec.	ACA/A	Format(3)	Format(4)
<u>+</u> 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
\pm 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
40 to 120 dB(re 2 x SP/A	10-5MM ²)	NL/A(1)	NL/A(2)

4.3 Frequency Histograms

These distributions are an indication of the ratio of time that a parameter is at a particular level with respect to the time to complete a roundtrip scheduled service run. These parameters may be used to describe how the vehicle was driven, the track conditions, and how the vehicle responded to these conditions.

5.0 DATA DISCUSSION

The vehicle operation was such that SOAC No. 2, the instrumented car, was leading and running in the forward direction for the Windermere to Airport run. For this run, the vehicle longitudinal acceleration has a positive value for vehicle start-up. SOAC No. 2 ran in the reverse direction for the Airport to Windermere run.

As defined in Section 4 there are three forms of data. These forms are discussed below with respect to three categories:

(1) Operation

How the vehicle is operated and maintained schedule.

(2) Environment

Track and truck conditions.

(3) Response

How the vehicle responded to operational environment.

Figure 5-1 through 5-15 present the frequency histograms for the CTS tests. Figure 5-16 is a sample of the interior noise level time history. The remaining time histories are shown in Figures 5-17 through 5-36. Table 5-1 is a summary of some of the test parameters and is derived from the histograms and time histories. Tables 5-2 and 5-3 are the Station Summaries with power consumption.

5.1 Operation

The Station Summaries show that SOAC run times were 8 and 19 minutes longer than the published schedule times. The basic reason for this is twofold. First, the tests were run during the car introduction phase of the program and the drivers were going through a learning process. The second reason is the schedule

itself which seems to be optimistic. The best that SOAC was able to accomplish during the revenue service program was around 4 minutes over schedule run time. Again from the Station Summaries, the extra run time is spread across the total route, with a particular delay being the approach to the Public Square Station.

The maximum acceleration from the time history charts is 3.27 mph/sec and the maximum brake rate is 3.0 mph/sec. Both of these values are within the SOAC specification.

The Station Summaries show that 12 percent of the test time was spent standing in a station. This compares to the histogram data for the speed distribution, which shows 20 percent of the test time in the 0 to 5 mph band.

Interestingly, the "P-Wire" distribution reveals a driving technique of the CTS operators while driving the SOAC. The major levels of "P-Wire" are between .5 to .7 amps. This is the slow acceleration and maintain speed level. A relatively small percentage of time was spent commanding full or larger acceleration rates. An even smaller amount of time was spent requiring full braking. The 12 percent station stop time is shown in the "P" = 0 amp. This very "soft" driving technique is again seen in the time history charts with vehicle acceleration and speed. Apparently the SOAC was eased out of stations and up to speed and very softly "braked" This is inconsistent with observations into a station. of normal CTS operations and must be attributed to the "newness" of the SOAC.

The SOAC consumed 216 KWHR completing the roundtrip. For the 42.4 measured miles this is a power consumption of 5.1 KWHR/Mile. For the 39 schedule miles it is 5.5 KWHR/Mile.

Neither leg of the route taxed the SOAC propulsion system. The SOAC has a continuous rating of 460 amps (RMS). The westbound leg required 195 amps (RMS) or 42 percent of the rating and the eastbound leg was 249 amps (RMS) for 54 percent of rating.

5.2 Environment

The journal accelerations and truck stress levels are intended to be indicators of track conditions. Summary values for these parameters are shown in Table 5-2. The 50th percentile is a statistical quantity taken from the cumulative distributions. It assumes a linear distribution of values within each class interval (e.g. 1-2 gs). The value is read as 50 percent of the time the vertical journal box acceleration was at or lower than 1.3 gs. The 95th percentile is read similarly. The "nominal" value is the 50th percentile for the time the vehicle is in motion.

As mentioned earlier, the vertical journal box accelerometer failed during the test run for which the remaining data is shown. The distribution shown for vertical journal acceleration is taken from a separate test run.

5.3 Response

Ride Roughness and Noise Levels are parameters which are related to "human responses". Ride Roughness is a ride comfort rating of vibration levels, and Noise Level is a hearing comfort rating of sound pressure levels. The parameters are described in the Standard Outputs Section of this report. A summary of values for the CTS tests appears on Table 5-1.

Some values for the car body acceleration levels are also shown in Table 5-1. In the time history charts the dominant frequency for the mid car vertical parameter is 7.5 Hertz. This is the car body second bending mode. For the forward car location the 7.5 hertz is apparent, but the dominant frequency is 1.5 Hertz. This is the suspension system natural frequency.

Interior Noise Level data was taken in the middle of the non instrumented car at a seated person's ear level. The original engineering tests at TTC indicate this is the quietest point in the car. The statistical quantities derived from the test data are:

L(99)	L(90)	L(50)	L(10)	L(1)	Ĺ(EQ)
65	66	67	70	74	71

A sample of the Noise Level Time History is shown in Figure 5-16.

	50TH %	" NOMINAL "	95TH 8	MAXIMUM
Journal Box Vertical Acceleration (G)	<u>+</u> 1.3	<u>+</u> 1.4	<u>+</u> 4.7	-
Journal Box Lateral Acceleration (G)	<u>+</u> 1.3	<u>+</u> 1.5	<u>+</u> 7.8	<u>+</u> 15.0
Truck Frame Stress (PSI)	<u>+</u> 160	<u>+</u> 180	<u>+</u> 680	<u>+</u> 2222
Forward Car Vertical Acceleration (G)	<u>+</u> .018	<u>+</u> .020	<u>+</u> .075	<u>+</u> .281
Mid Car Vertical Acceleration (G)	<u>+</u> .019	<u>+</u> .021	<u>+</u> .070	<u>+</u> .225
Forward Car Lateral Acceleration (G)	<u>+</u> .018	<u>+</u> .020	<u>+</u> .066	<u>+</u> .134
Mid Car Lateral Acceleration (G)	<u>+</u> .016	<u>+</u> .018	<u>+</u> .055	<u>+</u> .125
Longitudinal Ride Roughness (GRMS)	.005	.006	.012	.050
Forward Car Vertical Ride Roughness (GRMS)	.012	.016	.050	.175
Mid Car Vertical Ride Roughness (GRMS)	.011	.013	.045	.115
Forward Car Lateral Ride Roughness (GRMS)	.011	.013	.032	.088
Mid Car Lateral Ride Roughness (GRMS)	.007	.008	.019	.053
Pitch (RAD/Sec-Sec)	<u>+</u> .050	<u>+</u> .060	<u>+</u> .100	<u>+</u> .263
Roll (RAD/Sec-Sec)	<u>+</u> .060	<u>+</u> .070	<u>+</u> .184	<u>+</u> .525
Yaw (RAD/Sec-Sec)	<u>+</u> .050	<u>+</u> .060	<u>+</u> .095	<u>+</u> .099

Table 5–1. Summary Values for SOAC Operating on the CTS Airport Line

•		STATION		SCHEDULE	TE	ST	POWER CC	NSUMPTION			Gmon	N7. 17
. ₅ P	GEP NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)
	351	Windermere Street	· 0	0	0	0	0	0 ·	0	0	0	0
	2	Superior	.67	1.0	· .76	2.60	3.93	5.17	162.6	24.9	20.4	38
	30 ⁻² 30 ⁻³	Euclid E. 120th St.		55 2.0	.99	2.32	4.72	4.77	195.0	28.2	17.2	38
	70 ⁴	University Circle	.87 2	.42 1.0	.98	2.66	4.38	4.47	177.0	23.7	34.8	35
	30 ⁴ 40 ⁵	Quincy E. 105th St.	. 65 3	07 2.0	.72	1.82	3.95	5.49	241.1	31.7	18.0	35
	306	East 79th Street	1.174	24 2.0	1.30	2.64	5.11	3.93	189.4	23.6	16.8	45
	30 ⁷	East 55th Street		- 29 2.0	1.20	4.44	5,85	4.88	175.9	21.1	99.6	35
œ	- 8	Community College	.90 6	-19 2.0	.93	2.70	4.59	4.94	146.6	25.8	18.0	35
	49	Public Square	1.65 7	· EU 3.0	1.93	6.26	8.38	4.34	121.3	20.5	13.8	40
ភ្	70 40 40 45 12	Lorain W. 25th St.	1.05 8	- 89 2.0	1.18	3.94	7.41	. 6 . 27	159.0	29.6	16.8	34
		Madison W. 65th St.	1.94 /	0-833.5	2.12	4.12	9.05	4.27	173.6	26.8	16.8	47
	12	Detroit W. 98th St.	1.29 /	2.12 2.5	1.38	2.96	7.14	5.17	208.6	28.1	15.6	48
	25_{13}	Madison W. 117th St		3.58 1.5	1.17	3.44	6.58	5.62	167.7	28.6	18.0	32
	14	Triskett Street	1.07 /	4.65 2.0	1.20	3.04	6.47	5.39	166.3	25.0	19.2	37
	2513 3514 5015 516 5516	West Park		5.421.5	.86	2,16	5.68	6.60	270.6	21.3	19.2	48
	16	Puritas Street	1.23/	(. (5 ⁻ 2.5	1.41	2.58	7.74	5.49	273.9	23.1	16.8	54
	17 17عد	Brookpark	1.80/	5.45 2.5	1.91	3.08	9.84	5.15	284.0	20.7	16.8	54
	18	Airport	1.09/	9-543.0	1.25	4.14	7.29	5,83	238.0	27.9	21.6	36
						TOTAL	108.11	5.08	195.4	23.3		
		TEST RUN SUMMARY										

Table 5–2. Station Summary I

.

. .

.

··-- .

• • • • • •

SCHEDULE TEST 19.54 36.00 3216 30./ 1.15 21.29 54.90 23.3 23.5 1.25 Distance Time Block Speed Station Dwell Station Space

Table 5–3	3. Statior	Summary	11
-----------	------------	---------	----

	STATION		SCHEDULE	TES	ST .	POWER CO	NSUMPTION			Gmon	MD 17
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)
351	Airport	0	0	0	0	0	0	0	0	0	0
s^2	Brookpark		0.633.0.	1.26	3,96	7.39	5.87	177.1	31.6	19.2	35
523	Puritas Street		L432.5	1.91	3.20	8.17	4.28	244.4	18.8	18.0	55
50 ⁴	West Park		3.7 2.5	1.41	2.32	6.85	2.95	299.9	18.1	18.0	55
5	Triskett Street	.77 24	1.5	.87	1.76	5.40	3.07	343.4	23.2	16.8	52
50 50	Madison W. 117th St	1.0725	2.0	1.18	2.02	4.88	2.41	294.1	22.5	16.8	50
50 ⁷	Detroit W. 98th St.	1.462	1.5	1.08	2,74	6.04	2.20	264.8	25.9	21.6	48
508	Madison W. 65th St.		3 2. 5	1.46	2.70	6.62	2.45	240.5	20.2	19.2	48
- 0	Lorain W. 25th St.	1.9434	1.24 3.5	2.14	3.88	10.03	4.69	206.1	24.2	19.2	48
40^{9} 50^{10} 3^{11}	Public Square	1.05 3	1-29 2.0	1.21	3.20	6.10	5.04	240.0	22.5	19.2	45
, <u>1</u> 1	Community College	1.65 37	.44 3.0	1.89	4.32	8,55	4.53	159.7	27.4	15.6	49
12	E. 55th Street	.9033	-84 2.0	.95	2.18	4.58	4.82	213.0	28.5	19.2	38
ູ້ <u>1</u> 3	E. 79th Street		1.89 2.0	1.17	2.28	7.44	6.36	305.2	24.9	16.8	45
$\begin{array}{c} 3 & 12 \\ 4 & 3 \\ 3 & 5 \\ 4 & 4 \\ 4 & 0 \\ 4 & 5 \\ 4 & 5 \\ 4 & 5 \\ 4 & 5 \\ 4 & 5 \\ 4 & 5 \\ 4 & 5 \\ 1 \\ 7 \end{array}$	Quincy E. 105th St.	1.173	5.06 2.0	1.28	2.06	7.72	6.03	343.2	20.0	18.0	55
<i>1</i> 5	University Circle	.6530	2.0	.72	1,64	4.73	6.56	284.7	25.8	16.8	41
16	Euclid E. 120th St.		581.0	.98	2.02	5,02	5.13	254.1	24.7	16.8	44
17 3 18	Superior Street	.8838	2.0	.99	2.04	5.22	5.27	261.7	21.9	19,2	46
18	Windermere	. 67 39	./3 1.0	.76	2.44	4.01	5.28	197.5	26.5	18.0	34
				r	OTAL	108.8	5.12	248.6	24.5		
	TEST RUN SUMMARY										

 SCHEDULE
 TEST

 Distance
 19.54
 21.26

 Time
 36.0
 44.76

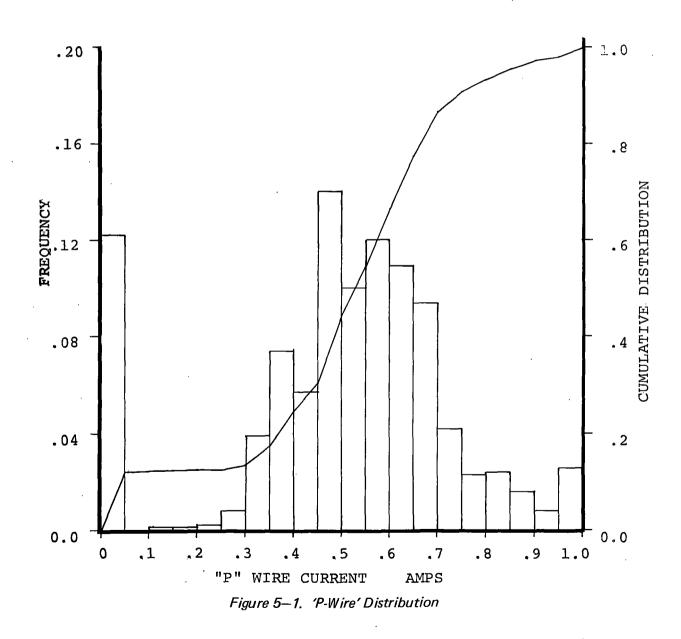
 Block Speed
 32.6
 28.5

 Station Dwell
 30.0
 18.1

 Station Space
 1.15
 1.25

32.6

State-Of-The-Art Car Revenue Service On CTS Windermere - Airport Line "P" Wire Distribution



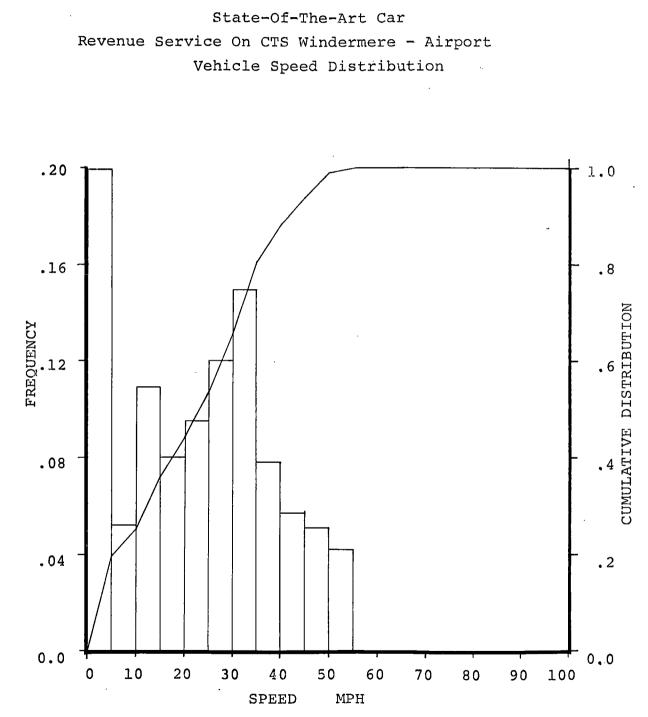
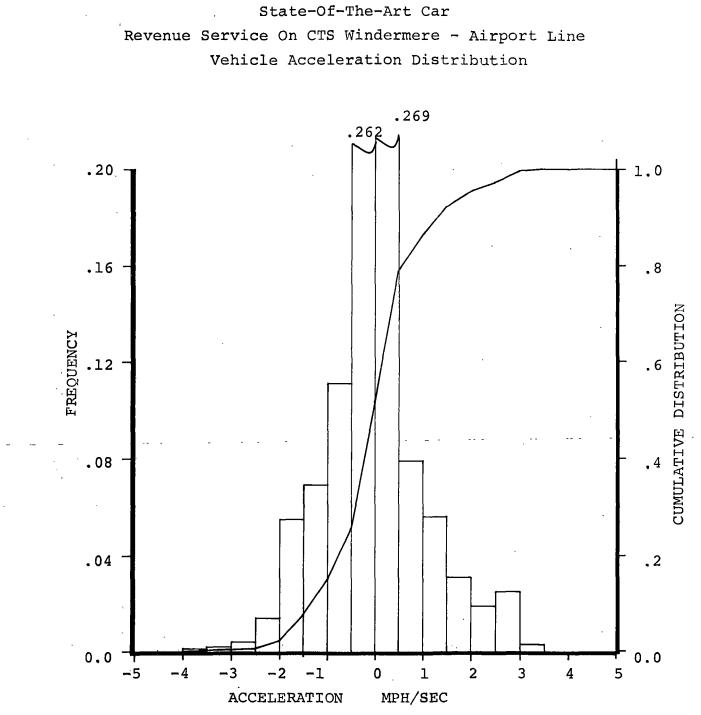
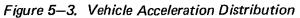


Figure 5-2. Vehicle Speed Distribution

B—18





State-Of-The-Art Car Revenue Service On CTS Windermere - Airport Line Journal Box Vertical Acceleration Distribution

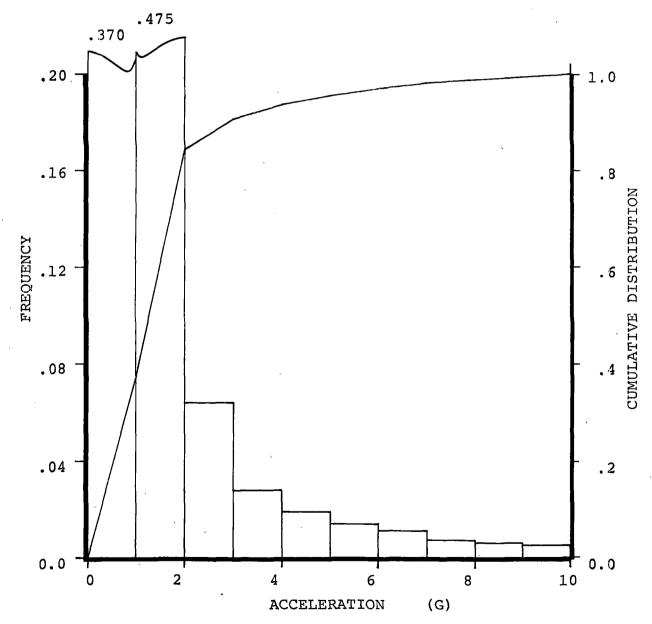
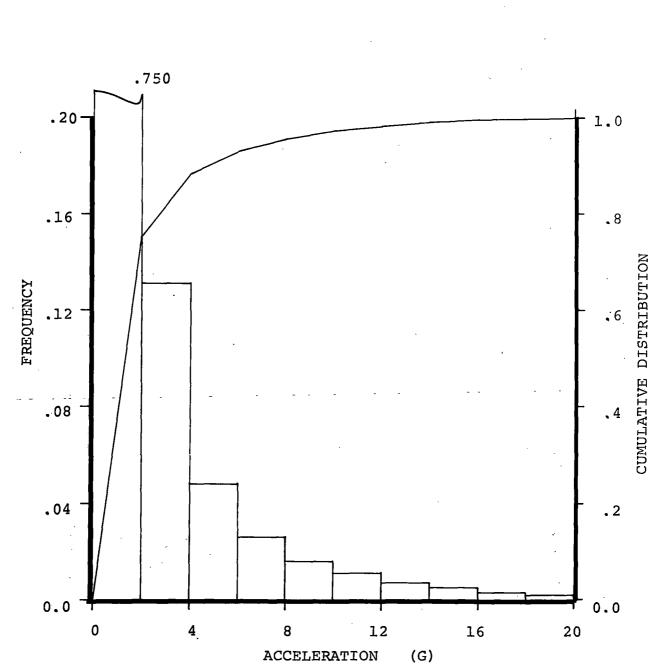


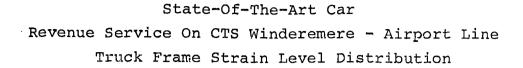
Figure 5–4. Journal Box Vertical Acceleration Distribution



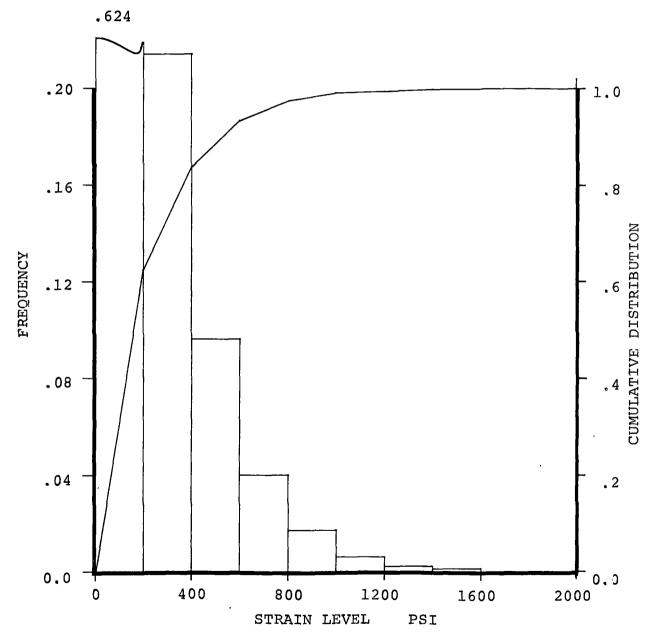
State-Of-The-Art Car

Revenue Service On CTS Windermere - Airport Line Journal Box Lateral Acceleration Distribution

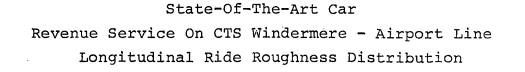
Figure 5–5. Journal Box Lateral Acceleration Distribution



1







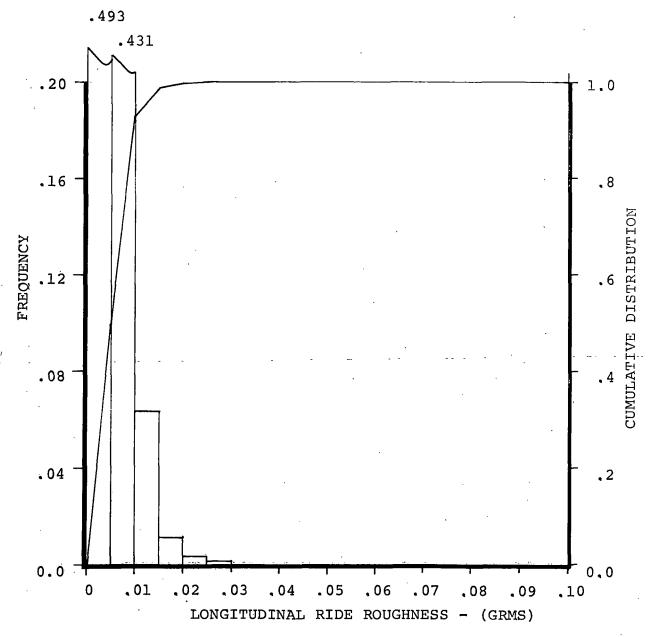
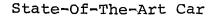
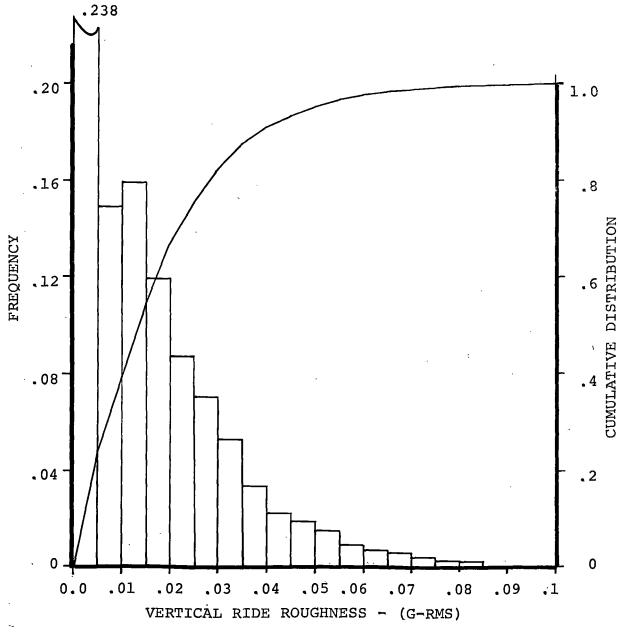
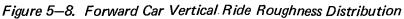


Figure 5–7. Longitudinal Ride Roughness Distribution



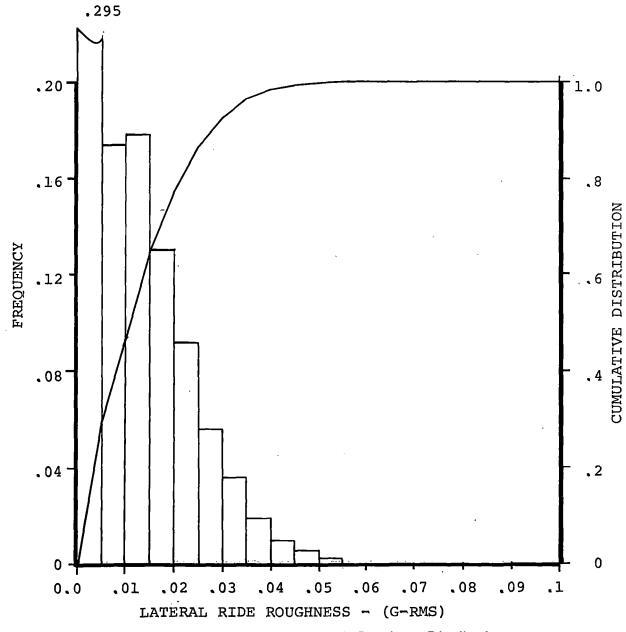
Revenue Service On CTS Windermere - Airport Line Forward Car Vertical Ride Roughness Distribution

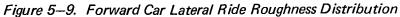


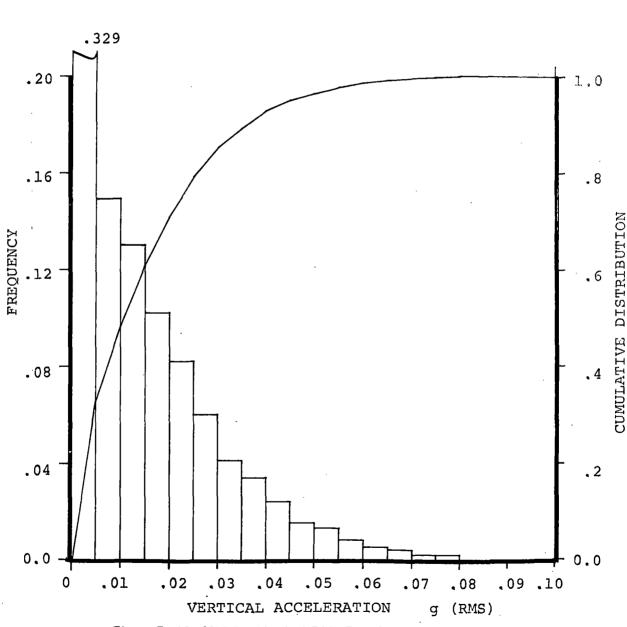


State-Of-The-Art Car

Revenue Service On CTS Windermere - Airport Line Forward Car Lateral Ride Roughness Distribution



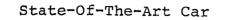




State-Of-The-Art Car

Revenue Service On CTS Windermere - Airport Mid Car Vertical Ride Roughness Distribution

Figure 5–10. Mid-Car Vertical Ride Roughness Distribution



Revenue Service On CTS Windermere - Airport Line Mid Car Lateral Ride Roughness Distribution

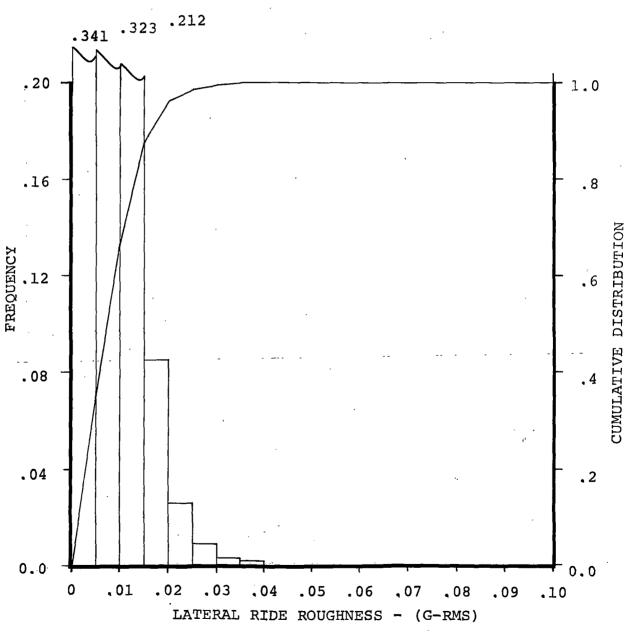
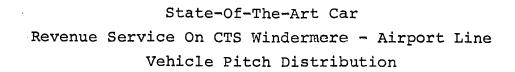
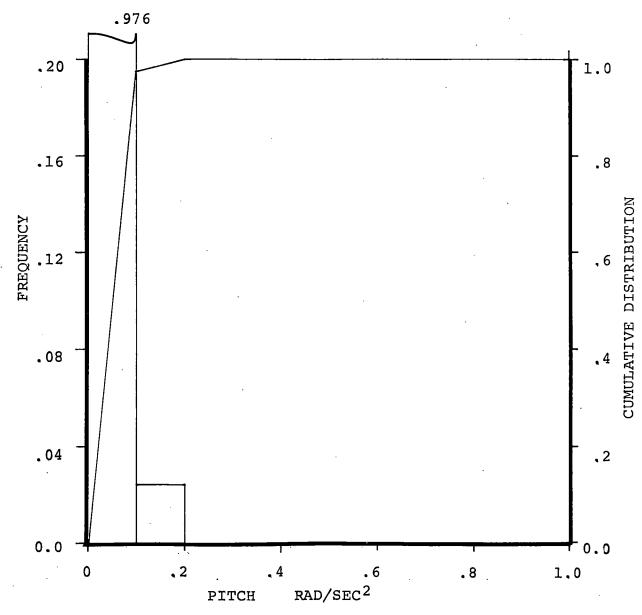
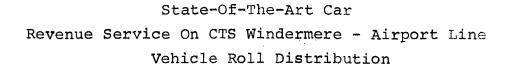


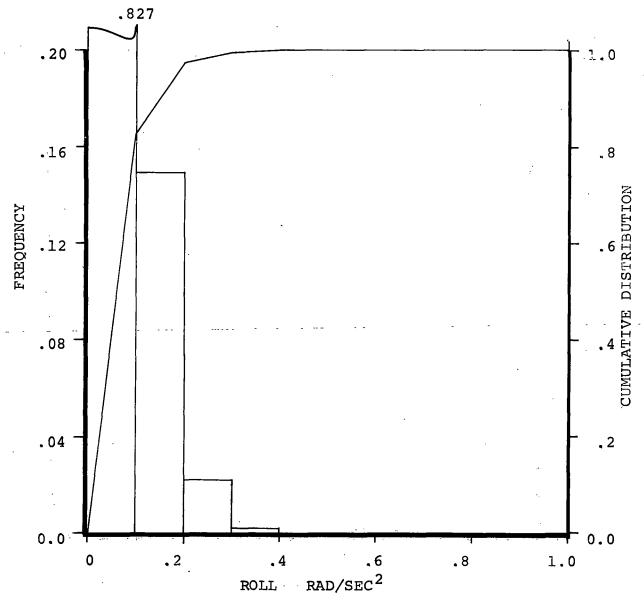
Figure 5–11. Mid-Car Lateral Ride Roughness Distribution





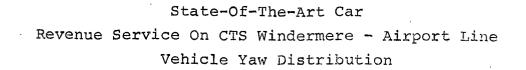


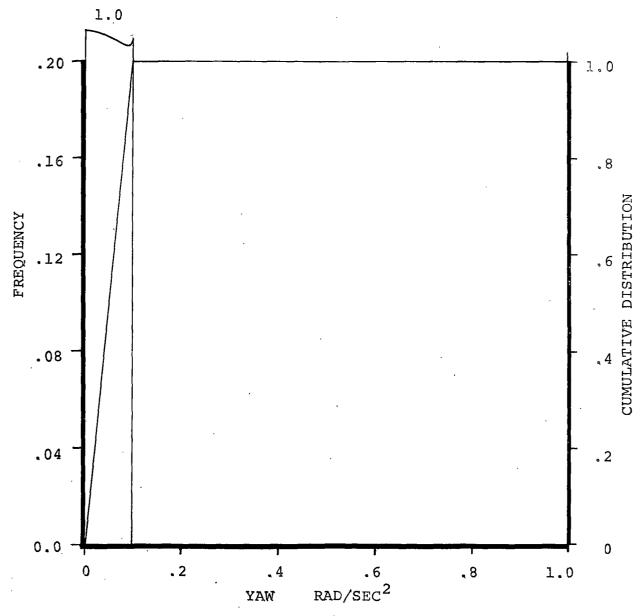






· B--29







B---30

State-Of-The-Art Car Revenue Service On The CTS Line Interior Noise Level Distribution

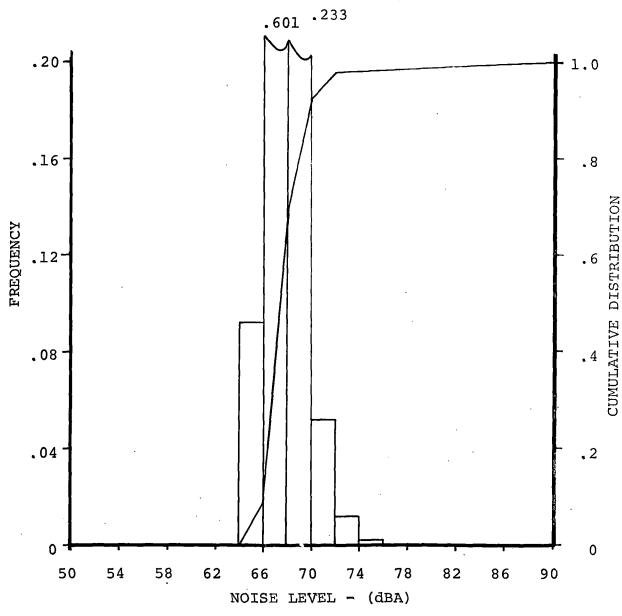


Figure 5–15. Interior Noise Level Distribution

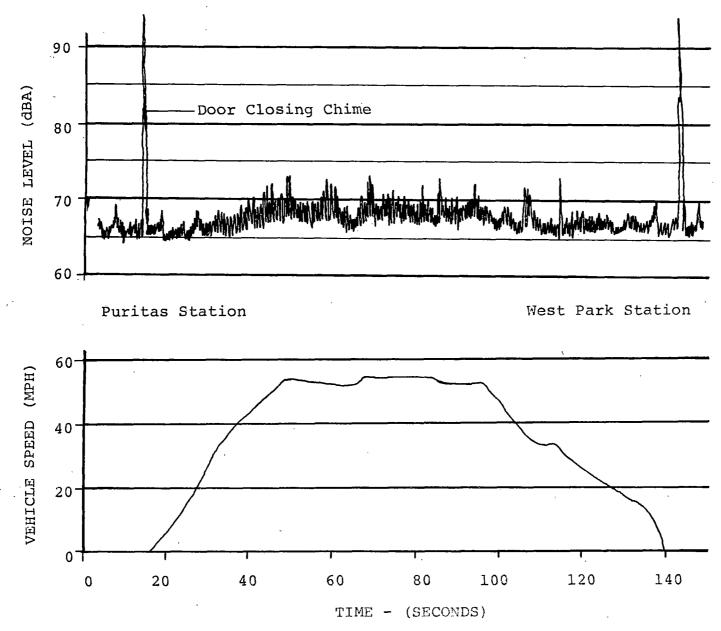


Figure 5–16. SOAC Interior Noise Level Sample

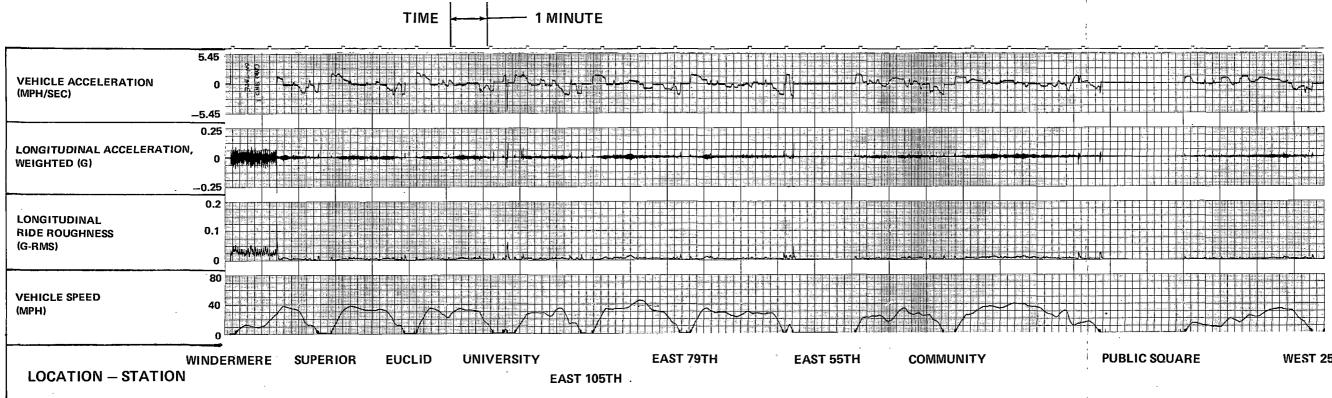


Figure 5–17. Vehicle Acceleration and Speed Time History Chart (WA) (Sheet 1 of 2)

WEST 25TH

1

.

.

, . ~ •

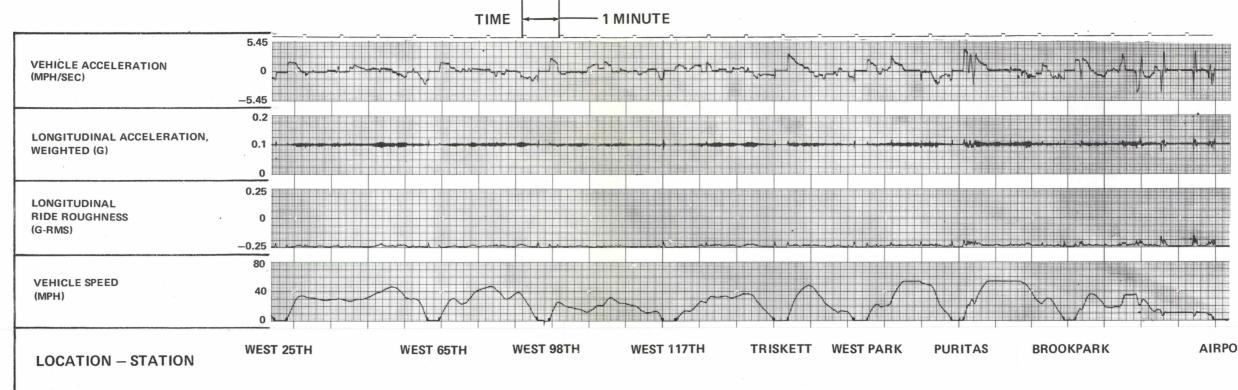
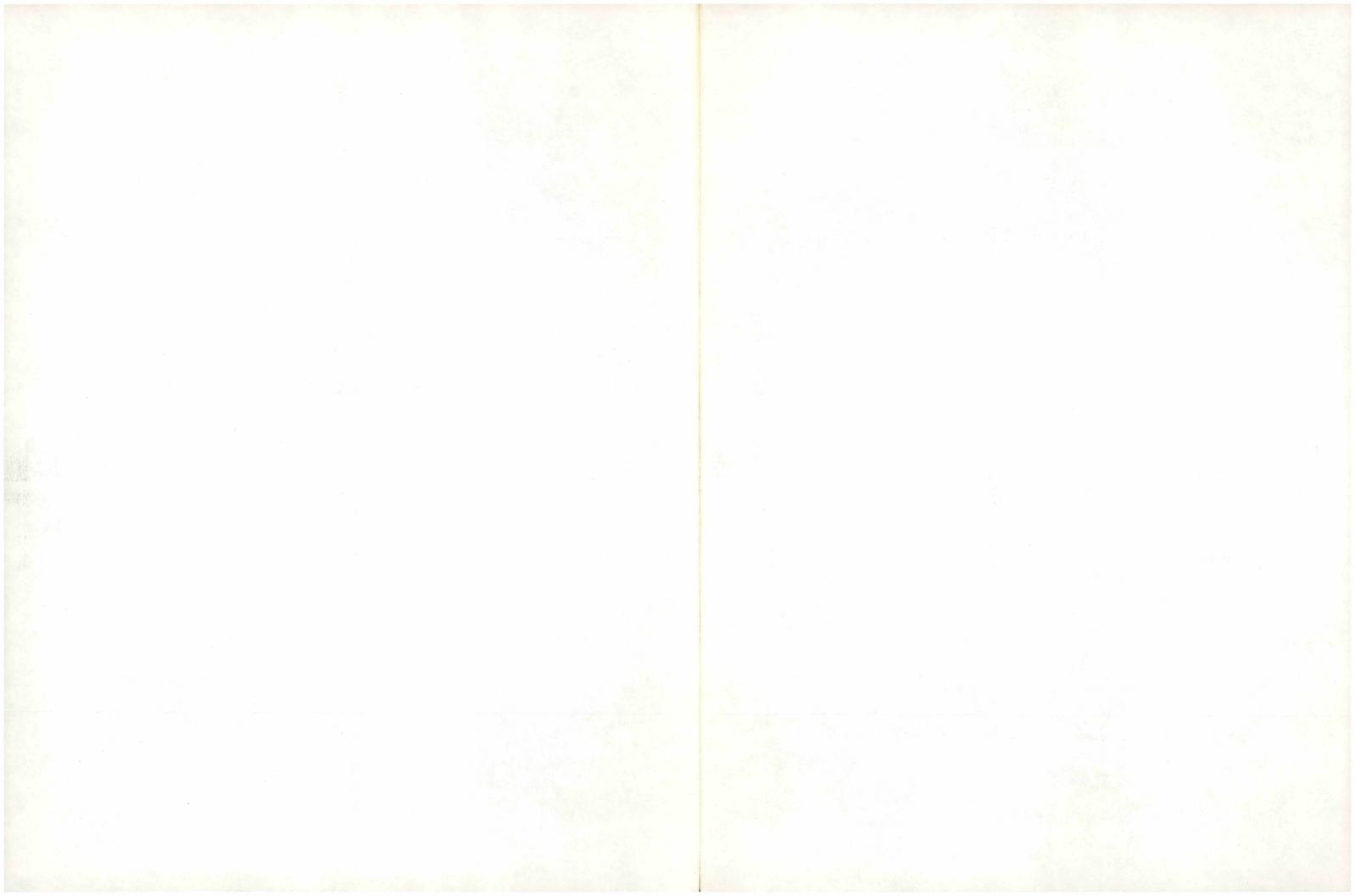


Figure 5–17. Vehicle Acceleration and Speed Time History Chart (WA) (Sheet 2 of 2)

AIRPORT



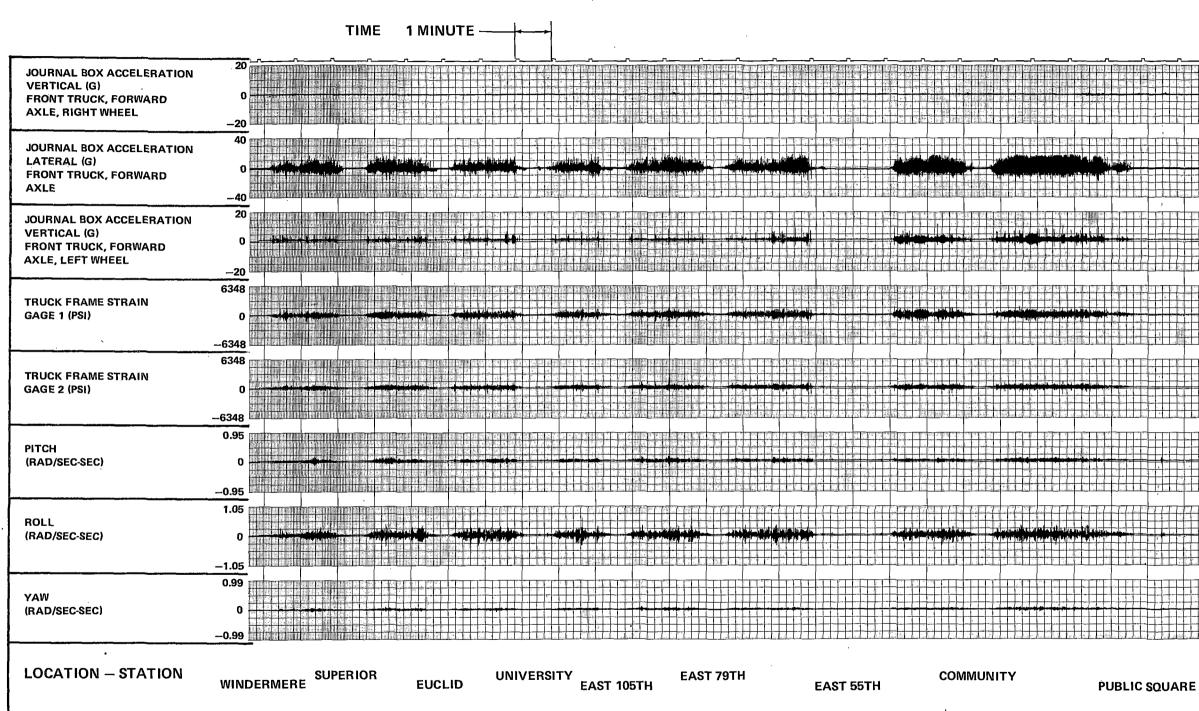


Figure 5–18. Journals, Truck Frame, and Angular Acceleration Time History Chart (WA) (Sheet 1 of 2)

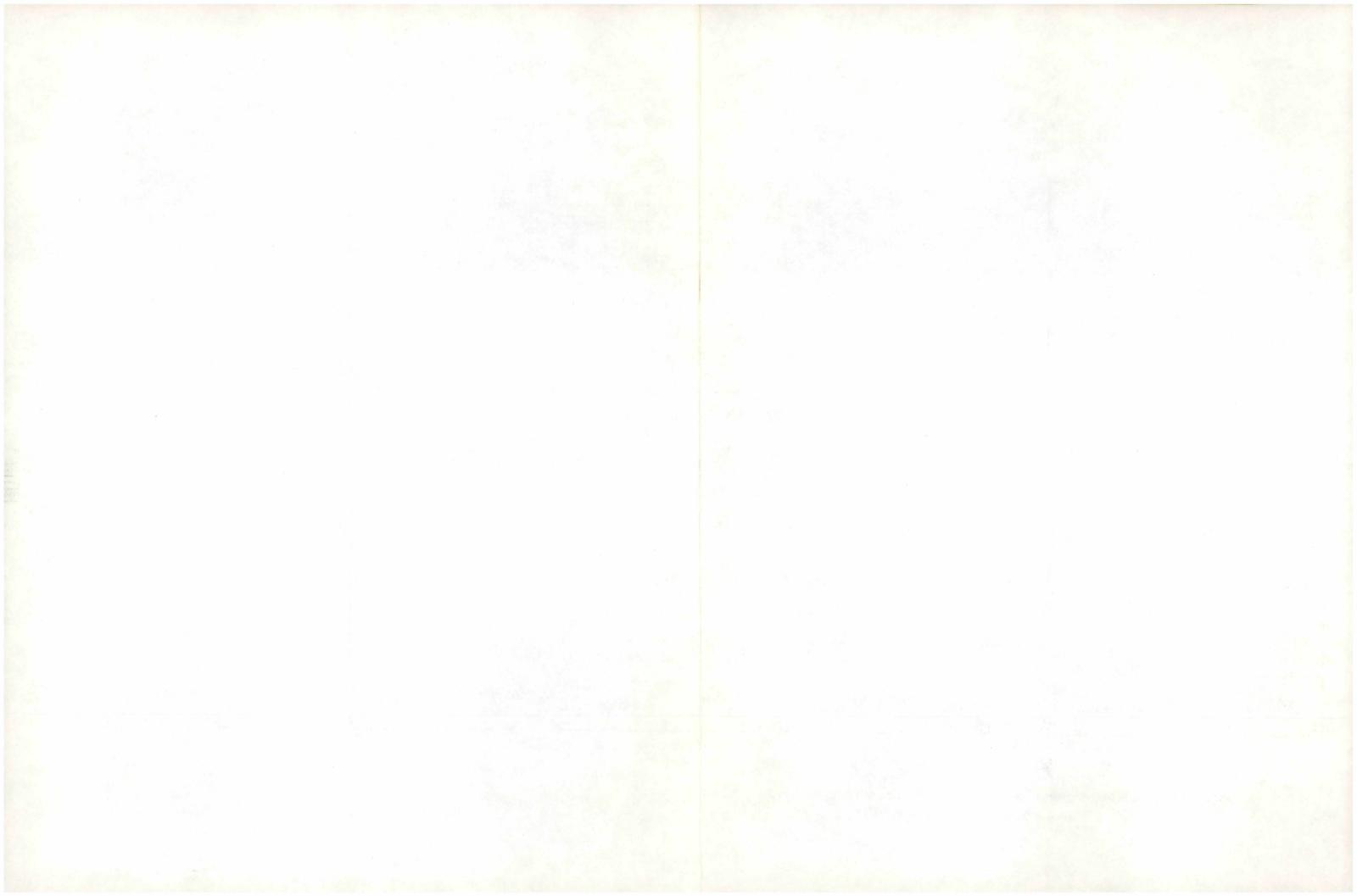
.

B--37

_		r	_				~	_			_	~					.					~_					~							_				_	_	_	~	_				_	_
Γ								1							D.	11		.8	1					.1	1												1										1
	1		_											-			_	-	_	-					_																			+		t	1
h	÷	ŀ	ŀ	┝	H			-			-	-	-		-	H	~	-	-1	-	-	1		1			5												1						:: <u>-</u>		1
F		F	1-	L	Π				Π	1			_	-	-		-	4	-	-			_				-	-	-		-	-			-			4	-				-	-		-	
ŀ	1	-		+						-		-			-							:				1	Ċ.		- 1 - 1																	12	1
			Γ																													Γ									T						
L	,		-				11												1			5			1.							Ĺ			T						1		1			1.	1
┝	╞	<u>.</u>	1	╞		-				_			-	H					-	-		-	-				-	1.2		1					-		12	1	_				-	-	-	ł	4
ŗ	t.			t			i.	1	11.6	J	Ņ			T	Ľ,	ji.	t,	H.	14	ĺĮ,	j.	T.	Ĩ				J.		17	10	T a	tu	-	13	d,	ш,						41		L.	-	Å	
┝	┝	÷			-	-	-		1	Η	T		-	1	1.	Π	1	-	- 1	P	Ĥ	Ŧ	-	1		-		H	Ť	T	70	ff		Ŧ		Π	1	1			Ī		Ţ				1
-			Ē					_		_				_	1			_															. 1														1
1	l	l	-		Ľ.,		40	<u></u>	i	1		<u>.</u>		سنا					<u>.</u>	d.	<u>.:</u> .		iii A	<u>l</u>		iig i	-	8. s			ali:	F		14	281	-		i;:	11		7	int:	21	21,0	8.3		5
r T	.	F-				- T	: -		- 1		-					-		-1						: .	. 1	en e				n pi	क		83	ti i				T		THE I					ar.		1
f	t	È-	Ľ	1	E	Ē				t-	E			Ħ				-	-	-			Ľ	1				H			t	Ľ								1		1		2		L	
£	L	£-	Ē	1	[-]	Ē	H	H	H		L	Ŀ	-	J.	-				_		1.1	÷t	-	Ľ													-		1	J.					E		
Ē	Г	Ē	ĩ	Ē	Γ	Γ	1										-				T.			Ē				ħ		1	T	Γ				1	1			٦	Ĩ			Ī	T		1
ŀ	$\left \right $	ŀ	ŀ	1-	ŀ			-			-	-	i		H	÷	Η	-	$\left \cdot \right $	-	\vdash	H		-				H			÷	╞	H	-	+	1	-	-		-	-		+				5
						i.			Зł.	241			4	÷							ء بير:										L						ĺ		1	Í			l	Ĺ	Ú.		1
																																				ļ											
[Γ		Γ.												-	Ξř.	_	q					П. 1															q			I					
-	Ξ.						1. 	-			-					r		-	-			-					-																				
-		-	-	-	-	- 14	-	-	1.	H	H		Ţ	ų	T.	ł.	-	-	÷,	ŧ,	ł,	ł	4	-			4	ini.	4	ŧ.	÷				÷,	W		đ						-			4
È	ţ.		-	L		÷												1		_			L							1		Ŀ				ł	1		1								1
\vdash	ŀ.		-			1		_	\square		-					e F	÷÷	-	-+	-	-			÷.,	-		1				╞	-	-		-									+			
		1.000	1	1	1.20														التناء				-				1					Г	1001		100											T	5
Г	1.	Г	f	ŀ					E I		1			8.					7					-6	ψ	E.L	7	1			1			1	÷	1						ė				┢	3
-	-	-		-		21					_	_			1				4		Ļ				_	-	-			-									-				_				-
		L	Ŀ	Ľ		÷				-			1	÷							Ë,	i.	0	÷	-					4					-	i.	-		a,					1			1
	1.	-	-	·			:			-		-	-+-		۲.					-				÷		+	-			-	-	F			-	1		ſ	-	-	+		-	÷			-
	1															-					1																										1
<u> </u> .						ii)	μų	<u>iid</u>	11.11		in:				ليب	÷			-		19	iui	-9				-		. 1	- <u>i </u> 3		-				4			_		-			î.,	-iliz	T	3
		r			— 7			The											e i						_		_		_		براد			1.77					24			cort i		1.12	- 15		a
F	t	Ŀ	ŀ	t	t	Ľ			÷		-		H		-	-			1			1			È		-		ł	-	1	ŀ				+				1							1
F	F	F	F	ŀ	Ē	H		П	H	-	H	Ĥ	44	H	Н		_	-	-		-	H	H	Ĥ	-	-7	-		J	-	F	E	9		Ŧ]		I	1			ł	-	F	Ŧ	ſ	
1	Ē	Ē	1			-						_																1		1	1		4 4 1					P		1	Ĩ						
-	ŀ		-	-	H	-		Η		-		-	-	-	H			-	4		-		ŀ		-	-	-		+	1	++	ŀ	Η		+		-	+	+		-	+	-	1		+	1
	i.	1	1	ŀ.,		T	Ľ.	i.																			1				Ľ		1						1	j.			ľ		1	T]
														_				_					L																								_
F	[Ļ	_	-	1			L.	4					-	7	1		7	7							7	7	1	7	Ŧ	T	1		1	4		1	1	1	7		4	1	ji			1
F	E		-							ция L	-		-	-			-	1	t			-	H				t	,		t	t	Ė			ł	+		·	T	j.	-	1		\pm	t		
-		-	ļ	P	H	-		-	ł		t,	-			-	-	н	ą	-	,	ł,	ł.		-	-	-	4	Ì		쎾	t,	đ.	2 1 4 1	н		ł.		I.		11	F)	200	ł	Ŧ	4		
	E		-	口		-		:	÷	i-i				-							L				.			1	1	Ê	ť	ľ	4		t	ť	ł	1	T	1	ſ			+	1		1
	-		-					 F.,		4	-		_	÷			-	4	4			-	-		_	+	-+	-+	+	+	F	1	_		-	+			+				+	4			-
	<u>.</u>		i	•	цц.	انيننا		ui.	0.1					لنس					÷-1		1.1		i-i-i			-1	٦		_	-1-	الله	t			ال	\dagger	<u>. (</u>		-	-46	Ť	-iili	-iil	<u>io lo</u>		ľ	2
	.	[-	m		1	-1	-1				H	-	-		-7	4	1	Ч	Т		-	-	-1	7	1	-	Т		Т	7	ŀ	- 1	- 1	Т	+	- Tr		- - -	- 10	-	51	- Tr	T	- Tri	+-	3
E	Ē	-	1					÷								_		1	1					-	_		1	1	1		t	Ľ		1	+	1	Ť	ļ	1			1	1	Ť	ľ		
ŀ	Ŀ		F	Ŀ		Н	$\left \cdot \right $	•				-				-			-	-			H	H		+		_	-	+		L	H		\pm	\pm			1	-			+	+	ł		-
_			Ĺ	_				_					_						4		_	_			-	-	-		-	Ŧ	F	Γ			Ţ	Ţ	1	T	1			1	Ţ	Ţ	T	4	-
F	E		E					C.,			H		-			_			\pm				H		_	1		+		-			H			+	1	+	+	╈	1	1	+	+	1		1
<u> </u>		:: <i>:;</i>	i		5.7				. in	ų,	i					<u>.</u>		-1	J]		цњ.			J	1	1	1	J	T]	aili		J	1	I]	d.	J	_	jje H	10	4

WEST 25TH

WEST 65TH



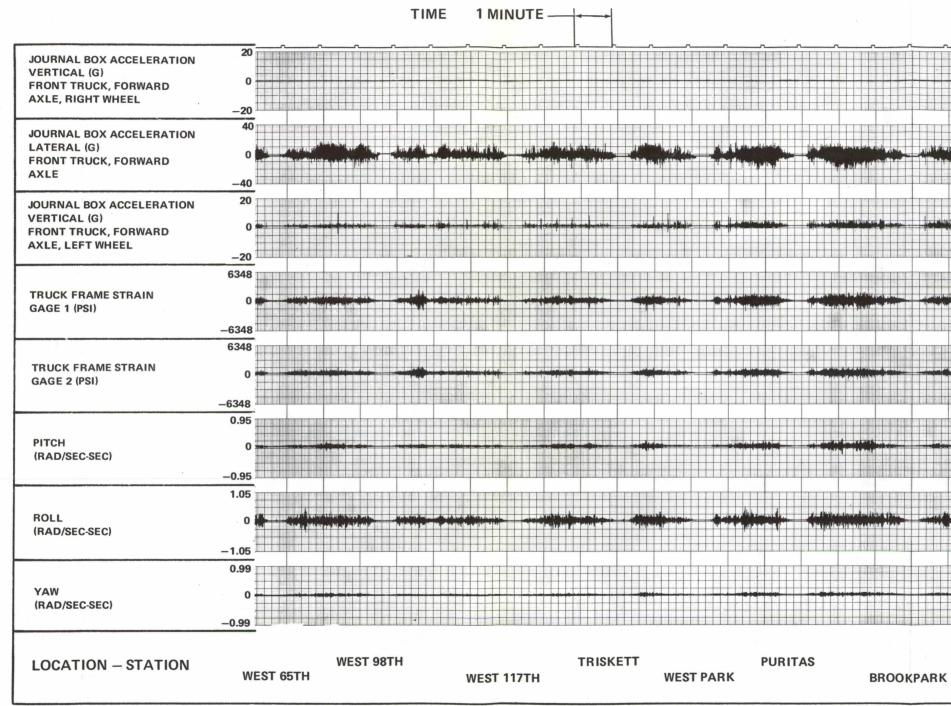
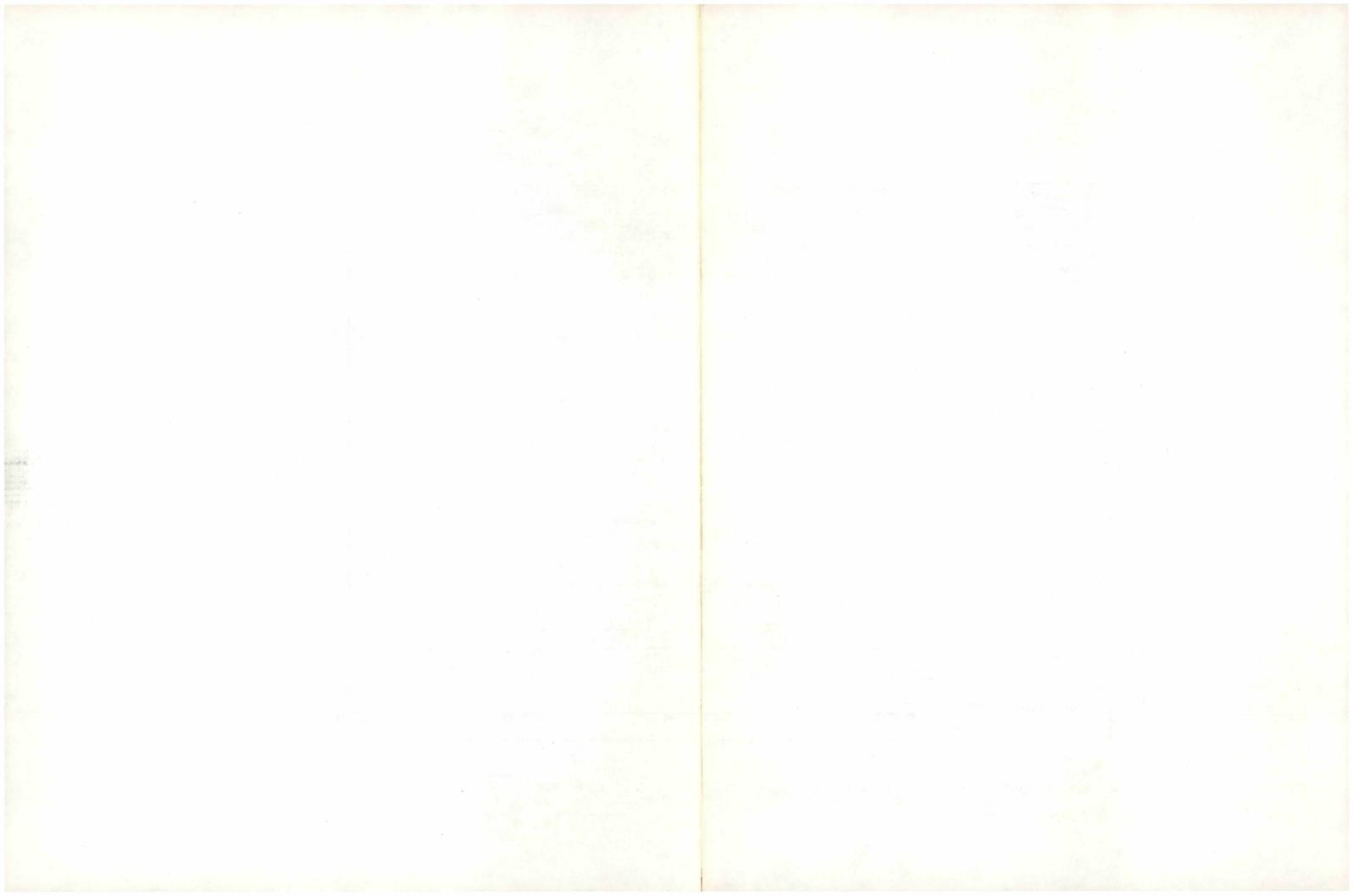


Figure 5–18. Journals, Truck Frame, and Angular Acceleration Time History Chart (WA) (Sheet 2 of 2)

			-					-					-					-	
	100		-				p					1							
1																			
1	-											-						-	-
-	-	1	-	-							-	-						-	-
•	-	-	-	-	-			-	-	-	-	-	-	-			-	-	-
	-	-	-	-	-	-	-	-	-		-	-	-			-	-	-	+
1	-	1	-	-	-	-	-		-	-		-	-		-			-	-
		-	-			-					-	-	-					-	-
1			1			1					1			111	1			1	-
				L										_		_			
	1			1													1		
		-																	
	4				L,		4												
l	a.			he	1			4	1.0	1	h.				1				1
1		-					4	1	-		.1	1	1		Ċ,	1	1	Ľ	
1		1	12		[ľ	1	1												1
1																			
						3													Γ
	_		_				_	_		_		_				_		_	
1																			
1			Γ.			1													
ļ		T.	N) I	th,	1		100		16.			L		Pere	1				1
1				11	T	1	1		1		T	ſ			1			1	Ľ
						Ľ													1
		t									H								1
į	H	ti i					H		H			F							F
1	niil	nill	6 61	1		niil	1111	1111	111	Hill		niil	1111	-	1111	1111	1111		٣
1		m																	
		-	f									f							F
							H												
į		100				1													ŀ
ģ					-					-	-					-	-	-	-
ļ		(T	1	Ľ		Ľ	F								1				-
		1	-														-		-
1		-	-									<u>III</u>							
i		00	100				Li li				1				111				F
1		I.	Į.				Ш			Ш	цŰ								L
		f i													1				
1																			
ġ			F.					-		-	-	-		-			-	-	-
ļ	LÍ.	Ľ			L)	UĪ.	UÍ.	Ű	U								L.	Ú.	
1																			
Ĩ	-	-	1							-	-	-			-		_		
												_							
1																			
1																			
ĺ																			
							μų	-											-
f																			
ĺ																			
1	mi	titii	mi	mi	uni	mi	uni	utti	mi	uui	1111	mii	urri i	- mi	-tri	mi	uri	rmi	-
1		1111																	
									1111										
j									-										
1										-						-	-		-
			ь			1			1										
													1						
			_					_										_	
1																			
j																1			1
1																-	-	-	T
			1.5																1
																-			
J																			
1	111	1111	1111	1111		uiii						1222		1111					

AIRPORT



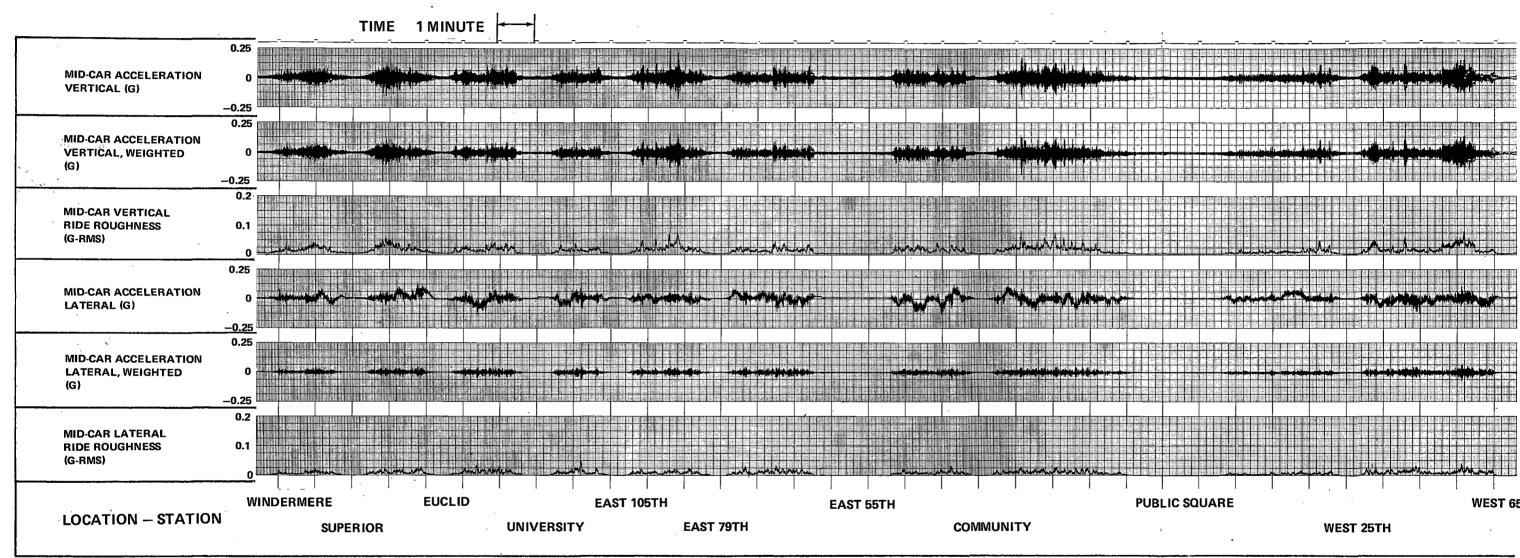
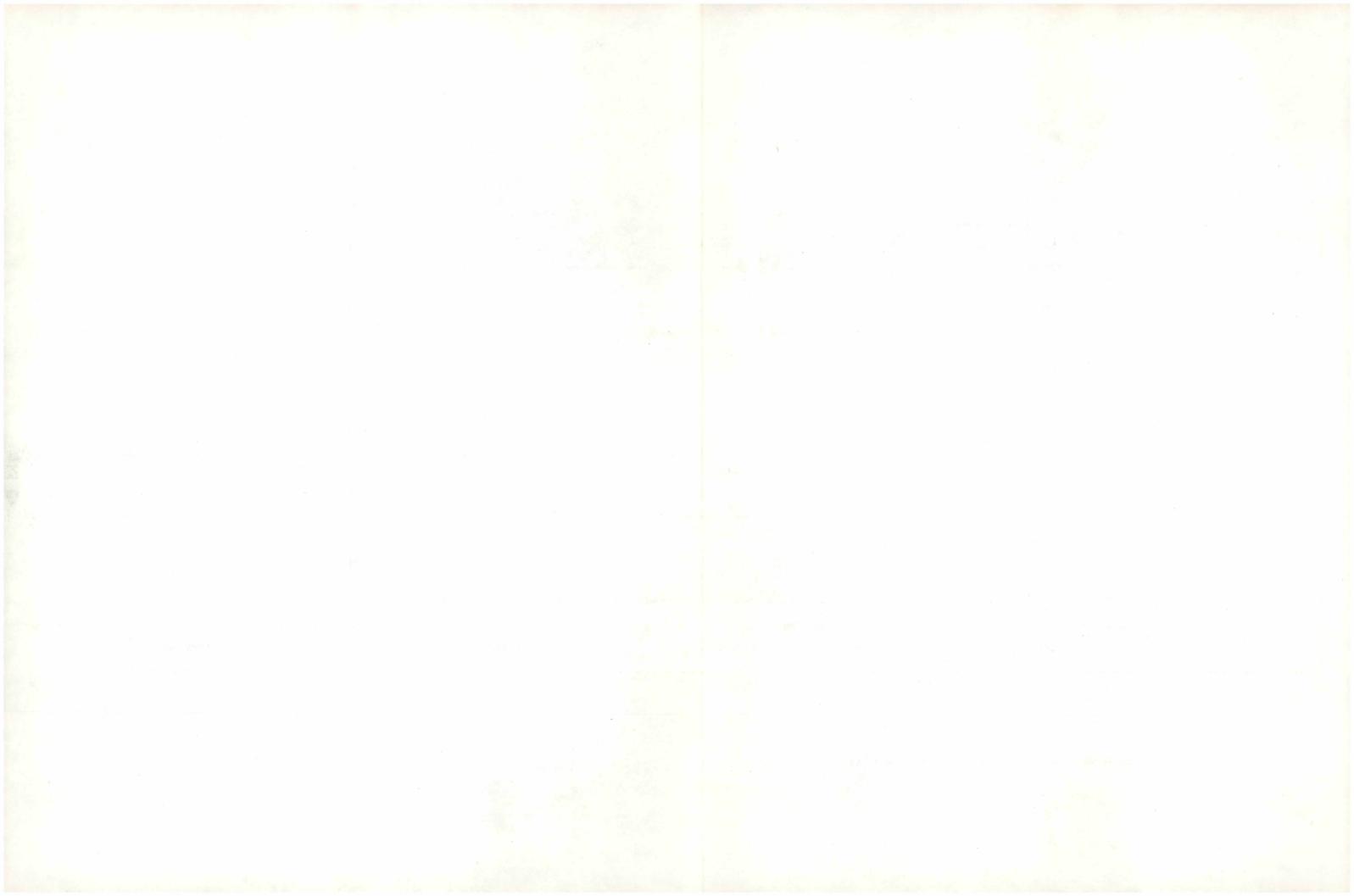


Figure 5–19. Mid-Car Acceleration Time History Chart (WA) (Sheet 1 of 2)

- - |

WEST 65TH



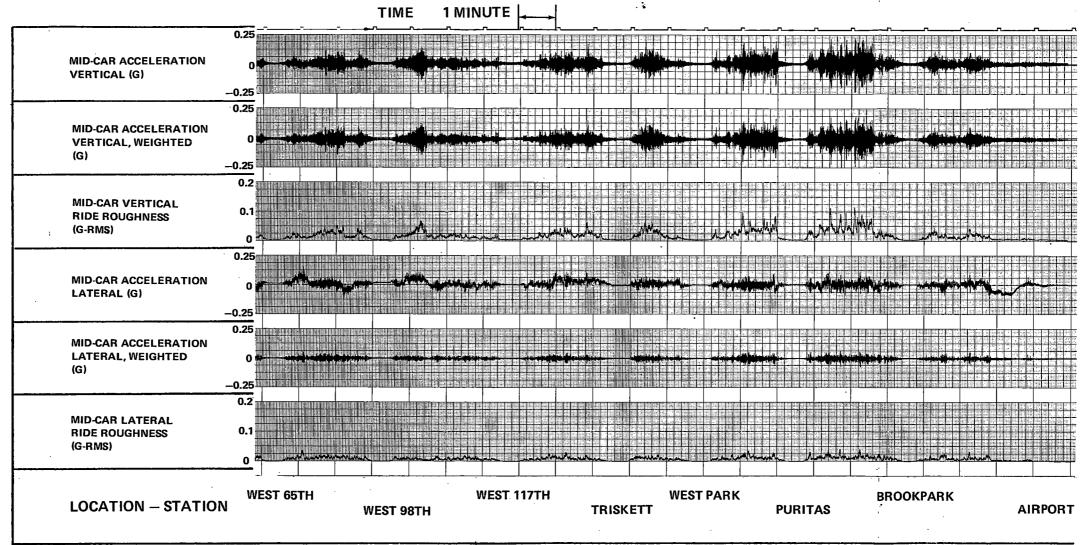


Figure 5–19. Mid-Car Acceleration Time History Chart (WA) (Sheet 2 of 2)

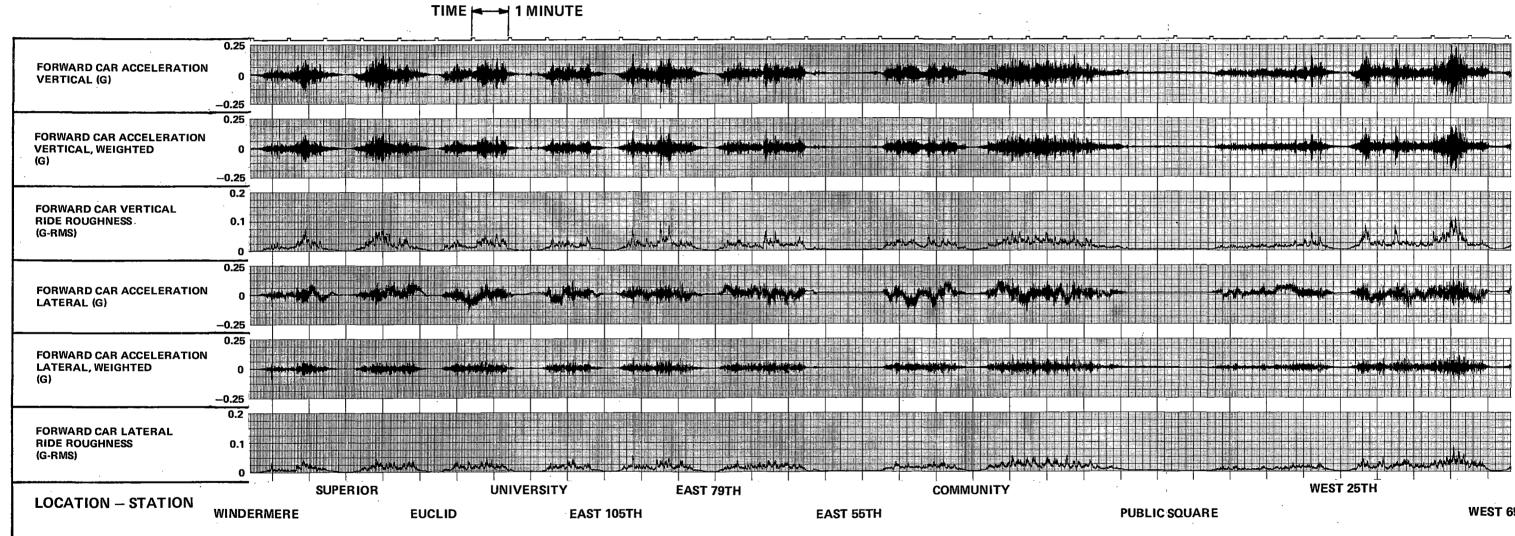


Figure 5–20. Forward Car Acceleration Time History Chart (WA) (Sheet 1 of 2)

B--45

WEST 65TH

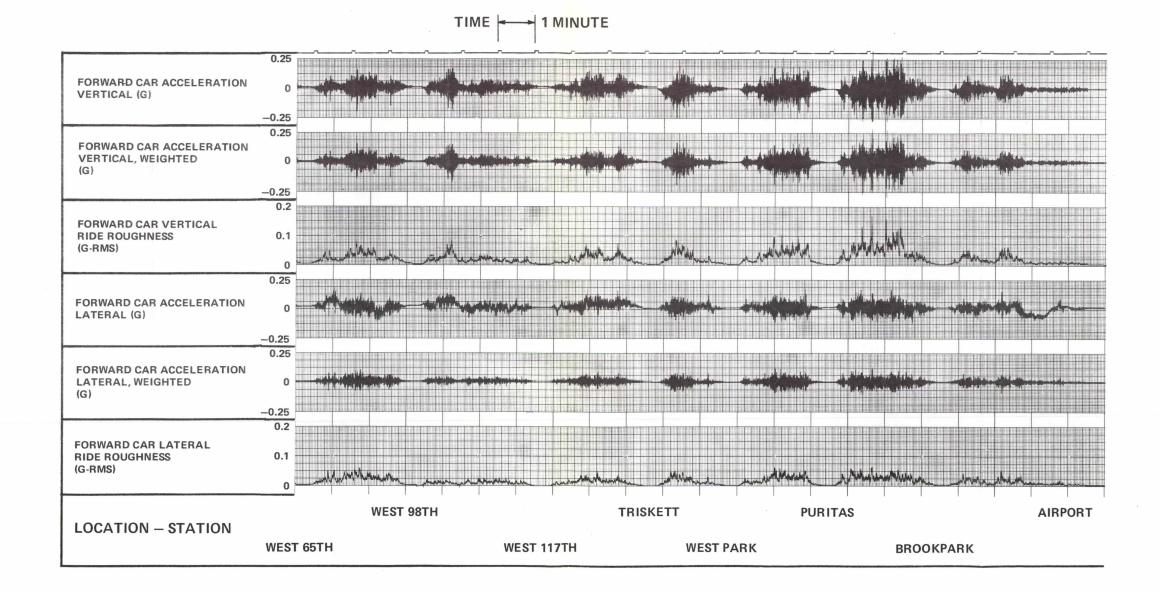


Figure 5–20. Forward Car Acceleration Time History Chart (WA) (Sheet 2 of 2)

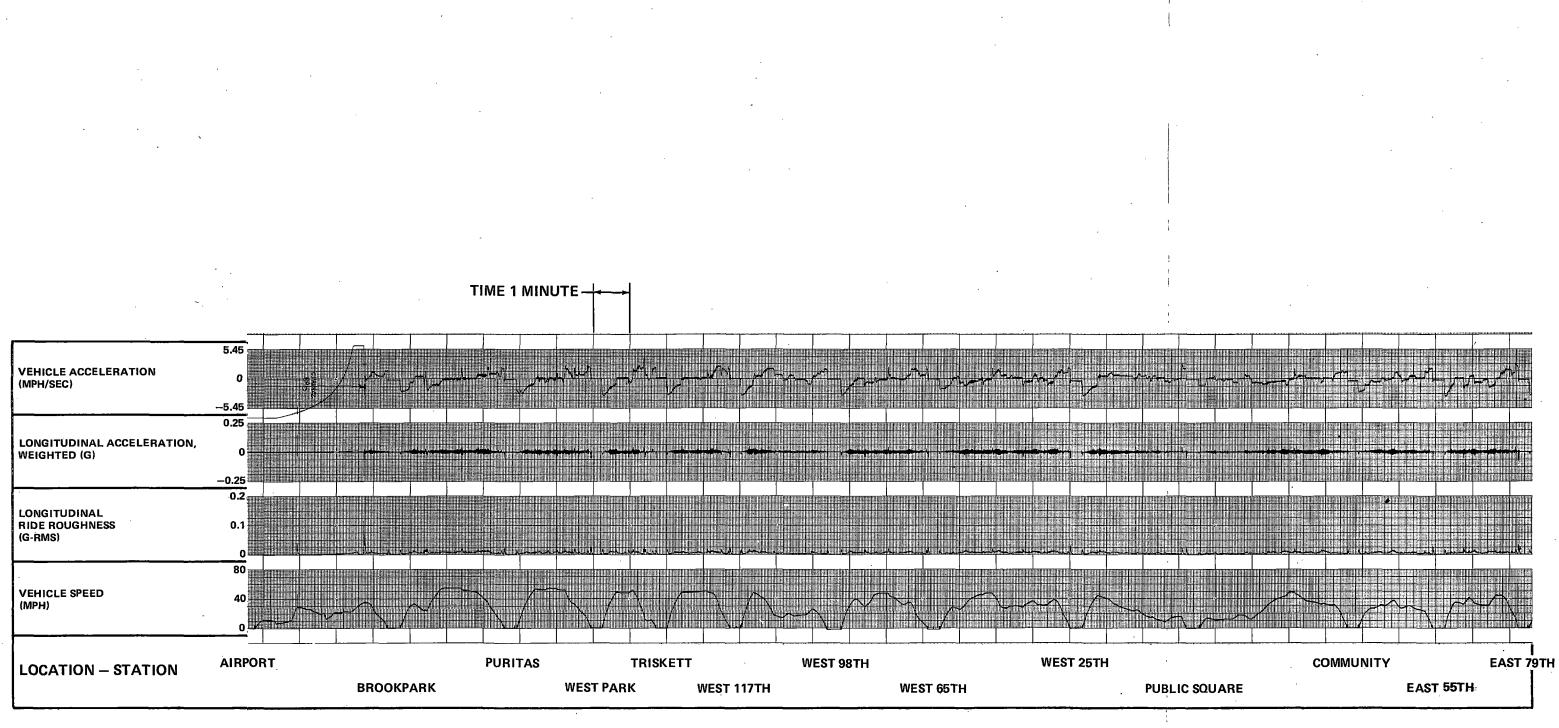


Figure 5–21. Vehicle Acceleration and Speed Time History Chart (AW) (Sheet 1 of 2)

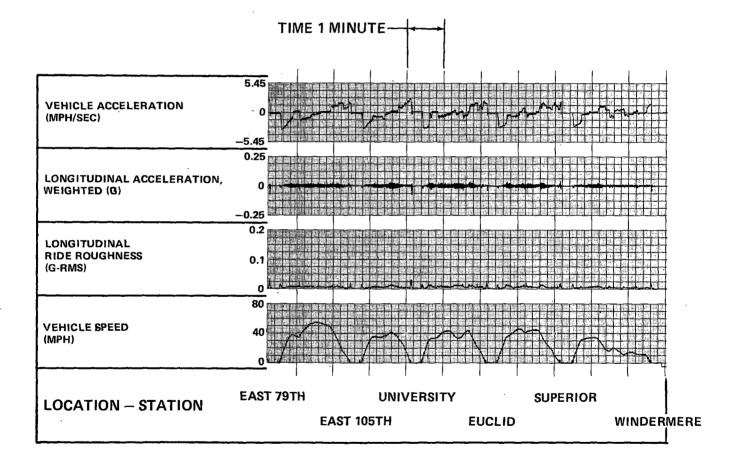


Figure 5-21. Vehicle Acceleration and Speed Time History Chart (AW) (Sheet 2 of 2)

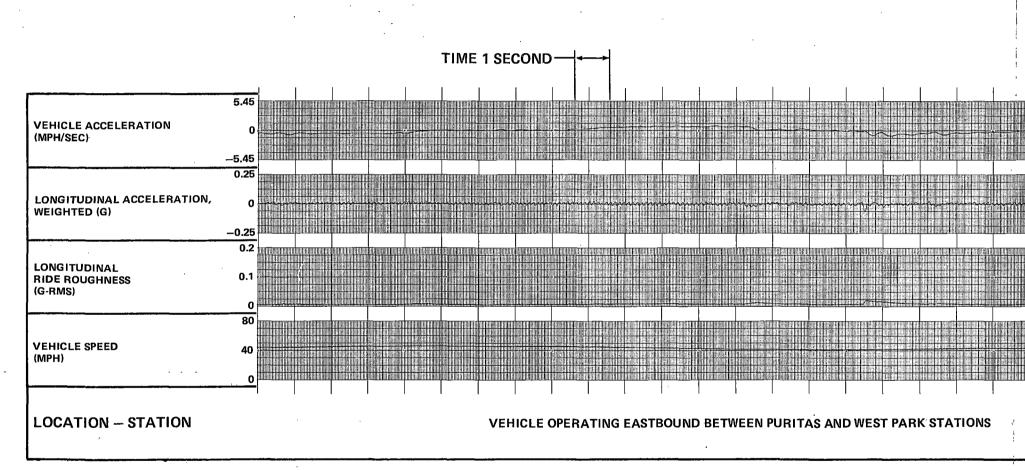


Figure 5–22. Vehicle Acceleration and Speed Time History Chart (~)

100 100 100 100 100 100 100 100 100 100	
	ļ
of the second se	
	l
	I
and the second s	

the second second second second second second second second second second second second second second second se	
and the second se	
PARAMETER AND A PARAMETER AND A PARAMETER AND A PARAMETER AND A PARAMETER AND A PARAMETER AND A PARAMETER AND A	
the second s	
	1
	ł
	IB
	I
	ü
	Ŧ
termination of the local division of the loc	
and an other states and and and and and and and and and and	
	ł
and a second sec	ĩ
	ï
	ï
	÷
	1
	Ľ
	H
	:
	1
and the second s	
	4
	ŧ
	1
	÷
	1
	The second secon
	The second s
	the state of the s
	the state of the s
and an an an an an an an an an an an an an	
and a second sec	
A DESCRIPTION OF A DESC	and and and and and and and and and and
	A T T T T T T T T T T T T T T T T T T T
	111

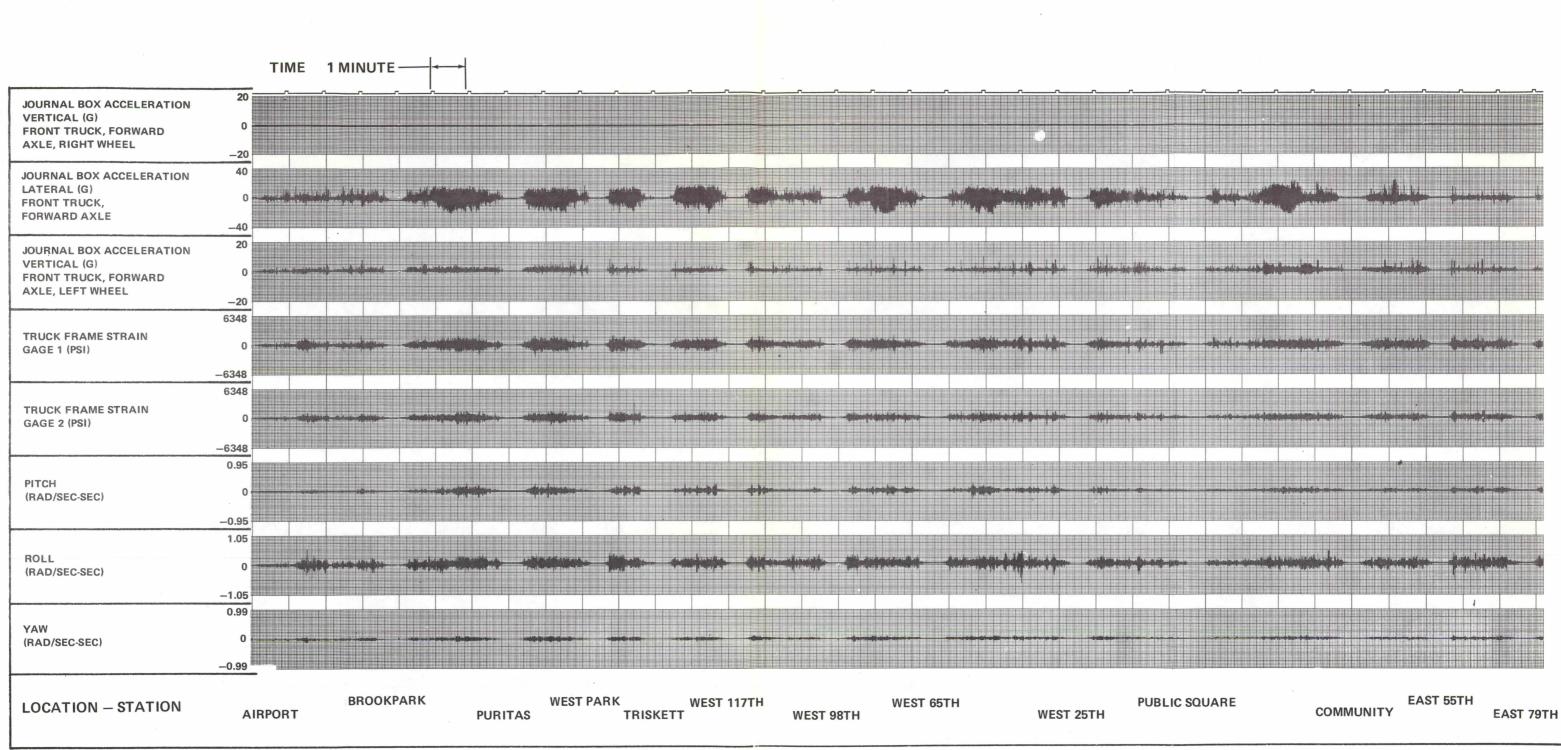


Figure 5–23. Journals, Truck Frame, and Angular Acceleration Time History Chart (AW) (Sheet 1 of 2)

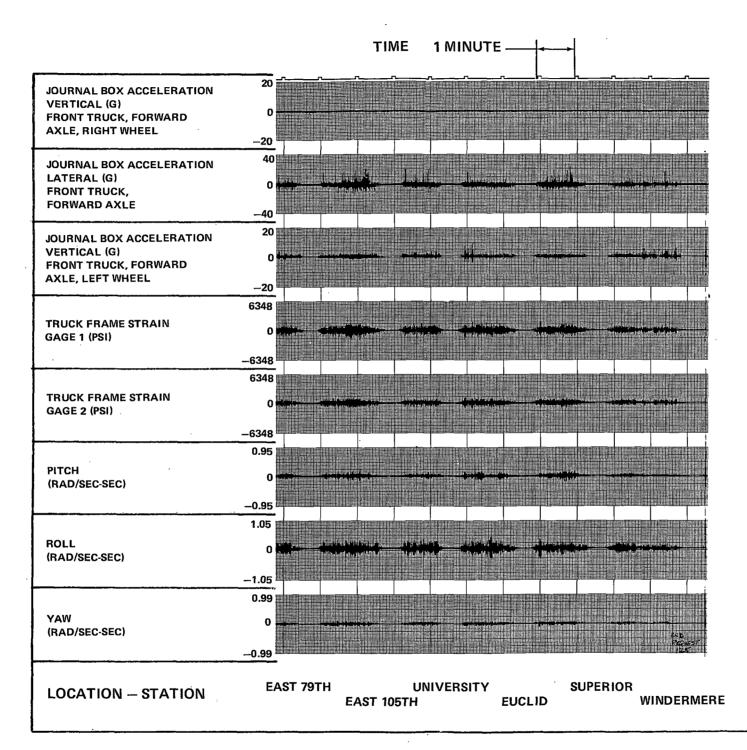


Figure 5–23. Journals, Truck Frame, and Angular Acceleration Time History Chart (AW) (Sheet 2 of 2)

B—57

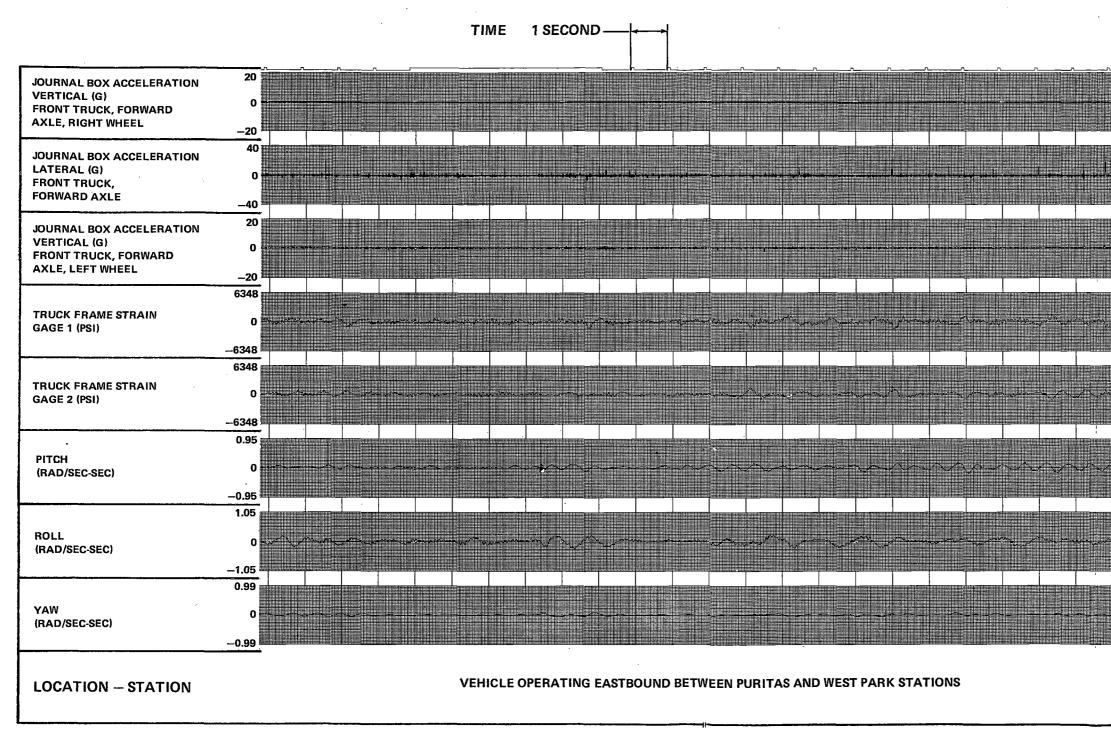
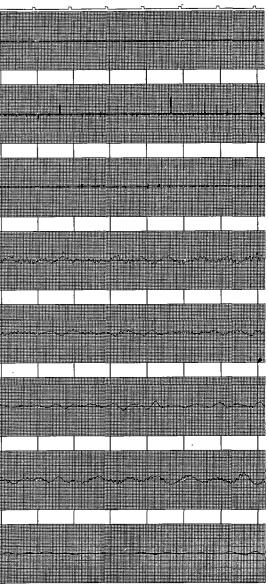


Figure 5–24. Journals, Truck Frame, and Angular Acceleration Time History Chart (~)

B--59



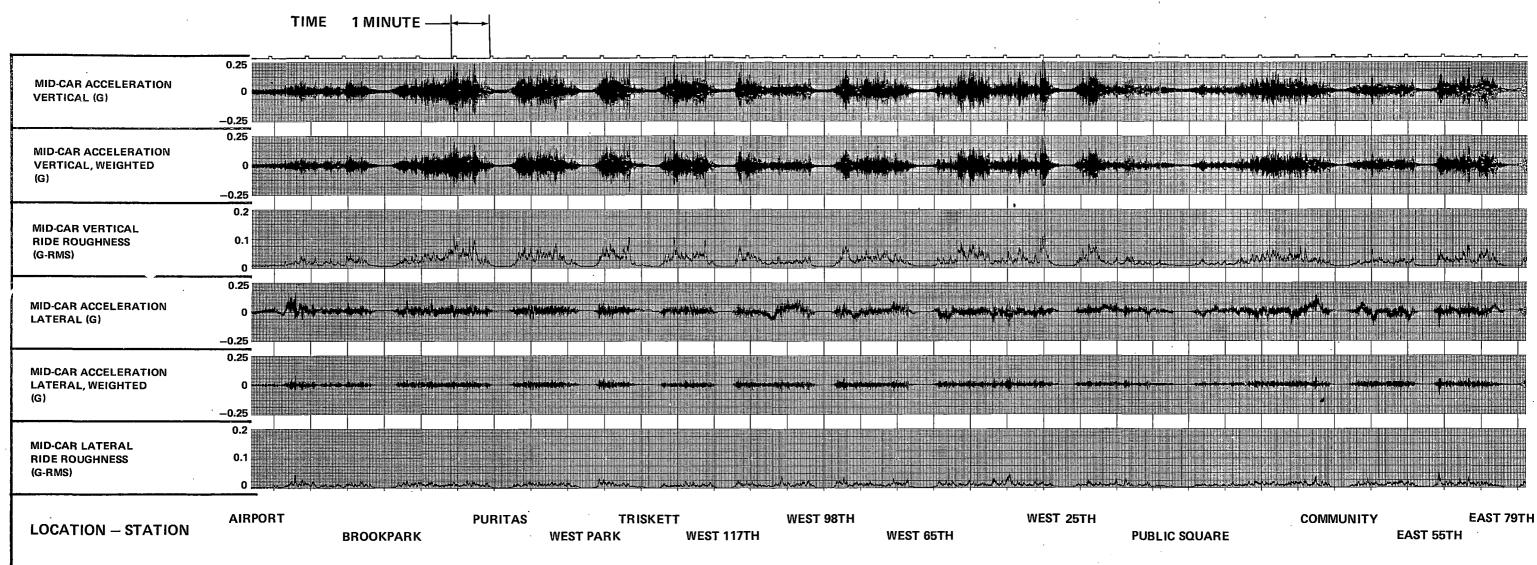


Figure 5–25. Mid-Car Acceleration Time History Chart (AW) (Sheet 1 of 2)

B--61

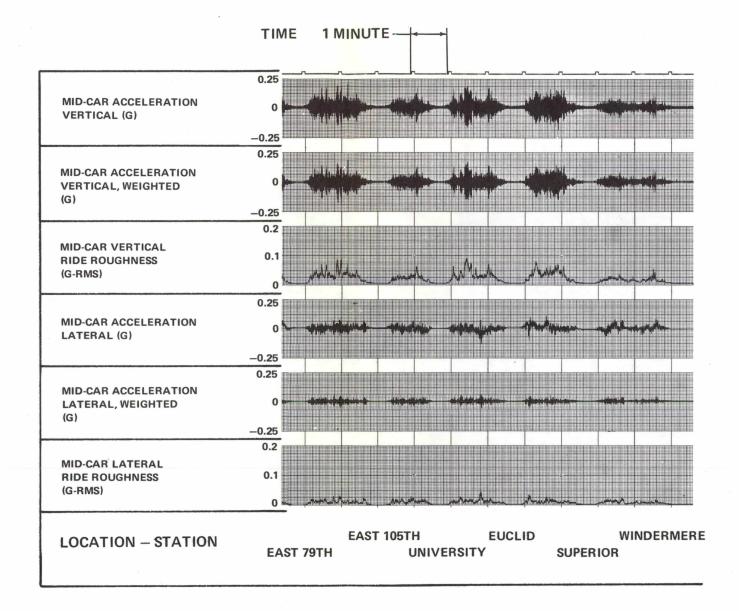


Figure 5–25. Mid-Car Acceleration Time History Chart (AW) (Sheet 2of 2)



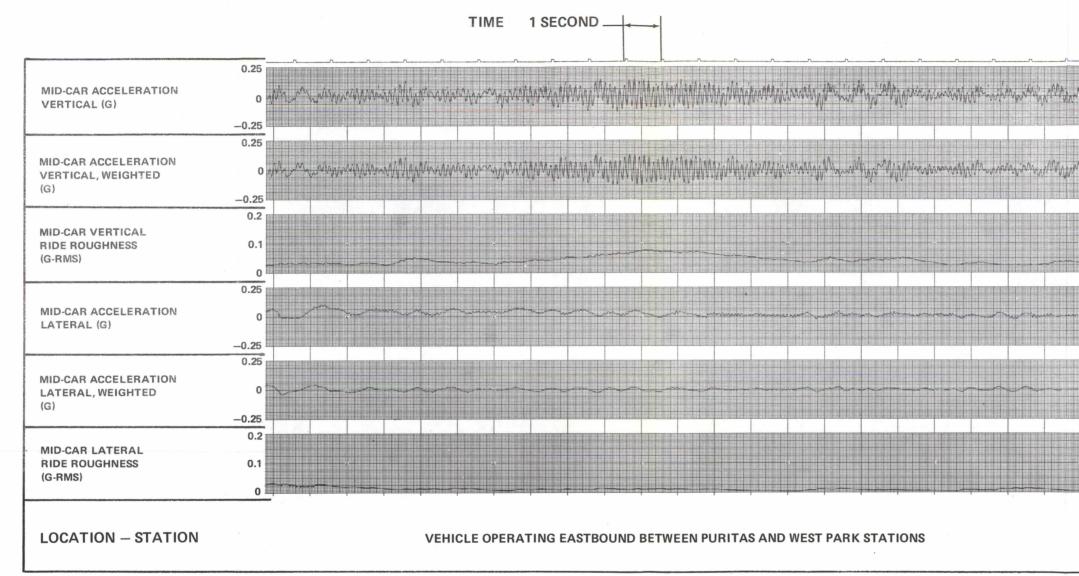


Figure 5–26. Mid-Car Acceleration Time History Chart (~)

~^					
⊳ M∖(st WP	MALAIM		MANNA	Manart
1 .	1			1	1 1
M.MM	wyW	AWAMA	~My	Manyal	Marthor
÷.					~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
	~~~		~~~~~		
		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	-		
					·~~^`
				2	

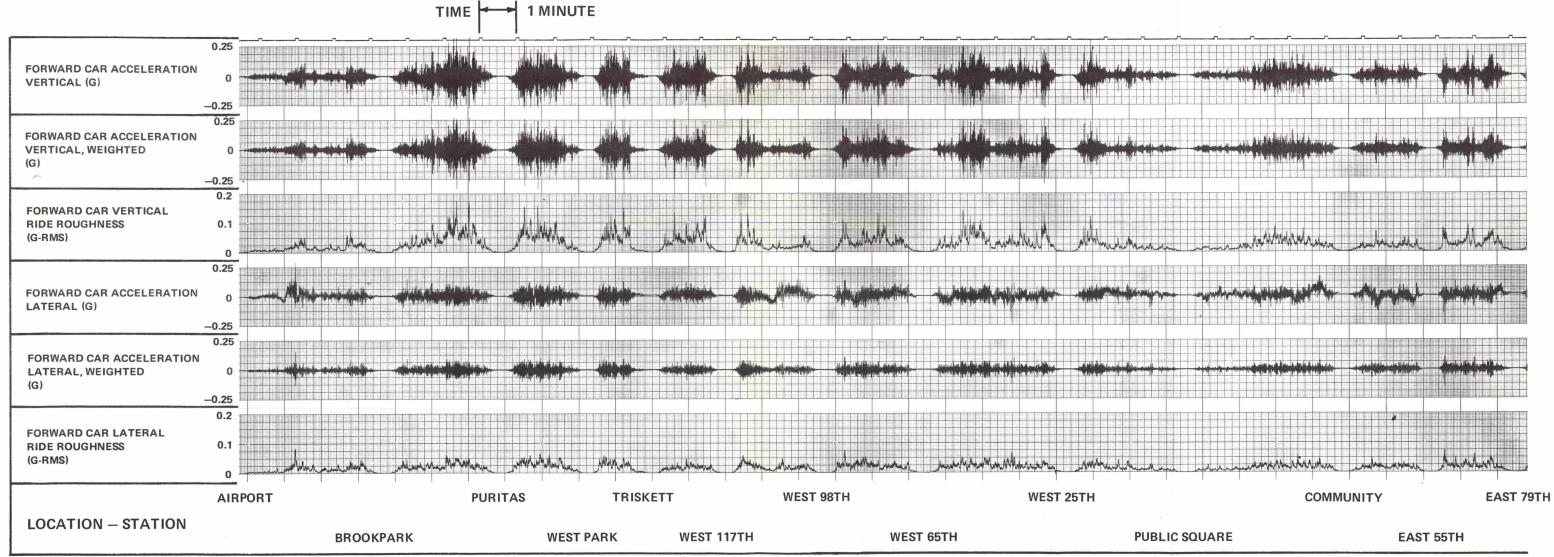


Figure 5–27. Forward Car Acceleration Time History Chart (AW) (Sheet 1 of 2)

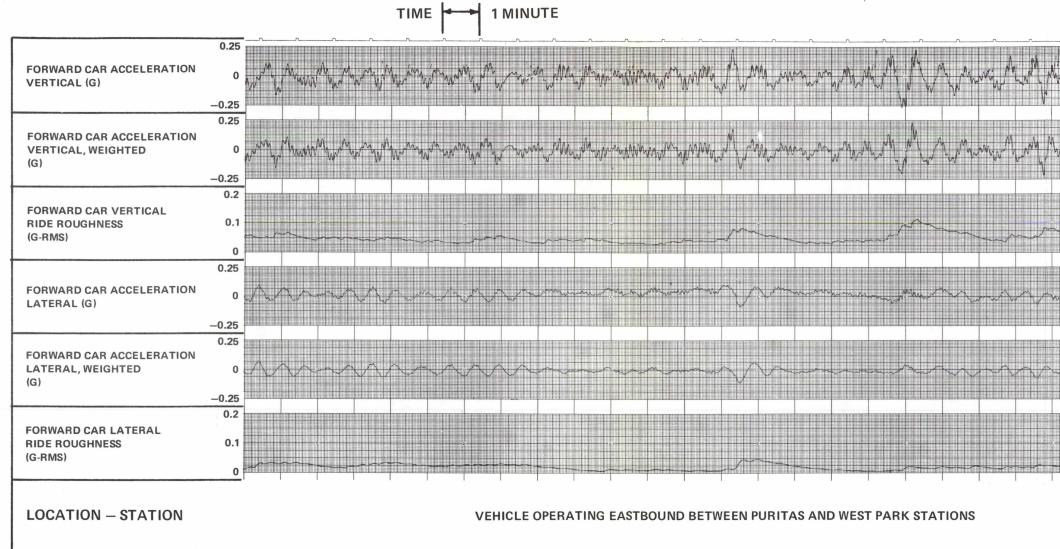


Figure 5–28. Forward Car Acceleration Time History Chart (~)

		r			r
	Â			I L	k
	. /		-		2 A.I
		- M I SAA		/ I // (e/Ne.
NTY MA		1 4 MV	Ŋ.		
<u> </u>		J VY	1		
			The second second second second second second second second second second second second second second second se		9
	A			1	
				Д,	A
	M	Ma Lata	M		1 L L
NY MUNA			NY		
1	M/ 1	/Y`	Y W	- W - 1	
					ny .
	p/			AA	n.
X	\rightarrow		~~~~~	/	
	~~				
		my m	e de la composition de la composition de la composition de la composition de la composition de la composition d		
ww	n www. w	n y	ų n _e ne vi	his The	Mujumayor
				~	
an and			han the second	ñ./ X./	ᠬᡃᡃᡞᡒᡘ᠊᠁
				*	
	1			1	1

	0.25			╶╱ ┾╿┾┨┧	╟╧╧┦					
FORWARD CAR ACCELERATION VERTICAL (G)	0						ulas isi			
FORWARD CAR ACCELERATION	0.25									
VERTICAL, WEIGHTED (G)	0 – – – – – – – – – – – – – – – – – – –									
FORWARD CAR VERTICAL	0.2									
RIDE ROUGHNESS (G-RMS)	0.1									
	0.25									
FORWARD CAR ACCELERATION LATERAL (G)	0		PPP PPPPP Residuality				RT, F Lina			
, ,	-0.25									
FORWARD CAR ACCELERATION	0.25									
LATERAL, WEIGHTED (G)	0	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	in the second second second second second second second second second second second second second second second Second second							
FORWARD CAR LATERAL										
RIDE ROUGHNESS (G-RMS)	0.1			LL, ,						
	EAST 79TH	1	UNIN	/ERSIT	Y	I	SUP	ERIOF	1 2	ľ
LOCATION – STATION		EAST 105	тн		EU	CLID			WIND	ERMERE

Figure 5–27. Forward Car Acceleration Time History Chart (AW) (Sheet 2 of 2)

APPENDIX C TESTING AT CHICAGO

1.0 TEST DESCRIPTION

As part of the Operational Test and Evaluation Program, the State-of-the-Art Cars were in Chicago from December 19, 1974 to February 10, 1975. The period during vehicle setup and checkout was used to install the engineering instrumentation system and to perform the Simulated Revenue Service Tests.

1.1 Test Site

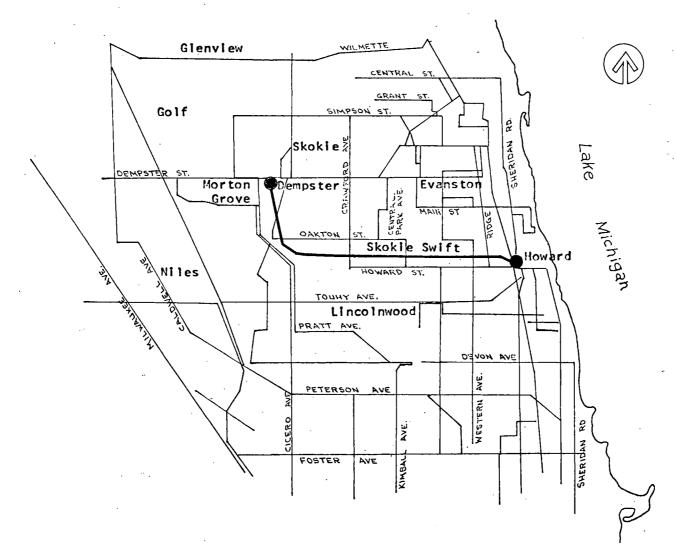
The SOACs were operated on the Skokie Swift Line (Figure 1-1). This line originates at the Dempster Avenue Station in the village of Skokie and terminates at the Howard Street Station on the CTA Evanston Line. Only the two stations are on the route which is 4.9 miles long. The scheduled trip time was 6.5 minutes. The line is at grade level with seven gate controlled grade crossings. Both third rail and catenary systems are used for vehicle power collection.

1.2 Test Operations

The test plan was to operate the SOAC in simulated revenue service over the test route. For safety and operational reasons, vehicle operation was entirely under the control of CTA personnel during the tests. The only requirement imposed by the test was to maintain the normal scheduled service as close as possible.

The test run was scheduled for and accomplished on the late evening on January 15, 1975. Due to the lack of work crews and other operations, there were no incidents which would reflect on the test data.

CHICAGO



C-2

Figure 1–1. CTA Skokie Swift Line

2.0 TEST PROCEDURES

Pretest

- 1. Mount all required sensors
- 2. Calibrate Instrumentation System
- 3. Brief Test Crew on Test Operations

NOTE:

One vehicle is instrumented for noise measurements, avoid other than normal conversation.

Test

- Operate the vehicles in a simulated revenue service,
 i.e. maintain the given schedule.
- Provide a nominal 10 second door opening at each scheduled stop.
- 3. Provide voice commentary on instrumentation recording during progress of test.
- Maintain a manual log of events during the test run, correlated to the instrumentation system records.
- 5. Monitor various preselected data channels to ascertain validity of test run.
- 6. The Test Controller will terminate the test if:
 - (a) An extended delay or train shutdown occurs
 - (b) One or more required data channels malfunction

(c) The test vehicle is not operating properly Advise Test Controller of any abnormal operations or events that occur during the test run.

3.0 INSTRUMENTATION

The SOAC Instrumentation System was used for this series of tests. This system is described in detail in Volume VI of State-of-the-Art Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center, Final Test Report, UMTA-MA-06-0025-75-6, January 1975. A synopsis is included below.

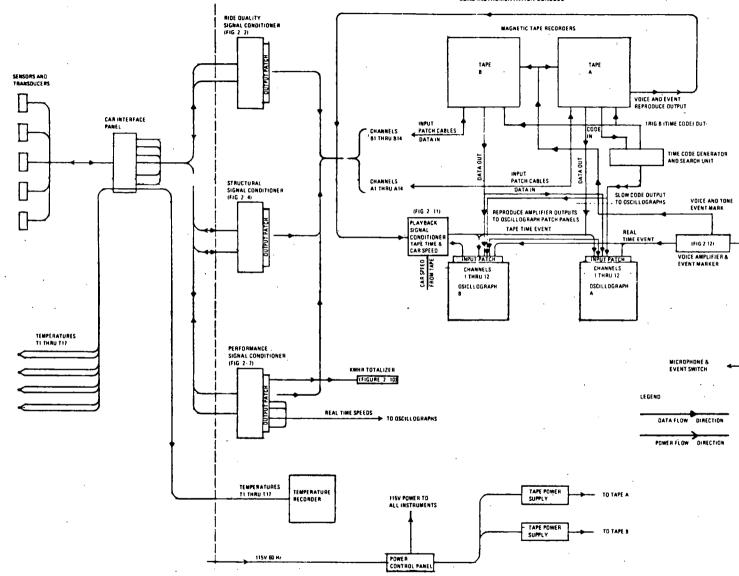
3.1 Ride Qualities, Structural and Performance Tests

Electrical signals from the vehicle mounted transducers are conducted by cables to an interface panel which is connected to an instrumentation console containing two magnetic tape recorders, two light beam oscillographs, a time code generator, a temperature recorder and signal conditioners. Any 28 selected test parameters can be recorded on tape and displayed on the oscillographs. In addition, wheel speeds may be recorded directly on the oscillographs; total power is recorded on tape and displayed on a mechanical counter. The time code generator provides signals that are recorded on both tape and the oscillograph. The oscillographs provide quick-look data to evaluate test progress and results during testing (See Figure 3-1).

3.2 Noise Tests

The instrumentation used for noise measurement consisted of a 1" condenser microphone with battery operated cathode follower and a 1/4" single channel tape recorder.

SOAC INSTRUMENTATION CONSOLE



ငိုပ

Figure 3–1. SOAC Instrumentation System Block Diagram

4.0 DATA

The parameters recorded during the property tests are described in Tables 4-1 and 4-2. The definition of the parameter measurements is contained in Appendix A, Standard Outputs for SOAC Property Tests.

Data was recorded for the roundtrip routes noted in the Test Description Section. All of the data was recorded on analog tapes and processed to provide three types of outputs.

Time History Charts

Station Summary Tables

Frequency Histograms

4.1 Time History Charts

A slow chart speed strip-out of certain parameters is included in this report. The purpose of these charts is to provide an indication of the maximum levels of parameters during various phases of the run. The complete run is described on the charts including station stops and any particularities that occurred. A series of time histories at a high chart speed is included to illustrate the cyclical nature of the data. These charts are a single time frame for all parameters and are representative of the worst case conditions exhibited for a particular test run.

Intermediate parameters, such as a weighted (filtered) car body acceleration are shown on some charts.

4.2 Station Summary

A summation or summary of specific parameters is made by each station stop. These include test running time and distance for comparison to the property's schedule. Power consumption, motor duty cycle parameters are also summarized by station to indicate the relative sizing of the SOAC propulsion with respect to operations on the property. Station stops and maximum speeds are also shown as another indicator of vehicle operation in a scheduled service environment.

P2	ARAMETER		STANDARD	OUTPUTS	
DESIGNATION NO.	DESCRIPTION	RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
301	Longitudinal Acceleration	<u>+</u> 0.25 g's	AP/A	Format(3)	Format(4)
302	Line Voltage	0 to 1000 VDC	LVD/A	None	-
303	Line Current	0 to 2000 ADC	LCD/A	None	-
304	No. l Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	. –
305	No. 1 Truck Armature Current	0 to 1000 ADC	MACD/A	None	RMS-MAC/A
306	No. 1 Truck Field Current	<u>+</u> 50 ADC	MFCD/A	None	RMS-MFC/A
307	No. 2 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	-
308	No. 2 Truck Armature Current	0 to 1000 ADC	MACD/A	None	-
309	No. 2 Truck Field Current	+ 50 ADC	MFCD/A	None	· _
310	"P" Wire Current	0 to 1.00 ADC	CS/A	None	Format(3)
317	Total Power Consumption	l Pulse/0.1 KWHR	PCC/A	Format(2)	Format(2)
315	Speed	0 to 80 MPH	VS/A	Format(3)	Format(4)
318	Brake Cylinder Pressure	0 to 100 psig	BCP/A	None	· –

Table 4-1. SOAC Revenue Service Data List A

C-7

Table 4–2. SOAC

PARAMETER

DESIGNATION NO.	DESCRIPTION
101	Front Truck, Forward Axle, Righthand Wheel Journal Box Vertical Acceleration
102	Front Track, Forward Axle, Righthand Wheel Journal Box Lateral Acceleration
103	Front Truck, Forward Axle Lefthand Wheel Journal Box Vertical Acceleration
115	Mid Car Centerline Vertical Acceleration
116	Mid Car Centerline Lateral Acceleration
120	Forward Car Centerline Vertical Acceleration
121	Forward Car Centerline Lateral Acceleration
219	Truck Frame Upper Strain Gage
220	Truck Frame Lower Strain Gage
221	Pitch Angular Acceleration
222	Roll, Angular Acceleration
223	Yaw, Angular Acceleration
	Interior Sound Pressure

C--8

2

Revenue Service Data List B

	STANDARD	OUTPUTS	
RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	-
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1)
<u>+</u> 6348 psi	STP	Format(3)	<pre>Fromat(4)</pre>
<u>+</u> 6348 psi	STP	Format(3)	- ·
+ 1.5 Rad/sec/sec.	ACA/A	Format(3)	Format(4)
\pm 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
\pm 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
40 to 120 dB(re 2 x SP/A	10-51/M ²)	NL/A(1)	NL/A(2)

4.3 Frequency Histograms

These distributions are an indication of the ratio of time that a parameter is at a particular level with respect to the time to complete a roundtrip scheduled service run. These parameters may be used to describe how the vehicle was driven, the track conditions, and how the vehicle responded to these conditions.

5.0 DATA DISCUSSION

Vehicle operation was such that while operating northbound from Howard to Dempster, the SOAC No. 2 was leading. A positive value on the time history chart is vehicle start-up. For the southbound run, vehicle startup is a negative trace on the time history.

As defined in Section 4, there are three forms of data. These forms are discussed below with respect to three categories:

(1) Operation

How the vehicle was operated and maintained schedule.

(2) Environment

Track and truck conditions.

(3) Response

How the vehicle responded to the operational environment.

Figures 5-1 to 14 present the frequency histogram for the CTA tests. Figure 5-15 is a sample of the Interior Noise Level time history. The remaining time history charts are shown in Figures 5-16 through 5-23. Table 5-1 presents a summary of some of the test parameters and is taken from the histograms and time history charts. Tables 5-2 and 5-3 are the Station Summaries with power consumption.

5.1 Operation

As mentioned above, the Skokie Swift route is 5.0 miles with one station stop. The SOAC was not pushed to its rated limits in acceleration or braking. As seen in the "P-Wire" histogram, most of the trip time was spent in cruising. The speed histogram shows that most of the cruising was accomplished at 50 and 35 mph. From the Station Summaries, it can be seen that SOAC took 8.7 minutes to complete the scheduled 6.5 minute trip. No reason can be forwarded for this.

The propulsion system was run at 50% of its continuous rating of 460 amps (RMS).

5.2 Environment

The journal accelerations and the truck frame stress levels are indications of track conditions. A summary of these parameters is shown in Table 5-1. The 50th percentile is a statistical quantity and is read as 50% of the time the journal box vertical acceleration is between plus and minus .55 gs. This quantity is dependent upon the distribution of the test parameter, which for this data, is assumed to be linear within a class interval (i.e. 1 to 2 gs, etc.). The 95th percentile is read similarly. The nominal value is the 50th percentile for the test parameter considering only the time the vehicle is moving.

The journal box lateral acceleration 50th percentile is <u>+</u> 1.0 gs. Unfortunately during a de-trucking operation, the strain gages were wiped off and truck stress data was not recorded.

5.3 Response

The car body Ride Roughness and Noise Level parameters are the indicators of how the vehicle responded to the operation and environment. Ride Roughness is a vibration parameter which is weighted according to human response characteristics in riding comfort. This technique is similar to using the "A" weighing on sound pressure to yield Noise Level. Noise Level and Ride Roughness are related to "human responses". Both of these parameters are described in the Standard Outputs section of this report. Summaries of these values are shown in Table 5-1.

Noise Level data was taken in the middle of the noninstrumented car at a seat passenger ear level. The original engineering tests at TTC indicate that this is the quietest location in the car. The statistical quantities derived from the data are:

L(99)	L(90)	L(50)	L(10)	L(1)	L(EQ)
59	64	65	66	69	66

A sample of the Noise Level Time History is shown in Figure 5-15.

C-11

Table 5–1.

Journal Box Vertical Acceleration (G) Journal Box Lateral Acceleration (G) Truck Frame Stress (PSI) Forward Car Vertical Acceleration (G) Mid Car Vertical Acceleration (G) Forward Car Lateral Acceleration (G) Mid Car Lateral Acceleration (G) Longitudinal Ride Roughness (GRMS) Forward Car Vertical Ride Roughness (GRMS) Mid Car Vertical Ride Roughness (GRMS) Forward Car Lateral Ride Roughness (GRMS) Forward Car Lateral Ride Roughness (GRMS) Mid Car Lateral Ride Roughness (GRMS) Pitch (RAD/Sec-Sec) Roll (RAD/Sec-Sec)

Yaw (Rad/Sec-Sec)

-12

Summary

50TH PERCENTILE	"NOMINAL"	95TH PERCENTILE	MAXIMUM		
<u>+</u> .55	<u>+</u> .60	<u>+</u> 1.7	<u>+</u> 13.5		
<u>+</u> 1.0	<u>+</u> 1.0	<u>+</u> 1.9	<u>+</u> 20.0		
	(DATA CHANNEL N	MALFUNCTION)			
<u>+</u> .022	<u>+</u> .022	<u>+</u> .084	<u>+</u> .250		
<u>+</u> .022	<u>+</u> .023	<u>+</u> .078	<u>+</u> .250		
<u>+</u> .023	<u>+</u> .024	<u>+</u> .101	<u>+</u> .150		
<u>+</u> .045	<u>+</u> .047	<u>+</u> .088	<u>+</u> .100		
.007	.007	.013	.030		
.024	.025	.049	.095		
.020	.020	.045	.100		
.015	.015	.032	.060		
.007	.007	.040	.040		
<u>+</u> .050	<u>+</u> .052	<u>+</u> .095	<u>+</u> .100		
<u>+</u> .058	<u>+</u> .060	<u>+</u> .160	+ .263		
<u>+</u> .050	<u>+</u> .052	<u>+</u> .095	<u>+</u> .100		

	· .	·					·	,			
	STATION		SCHEDULE	TES	T	POWER CO	NSUMPTION				M2 W
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED [·] (MPH)
1	Howard Street	0	0	0	0	0	0	0	0	0	0
2	Dempster	4.93	6.5	5.45	8.60	23.85	4.38	234.2	19.1	15.0	54
				I	OTAL	23.85	4.38	234.2	19.1		
	MECH DIN CIMMADU							`			

 Table 5–2.
 Station Summary I

TEST RUN SUMMARY

	SCHEDULE	TEST
Distance	4.93	5.45
Time	6.50	8.60
Block Speed	45.5	38.0
Station Dwell	30.0	15.0
Station Space	4.93	5.45

C-13

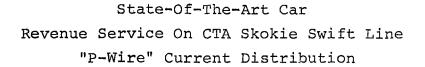
STATION		SCHEDULE		TEST		POWER CONSUMPTION				CHOD	MAX.
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	SPEED (MPH)
1	Dempster Street	0	О	0	0	0	0	0	- 0	0	0
2	Howard Street	4.93	6.5	5,47	8.97	21.53	3.94	238.2	20.0	21.6	54
					TOTAL	21.53	3.94	238.2	20.0	,	
	TEST RUN SUMMARY										

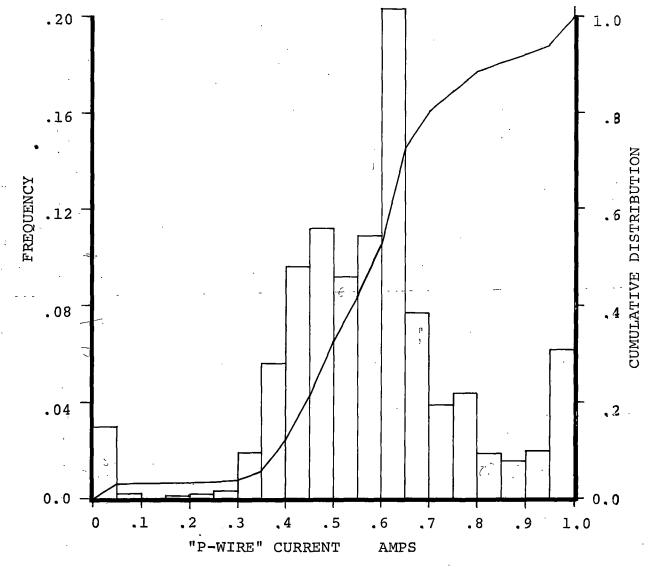
Table 5–3. Station Summary II

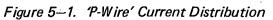
	SCHEDULE	TEST
Distance	4.93	5.47
Time Block Speed	6.50 45.5	8.97 36.6
Station Dwell	30.0	21.6
Station Spacing	4.93	5.47

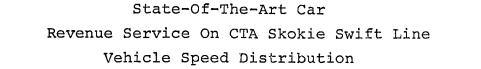
C-14

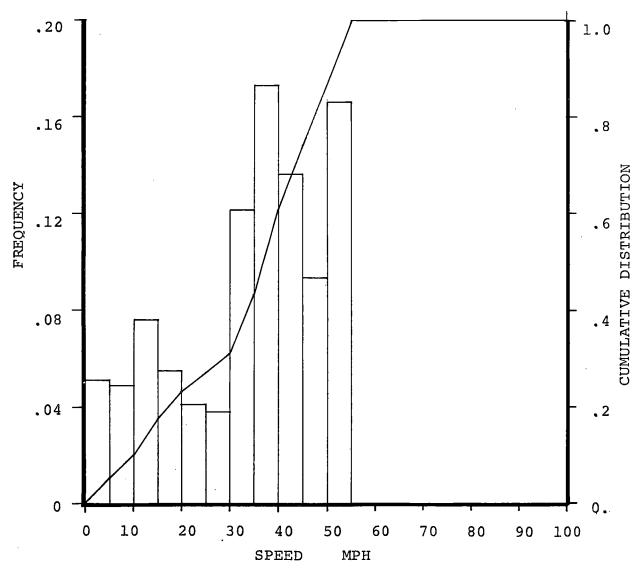
`,



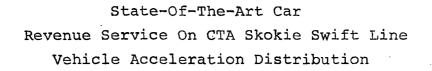












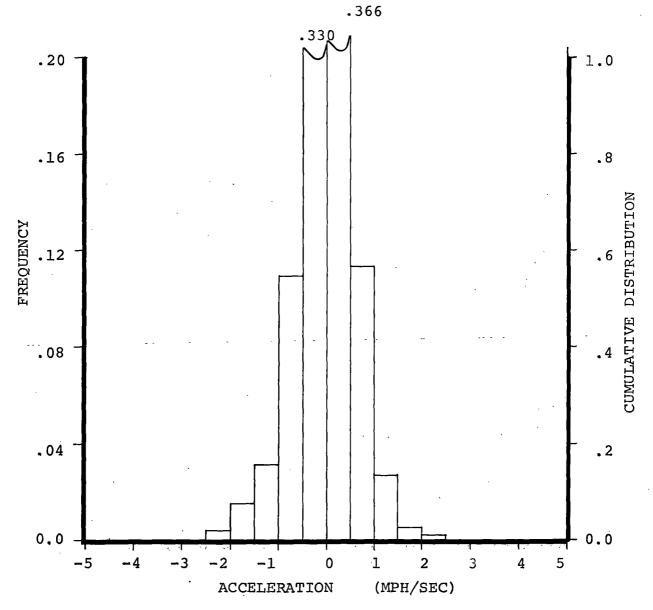
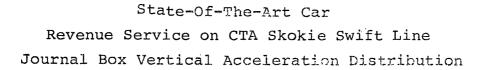
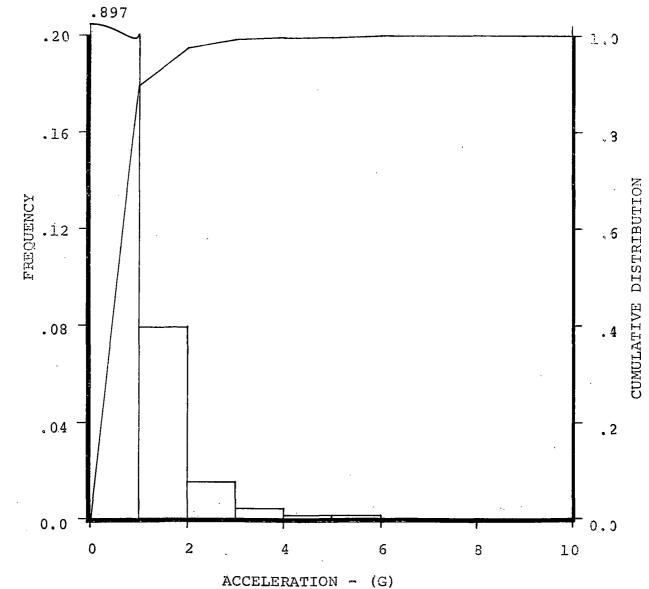
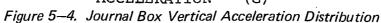


Figure 5–3. Vehicle Acceleration Distribution







State-Of-The-Art Car Revenue Service On CTA Skokie Swift Line Journal Box Lateral Acceleration Distribution

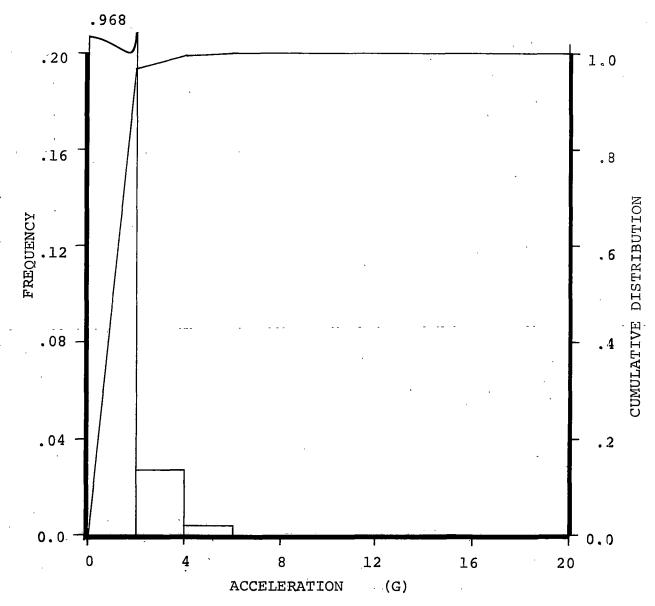
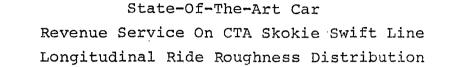
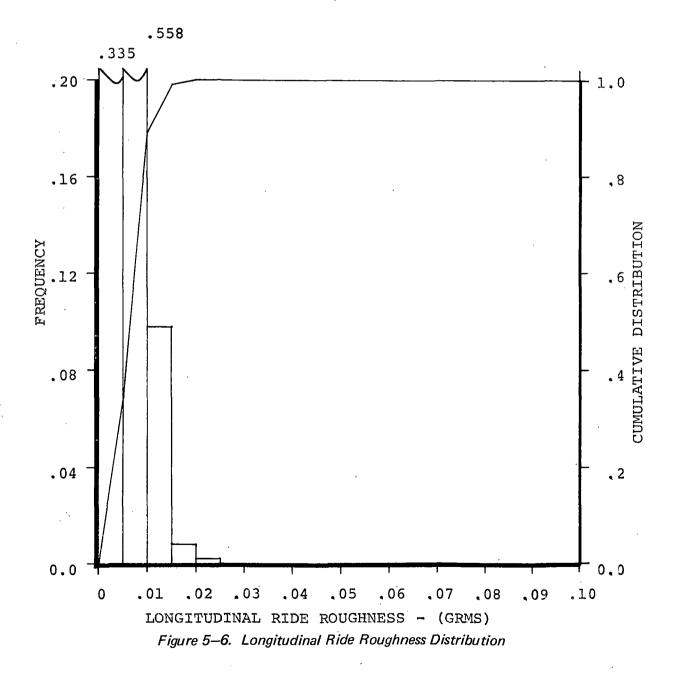
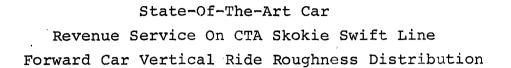


Figure 5–5. Journal Box Lateral Acceleration Distribution







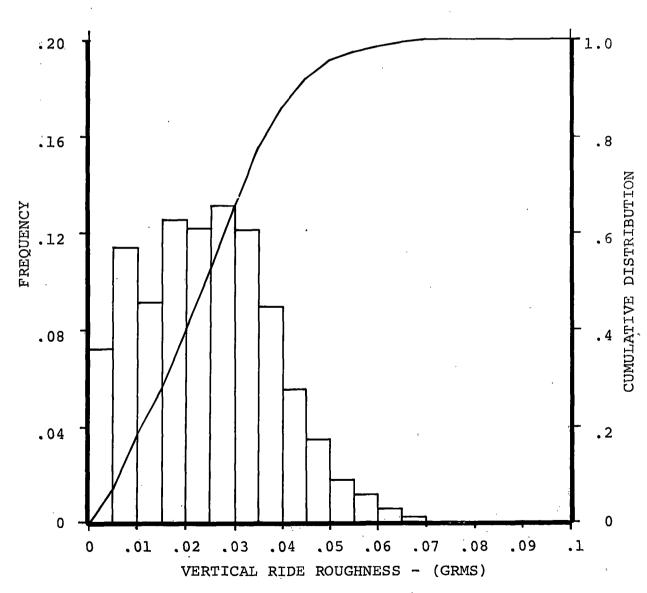
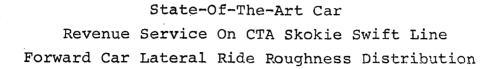


Figure 5–7. Forward Car Vertical Ride Roughness Distribution



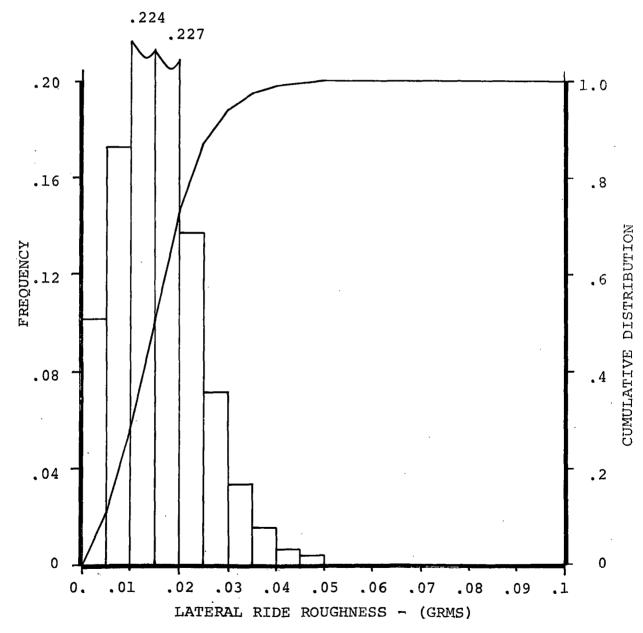
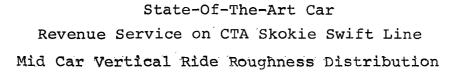


Figure 5–8. Foward Car Lateral Ride Roughness Distribution



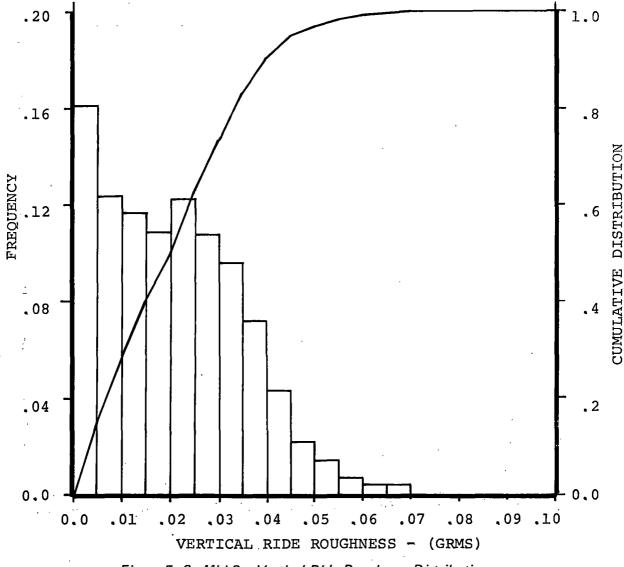
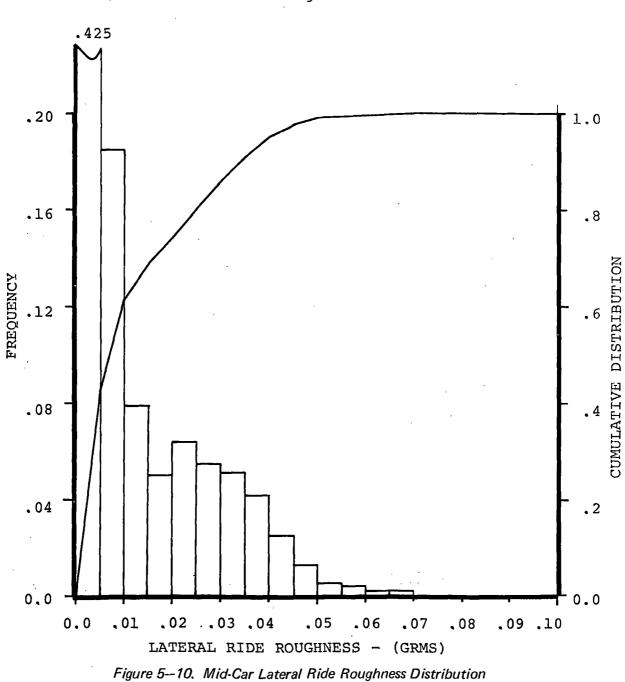


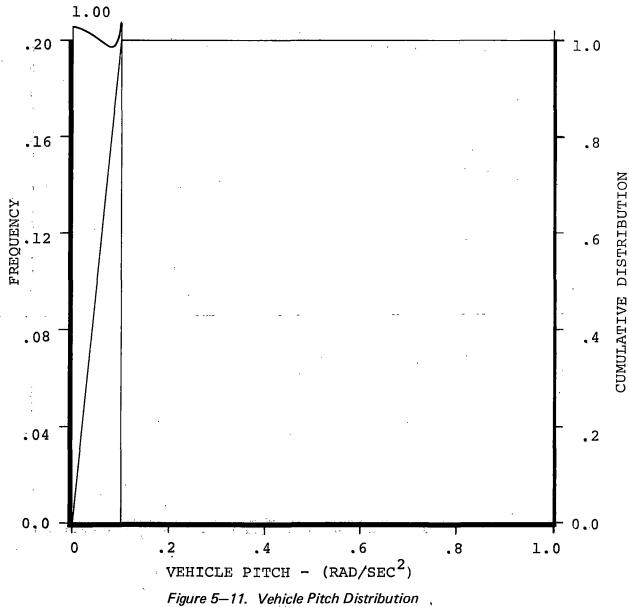
Figure 5-9. Mid-Car Vertical Ride Roughness Distribution

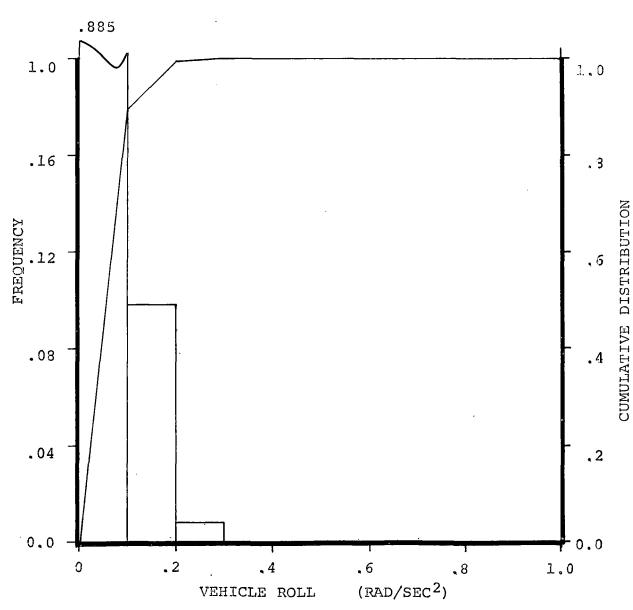


Revenue Service On CTA Skokie Swift Line Mid Car Lateral Ride Roughness Distribution

State-Of-The-Art Car

State-Of-The-Art Car Revenue Service On CTA Skokie Swift Line Vehicle Pitch Distribution





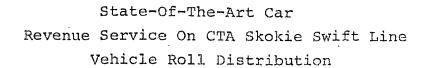
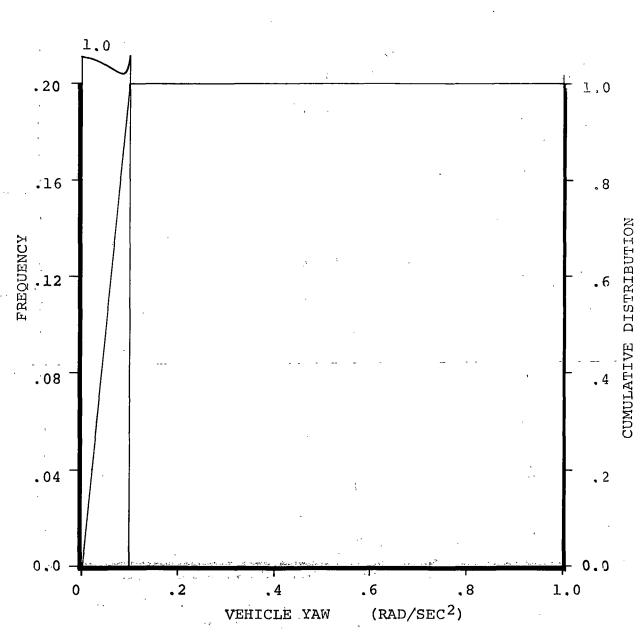


Figure 5-12. Vehicle Roll Distribution



State-Of-The-Art Car Revenue Service On CTA Skokie Swift Line Vehicle Yaw Distribution

Figure 5–13. Vehicle Yaw Distribution

. C–27

State-Of-The-Art Car Revenue Service On The CTA Line Interior Noise Level Distribution

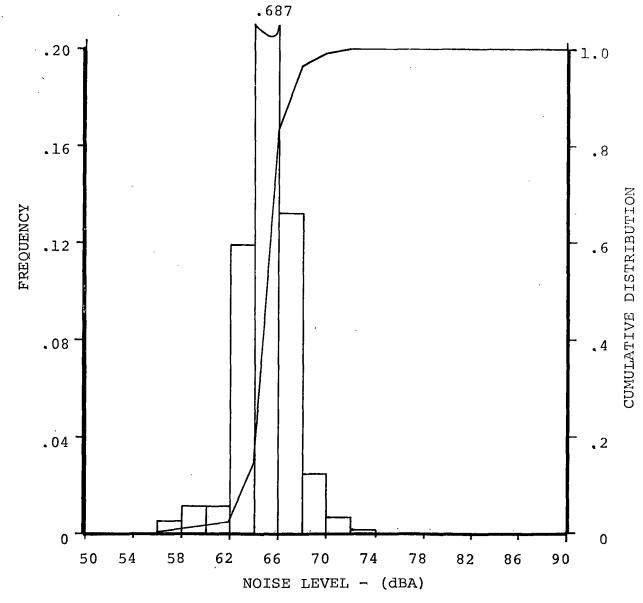


Figure 5–14. Interior Noise Level Distribution

C--28

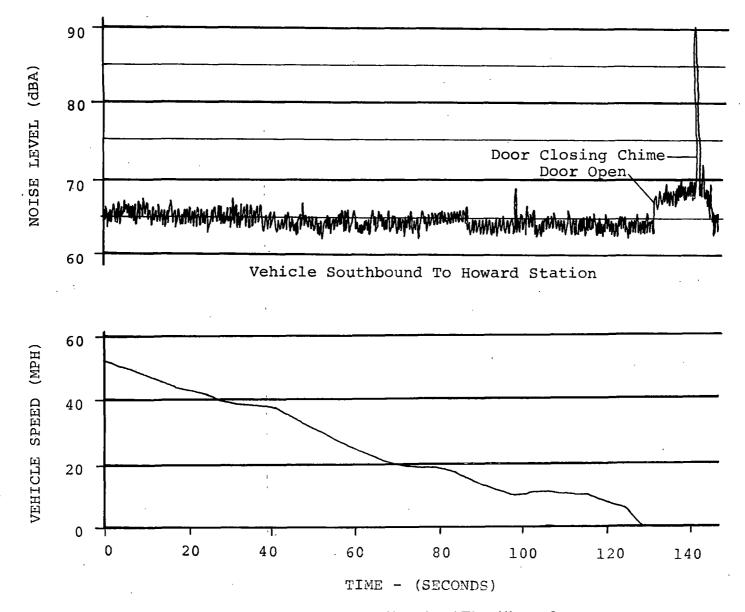


Figure 5–15. SOAC Interior Noise Level Time History Sample

C--29

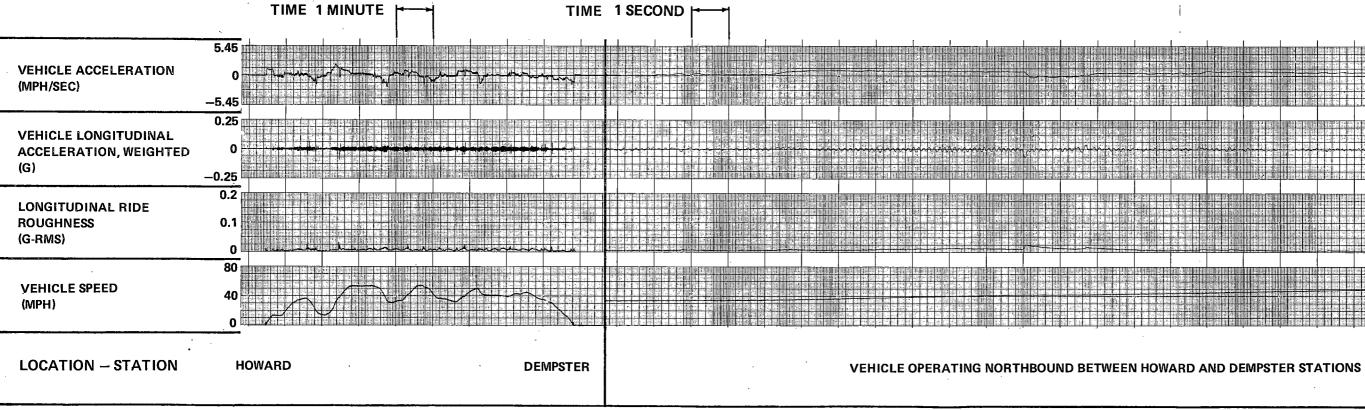


Figure 5–16. Vehicle Acceleration and Speed Time History Chart (H–D)

										Π
1111								•		5
						•				Ť
				ت الجوم التي تا الم معالم						£ .
ETON)										3
										5
										3
		I								
		!								-
										<u>1</u>
										4
										4
	han an an an an an an an an an an an an a	تبار لمسامل		- احاصا ما	الململمام	ممحل فلمحم	لملم لمم	time darlar	بملحم حمل حمل حمل	٦
										8
										8
					li di di di di di di di di di di di di di	44.8.7 58 98				E.
			1	1						
	THE REAL PROPERTY OF	mmmmm				ana kina kan bandara				T.
										ŋ
										Ð

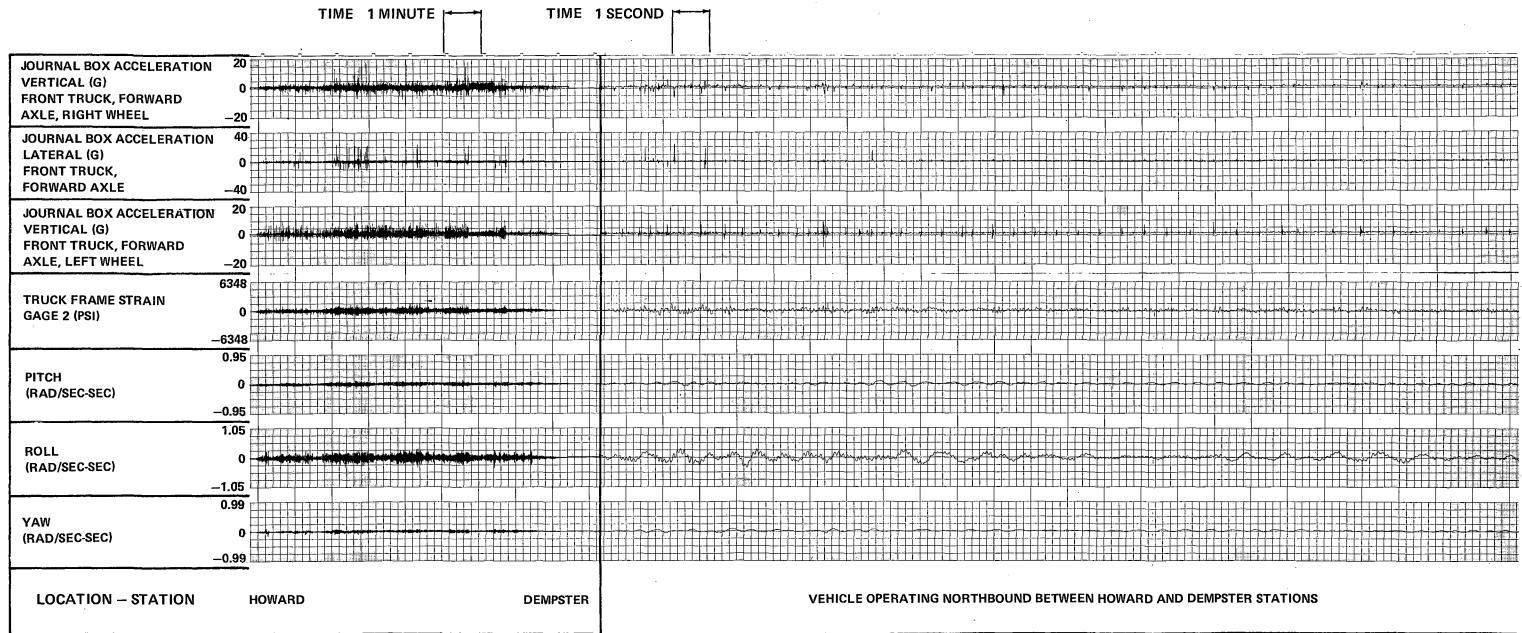
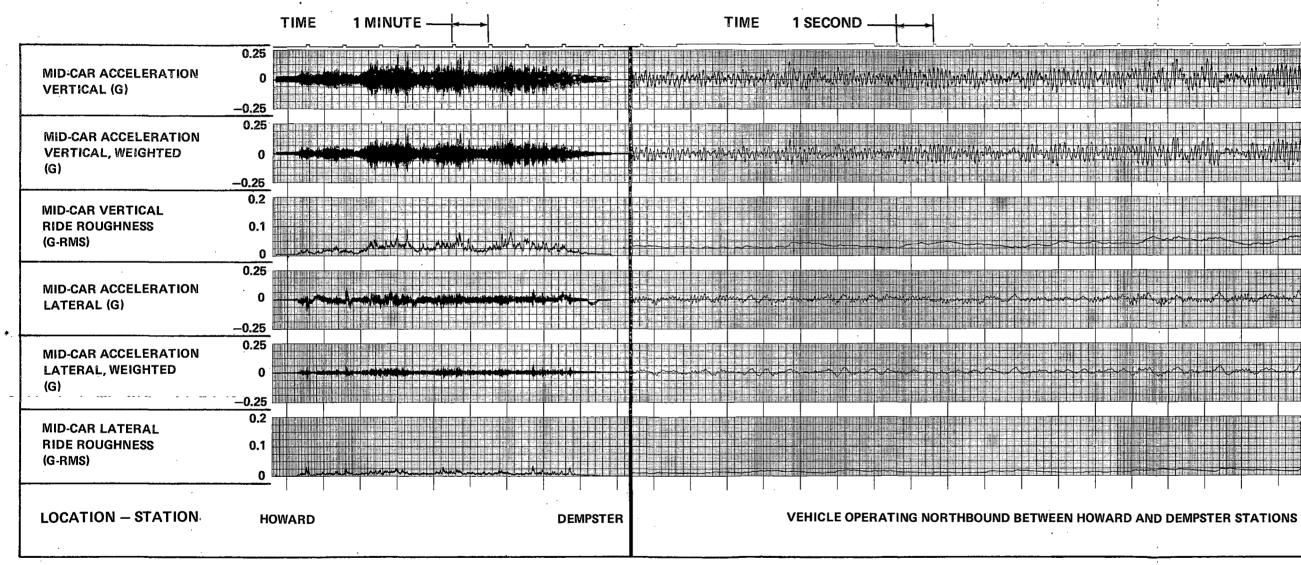


Figure 5–17. Journals, Truck Frame, and Angular Accelerations Time History Charts (H–D)





																									Ŧ													
l				Ā	I,	ļ	-				A				Å	I	I					N	1		h					4								
ł	0	h	h	ť		Í		Ŷ	f	Y	ľ	Y	ł	f			ľ	ť	ų	l.		Ľ	1			ľ	V	Ľ.	ť	Ĺ)	V		Ť,	N	Ť			Ĩ
			ſ.	F									ĺ.	_			-	-	-	y										÷								5
		Π															ir.				Ĩ	IÏ					l	Ĩ		Ш								Щ
																			1																		-	Щ
1	Λ				Π										L.			I	Î,							Γ									1.1			Ţ.
ļ	H	κ.	Ņ	Ŵ	Ų.	h	ليها	Ņ	٨,	N.	Д		H		7	H	h	Щ		t	Y	Η	h	A/	H	H	A,	A	ł	A.	ų	Ŵ	A	Ы	r		榊	
				Ľ	I	V,					2			1	1	ţ	H	ŧ		ij,				Y	Ц	ŧ		İ.		Û				Ĩ		1	++	Ť
			2112		Г				- 11																													_
		11												11											61			1		1								
																							18. 			_							_					-
		101		-													Ŧ	,,	r						P		J		~	2								-
-				F					1	-	×	-		1																						1		
									610				86			22	1112	1222	555	1212	10	111	1941	1:115	92	94		1112	114	116	lije:	10	iin:	<u>l:tt</u>		1111	1611	
		HIH	1111	111			1111	RIF	m	80			644											80		141	60	511		1111	RII		E.O	m				
0												í.																			III			Ш	Ш		Π	
						,	١.			.n			~				J	4			1						Ŷ					~	w.					
Γ		r,	Y	1	T)		12	P1		ľ	Y	ſ				Y							Υ	`	ľ			2	10.						3	ſ	P	Π
				y nr										Ĭ.																								
													LU.			19																						
	E		11751		98		1:1:	m	,				en:			1111	110	199	pint.		ae	tit.	1:11	111			HHE		ĦĦ	1:10	Bas	e n	199	1111	111	1111	m	सार
								Π																				1										
	×.		5			H	η.			L.			L	L		╞	7				H					-		H				2	L			H		H
ľ		-	Ì			Γ		Ľ			h	ľ		Ľ			Ľ		٣				ľ					2	t.		2			m	IT	Π		
						F																														h		
					ļ							1			H										ļ					ļII					μ			
					L					L																												
	H				ľ		ľ				H								⊢				⊨									₩	H					
1							L																						I						Ш			
					ŀ		ľ		-		┢	⊨																	H	╟								
							Ι																															
																	Ļ					-	-			-							H					
					Γ															ŀ																		
					č.,					-																												

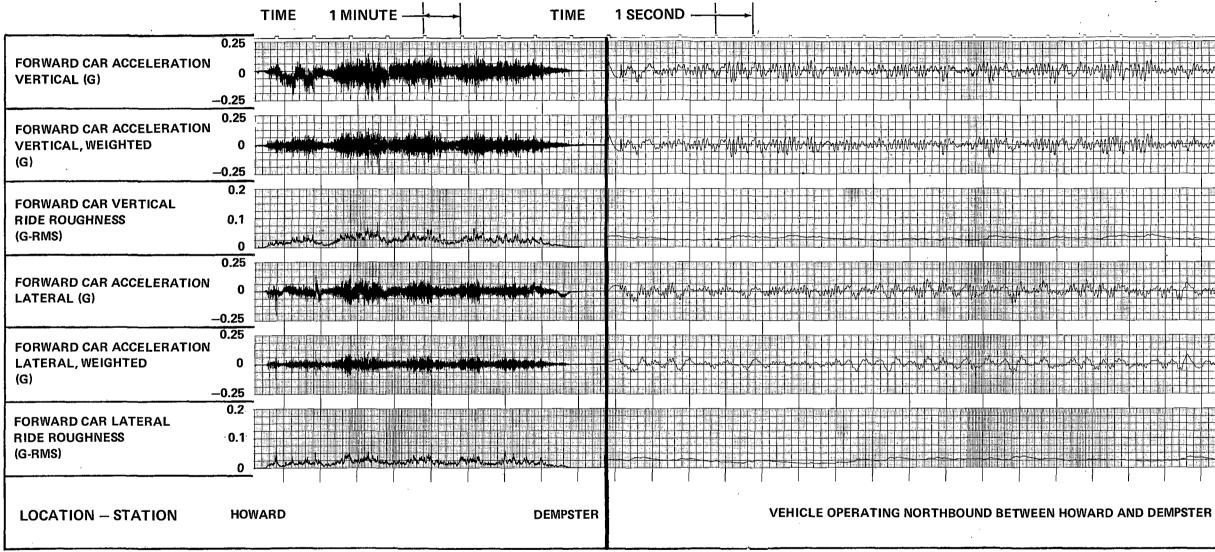


Figure 5–19. Forward Car Acceleration Time History Chart (A–D)

	_				÷		_								_~	_		_		_	_				_`	<u> </u>				_;	_				<u>.</u>		_	_		_	_					_
Ą		M	N	A	Ą	4	-	V	4.	7	4	n	Ş.	V	Ņ	ł	4	A	V	Ŵ	1	۸Ż	Ą	٩ ۱	М	Ŵ	N	Д	Ŵ	Ņ	Ą		Ą	ľ.			4	1 ,	L A		Ń	4	K	4	Ą	П Д
_								<u> </u> -	Ē	E				-											Ē	•										1										
V	ff-	M	Ŵ	1	A	-	<u>_</u>	V	A.	ľ	h	~	~	V	A	W	~	Ā	V	N	A	4	Ą	₩.	M	V	N	A	V	A	A		V	ſ	Ň	ľ	Ā.	ł	Λ	V	V	- 2	8	N	Ą	- A
				ļ.					L_ 	L.								_	_																										T	
			:												_																		1	-			h - 1 - 1									
					Ē										1				7				2																							
			Ŵ	v	2	Ŷ	M	٦	7		s,	4	W	5	f.,	₽¥	4	5	a۸	4	5	ç		M	N	29	Ţ		N	7	1	'n	1	V	Ś	ţ,	<u>ل</u>		1	ŗ	۲. ۲	3		1.11	Ŵ	Ì
				4		7	, ,	4	7			\downarrow	3.0		2	×2			M	1.5	20	Z		4	Ā		\$	7		1	1 1/1		N	2	~	1,	4			7		1	Λ	1	n.	
																		j																												
																																				•										
									-																				1	Y								-								

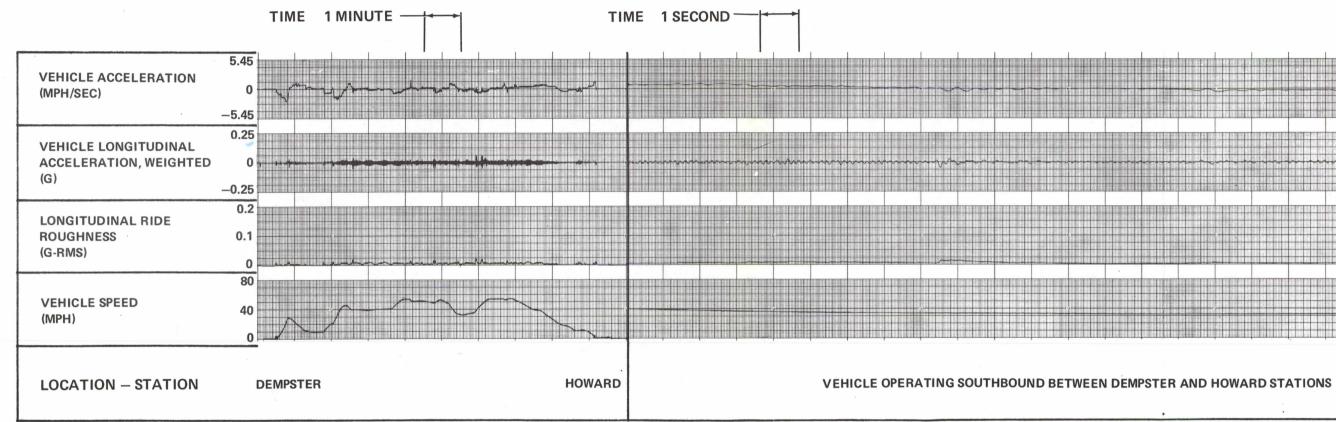


Figure 5–20. Vehicle Acceleration and Speed Time History Chart (D-H)

									H.::	111		H 18				111																											íll I
										Π	Π	I	Г	T		T		Т				III																					ſ
																																											m
										t:				Ħ																										Ħ			m
						=	 					###		#		+		٠	#.				÷Π	****	P+++					*		-		****			-				÷	=	N#
																																											H
																		-																			1111						₩
																																									ш		ш
																																					1111	ш					ш
																							1																				
																																						L					L
														IT	Т					T	1																	m					Ш
			m							ttt	TIT.																											m					П
										I			1	t						٠		111																m		m	m		
														H:		+	-++		1+		1	10										1111					₩	m		ttt	H		m
-	-	n	50	-	à	-	 -	-	-	-	*	+++	÷	+	+	+	÷	4	***	+	+-	44	0- 00	<u>ل</u>	P-u	-	-	-	<u>,</u>	Þ	H.P	-	2	×.,	/		er s	-	n. ,	ЪP	-	÷,	m
					-									-				+		+																		H					H
														4																								ш					ш
																																									ш	ш	ш
														Ш																								đШ					Ш
													1																									£					í.
						Ш				Π	III	111		T				T			T				HIII													m					Ш
						11				III		T		T				Ħ	1																			m			m		Ш
										ti				Ħ																								m	H		H		Ш
																			+++	+++																			₩	₩	H		m
										1				++		1 1				+			¢															HH					H
						HÍ								+																								<u> </u>					ш
						ш																																					Щ
																																											ш
																																						Jerre .					ш
							1.						L					T																									1
													I.										Ŀ.,																			_	1
						111			I		111			Π			Ш	1	III					111														m					
														T										1														m					m
						H				tt				t				+++				tt																			H		m
											+ + +		+	+								+++		-														H					H
			щЧ		н				Lí.			Hii	-	+		+	-	-		+	+	+		-												HÌ		щł		mi	mil	Щ,	Щ
										-			-					#		+++	-	+++		hiii			****			****	i i i			H		****		mil	***	m	mŧ	***	fΗ
											11																													111		Ш	<u>I</u>
		ПШ			Π	Π			IП	IП	T	T	Г	Т		Т		I	T	1	1	177																ШT	Π	111	ΠT	П	бŤ

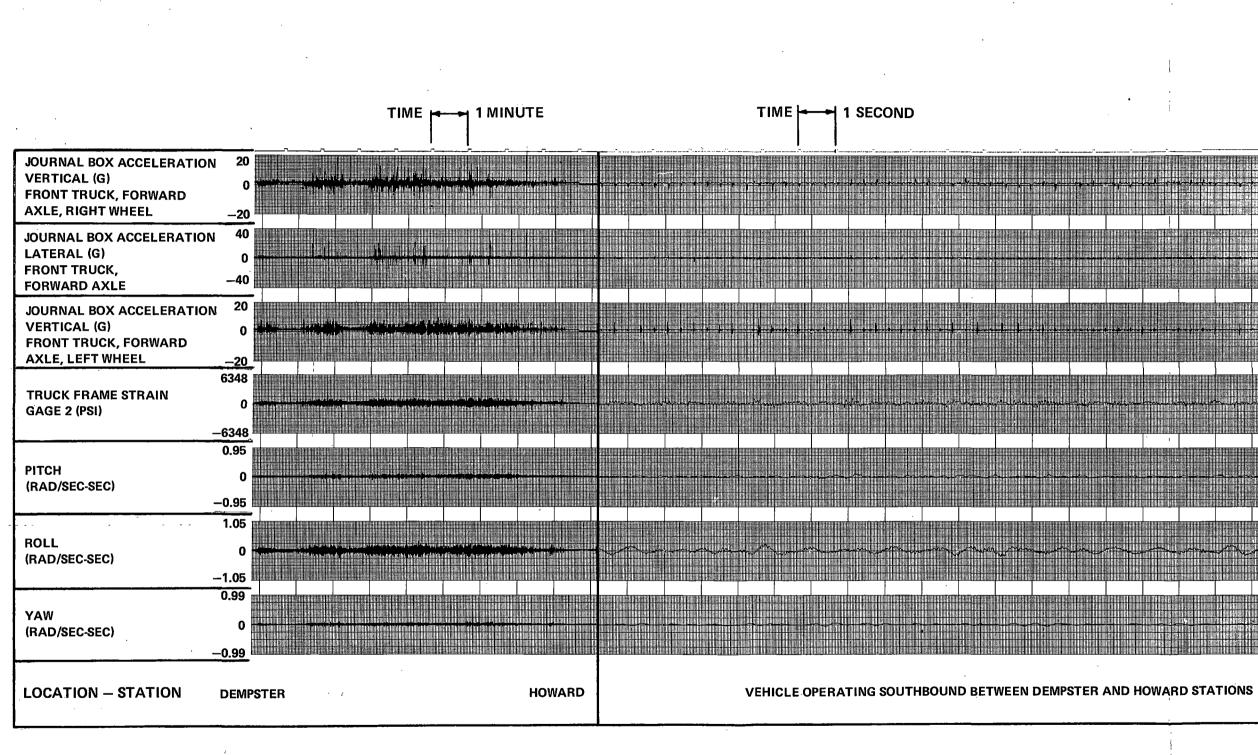


Figure 5–21. Journals, Truck Frame, and Angular Accelerations Time History Chart (D–H)

C--41

		┉┉┉┎┉┠╌╍╍╍┉┵╌┎┉┯╴╼╼┯╴
	ار از این از این از این از این از این از این از این از این از این از این از این از این از این از این از این از این از این از این از این این این این این این این این این این	
N		

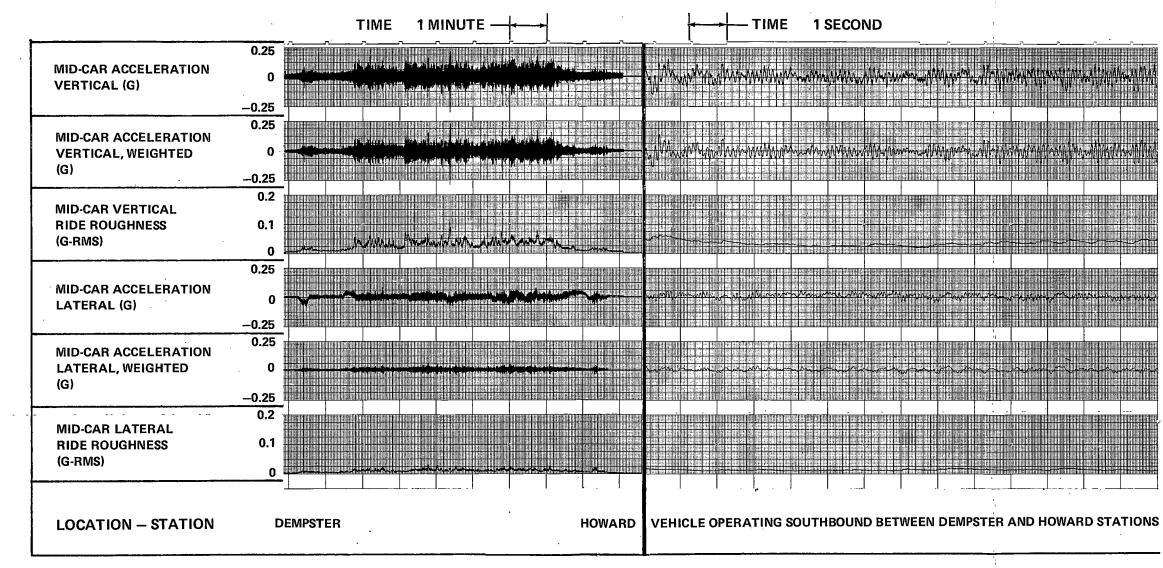


Figure 5–22. Mid-Car Acceleration Time History Chart (D–H)

		~				_				_	_		7	-		_		_					_	-										-	-		71	-	to			
H	l		l	Í		Í	Í	Í	l	Í	Í	l	f	į	Í	Í		1	Í		Í	Í	ĺ	l	l		ĺ	1			Í	Í	l	Í		ľ	۱	l	1	l	l	
Ű	ł	f	f	l	l	-	1	Í	ľ	H	ł	l	H	Í	ĺ	ſ		f	Í	l	f	H	ſ	l	ſ	ł	f	f	H	l	l		l	İ	ĺ	H	l	f	i	1	f	Í
Ū	Ü	ł	ľ	ŝ	ļ	f	Í	Ï	ŧ	É	Å		t	l	ĺ	f		Î	Ē	Í	ĺ	ų	ŧ	Í	l	Ĵ	ţ	l	Ē	Í	ŧ,	ļ	Í	Ú	É	İ	i	t	ţ	i	Ī	Ē
ł	I	Į	l	ļ		l	I	l	ļ	ſ	I	ľ	ſ	i.	l	1	l	I	ľ	ł	ľ	ľ	l	l	l	ĥ	l	í		l	I	l	1	ļ	I	l	I	Í	i	6	ļ	1000
Щ		1	ĺ	ļ		I	1		l		4	ļ	ļ	I	ļ	I,	l	l	l		l	1	ľ		ľ	l	1		1	H			1	ļ	ļ	ļ	l	ļ	ļ	1	ļ	ł
H	ł	ł	₽			I	l	H	P	∦	4	H		l	1	l			l		ŀ		ł		H		╢	H	ľ	╟	₽		1		1	İ	H	H		1	Ĥ	ł
Ш	Uki	μ	ŧ	Ľ.	U)	t	1	B	U	۳	1	1	ži	1	4	III.	Ш	11	11	U	ŀ	Ш	Ľ	1	f li	11	Ħ	Ð	U.	14	Ŧ	n.	1	H	ŧ	U	l	1	1	1	1	Ŧ
																					ł										1											
	T	Π	I	I		I	İ	1			đ	1	Ī		1			Π			t		ſ		I		I	I	I	I	t		I	Ī	I		I	Ī	l		I	ļ
I	I	ļ	Į			l			I	ļ	I		Ĩ	l	1	l		ļ	ľ	Í	ľ		L		ļ		ſ	I					ļ		l		1	ĺ	l	1	I	I
Щ	ļ	1	l	ļ	ų		1	ļ	l	ļ	1	l	H	ļ	ļ	ļ	ļ		ļ		l	ij	l	ł	ļ		ļ			l		l	1	ļ	ľ	l	ļ	ł	ļ	1		l
ų	b	H	f	n	í	ł		Î	1	╢	Å	ł	ł		Ĥ	+	ļ	ł	ħ	A	ĥ	Ā	A	A	f	1	ł	ł	ŧ	ŀ	ł	Ļ	ł	G	ł	Í	Í	ł	1	ų	ł	
H		ŧ	ť	l	ł	l	1	ł	ľ	ᡰ	ł	ł	Ĥ	i	l	l	l	#	f	ļ	ľ	ľ	ť	H	l	h	ł	ŧ.		ł	f	f	H	l	1	ł	l	l		4	ł	Ì
Í	t	Ű	ť	Í	t	Ì	ij	H	l	f	t	i	ð	İ	l	f	t	Ħ	ť	ľ	ť	T	t	i	ť	ľ	f	h		Í	ľ		ij	l	Í	l	l	ľ		đ	l	1
Î	t	Í	Í	Í	ľ	İ	1	ľ	t	ľ	l	İ	đ	t	ij	Í	ľ	Ï	Í	ľ	f	Í	ţ	ť	Í		ţ	ļ	ľ	Í	ľ	Ì	ľ	İ	Í	ľ	ĺ	l	į	Ì	Í	
				1		1	1	1		ſ	Ĩ		1	1	1			1			ſ						1				Γ			1	1		1	1	1	1	1	
	a.		T	17					R,	L	R	R		17	47			EL P	P		Ļ		r	m	æ	R,	Ŧ		D.		Ļ	T	TF.			H.			P			
H			ł		H				1	l		H		1	1	1			⋕		ŀ				ł		ł	l			╟		⋕	╟	ļ	ł	ļ		1	-		l
		╢	ł	H	l		l		1	ł	H	H	∦	1	1	ł	H	⋕	╫	H	ŀ		ł		ł		ł	ļ			ł	ľ	ł	ł	ļ	H	ł	l	1	đ		l
Ħ			ľ	ľ	l	l	f	ľ	ŧ	t	Ħ	ľ	H	i	ij	Ϊ	H	Ĥ	t	Í	t	ľ	ľ	I	t	i	t	t	t	ľ	t		1	ł	f	t	ĥ	f	Í	i	Í	l
Ĥ	İ		ľ	Ú	Í	l	İ	ľ		t	Ì	İ	ľ	l	ļ	ij	ľ	Ű	Í	Í	Í	ľ	Í	İ	Í	Í	İ	Ï	ľ	ĺ	Ĭ	Í	J	Ï	Í	ľ	l	ļ	Ì	t	ſ	j
			I	ļ			I			I	Í		Ĩ		ļ	ļ	l	I	ļ		I		Į				I	l		l	I		I		ļ				l	I	ļ	l
t	ł	4	ļ		ł	ł	1	ļ	ļ	I	h	Ħ	ł	ļ	ļ	1	I	I	ľ	ľ	ŧ	ł	ŧ	H	l	ļ	ļ	1	ľ	ļ	Ť	İ	i	H	ł	ľ	1	l		ſ		ļ
Ĥ	lli	ti	ť	t	1	ł	1		Í	1	l		#	1	1	#		H	1	1	ł	l	ŧ	lİ	ŧ	U	ŧ	1	l	l	4	l	lÉ	ť	li	ŧ	l	ľ	1	#	l	l
										L											L										I											
H	H	II	Ħ	1	Π	D	H	Π	Ħ	h	f	I	Ø	9	Ð	IJ	I	Ð	F	I	ŀ	Π	Đ	Π	ij	Π	Ð	I	D	H	t	Π	Đ	Π	Ī	I	I	I	ŋ	A	F	ß
Í	ľ	Í	ĺ	Í	Í	I	Ì	ľ	Í	Î	İ	ľ	Í	Í	Í	Ű	ľ	Ű	Í	ľ	Í	l	l	t	Í	l	t	ľ	ľ	Í	ľ	l	Í	Í	Í	Í	l	Í	İ	đ	Í	İ
I		I	ľ				I				l		J			I		I	I	I			I	Π	l		I	ľ			ľ		I	I		I				Ţ		l
4		l	ļ	ļ		ļ	ļ	ļ	ļ	I	l	ł	ŕ		Ï	l	ļ	ļ	ļ	v	k	ł	l	ł,	ļ	l	ł	Ц					l	l	li		I		ļ	J	ļ	ļ
Щ		ľ	p		H	ſ	ļ	H	ļ	ŧ	Í		ļ	ļ	1	H	l		ļ	1	ŝ	ļ	ł				ļ	4	ľ	í	H	l	lĺ	I	H	Ű	d	ĺ				ļ
			ľ		H	l	1	I		╟	∦		H		1	l	H	╫	H		ł	l	ŀ		ł		ł	1	B		ł		l	ľ	li	l		l	l	đ	Í	
		H	t	ľ		l	ť	ļ	ľ	h	ł	H	h			i		H	ť		f		t	I	ł		t	t	ł	l	H		ľ	l	l	l	l		l	đ	l	ľ
		ш				T	1			ľ	1	d	-		18	**			-		ť		1	•••	•11	1		-1			Ť		rd:	**		211				-		
	_		_	_	_	_	_			L	_							_	_	_	L	_	_					_		_	L	_			_		_	_	_		_	_
		l	ļ	Í	l	ļ	ļ	ļ	IJ	ļ	ļ	l	l		ļ	l		l	Í		l	l	Í	I	Í		ļ	I	l	ļ	l	l	l	ľ	l	l	l	l	ļ	j	l	Í
	4		ļ			ļ	ļ	H	l	ļ	#	H	l	l	1	ij	H	1	ļ	H	∥	ļ	ļ		ļ		ļ	1		ľ	ļ	l	1		ļ	l		ļ		1	ł	
Н	ł	'n	╂	Ĥ			ł	ł		╂	l	H	H	1		f	ĥ	ł	l		₽	ł	╟	ł	#	ł	ĺ	#		ľ	╢	l						l			l	
f	f	i	ł	Ĩ	H	Î	í	l	ľ	ĥ	ł	Í	ł	Í	1	۱	H	ł	Í	Í	t	ľ	f	i	ĥ	l	f	Ì	ł	ĥ	Ħ	۲	1	ł	i	ň	1	l	1	f	ľ	1
	ľ	ľ	t	Í	ľ	ľ	Į	Ŭ	l	ľ	İ	I	đ	ĺ	j	ij	Í	t	ţ	ľ	Í	ľ	ť	t	Ű	l	ť	t	ľ	Í	ľ	İ	İ	ľ	Í	ľ	ľ	ľ	Í	İ	Í	İ
		1	I	I	I	I	1	l		ſ	1	1	1		1	1	I	I	I	0	ſ		1		I		I	I		I		I	1	I	Í	I		I		1	I	
		Ш	l	l	l	l	l		l	l	1		1	l	1	1	l	1	Í	ľ	ľ	l	l	l	l	1	ŧ	1	Í	l	H.	Í	lÍ	l	l	l	1	l	ļ	4	ľ	l
										L															_							_										
П	Ð	Π	V	8	Π	1	1	D		h	ſ	I	Æ	D	I	Ħ		Ħ	IJ	I	┟	I	V	H	Ī	ļ	P	I	ß	I	┢	ſ	ñ	Ī	Ħ	P	Ð	F	Ð	Ħ	p	
t	H	ť	f	Í	H	1	ij	l	ľ	t	ł	t	f	i	Í	f	H	⋕	f	ľ	f	H	⋕	I	f		f	t	ľ	ť	ľ	ľ	t	ť	l	ĺ	ĺ	l	į	Ť	Í	İ
Í	t	ť	t	Í	ľ	ł	l	ļ	ľ	Í	İ	t	t	ţ	ĺ	Ű	l	Ű	Í	Ú	Í	ľ	Ű	l	ĺ		Í	ľ	ľ	t	l	Ì	ľ	Í	l	l	l	ľ	Í	t	l	ļ
	I	Π	l	I	I	I	I	l		ſ	I		I	l	l	I	I	I	I	l		I	ľ		ļ		l	I		I			1	l	I	I		I	I	1	I	
III.	ļ		ĺ	l	ļ	ł	1	ļ		l	l			l	ļ	l		l	l	l	L		l	ļ	ĺ		l	1	ļ	l	I	Í	ļ	l	l	l		l		1	l	ļ
Щ		l	l	l		Í	ļ	ļ		l	4	l	4	ļ		l		1	l	ļ	ŀ		ļ	1	ļ	l	ļ					1	l	l	l	ł		ļ	Í	1	ļ	ļ
Ш	l	l	l	4		1	1	J		ľ	╏	l	₽	ļ	ļ				₽	H	l		₿		₽	l	ł	l	l	l			╢	l	l		l	1	ŧ	Ĵ	l	l
i Mi	Ш	đ	ŧſ	f	H	1	1	đ	1	Р	Ĥ	uf	fi	1	ų	11	l	11	lí	ШÍ	۴	ul I	ſ	П	ſ	Π	ľ	Π	n	Ľ	Ψ	ú	đ	1	1	Ħ	1	f	ľ	1	Ē	ľ
										1																																

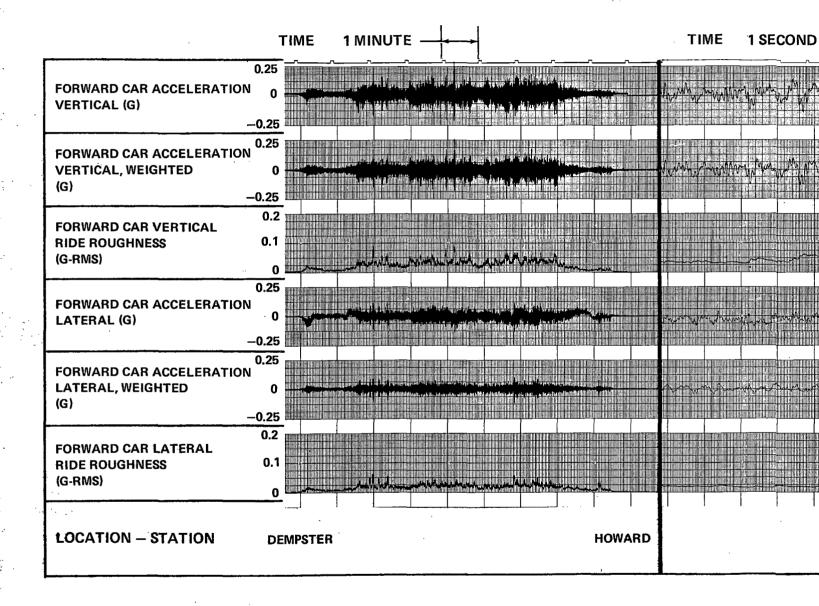
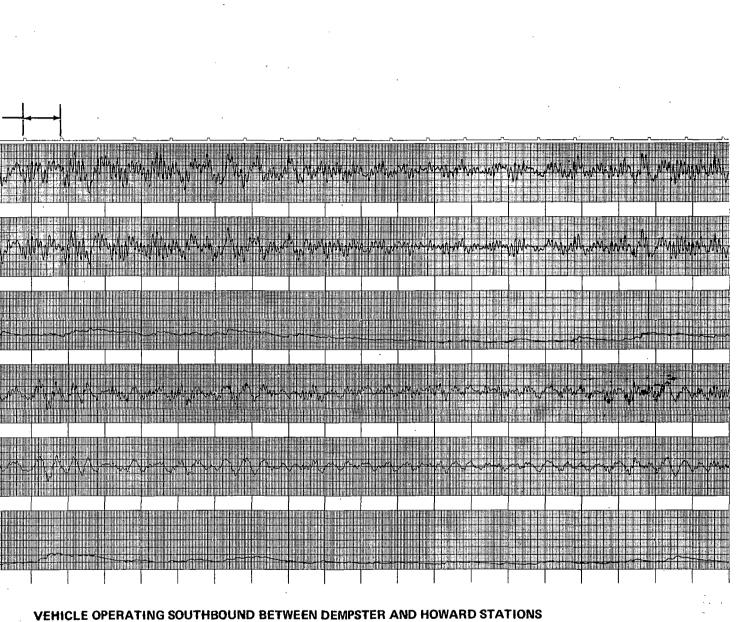


Figure 5–23. Forward Car Acceleration Time History Chart (D–H)

C--45



APPENDIX D TESTING AT PHILADELPHIA

1.0 TEST DESCRIPTION

As part of the Operational Test and Evaluation Program, the State-of-the-Art Cars were in Philadelphia from February 20th to May 1, 1975. The period following the completed operational demonstration phase was used to perform the Simulated Revenue Service Tests.

1.1 Test Site

The SOACs were operated on the SEPTA Broad Street Subway. This line is entirely underground with the exception of the northern terminal Fern Rock. From Fern Rock the line runs southward through the central business district and terminates at Pattison Avenue, a distance of 10 miles. There are 22 stations with a scheduled service time of 34 minutes.

1.2 Test Operations

The test plan was to operate the SOAC in simulated revenue service over the test route. For safety and operational reasons, vehicle operation was entirely under the control of SEPTA personnel during the tests. The only requirement imposed by the test was to maintain the normal scheduled service as close as possible and to simulate the normal station stop by opening the car doors on the side opposite the station platform.

The tests were scheduled for and completed on the evening of April 23, 1975. No significant events occurred which detract from the validity of the test data.

Subsequent to the engineering tests, an exploratory type test on gearbox resonance was accomplished on the SOAC. These tests showed a car body vibration at 74 to 84 mph induced by wheels and gearboxes. This speed range was far above the speeds for the SEPTA tests and no influence on the SEPTA test data was expected or found.

D-1

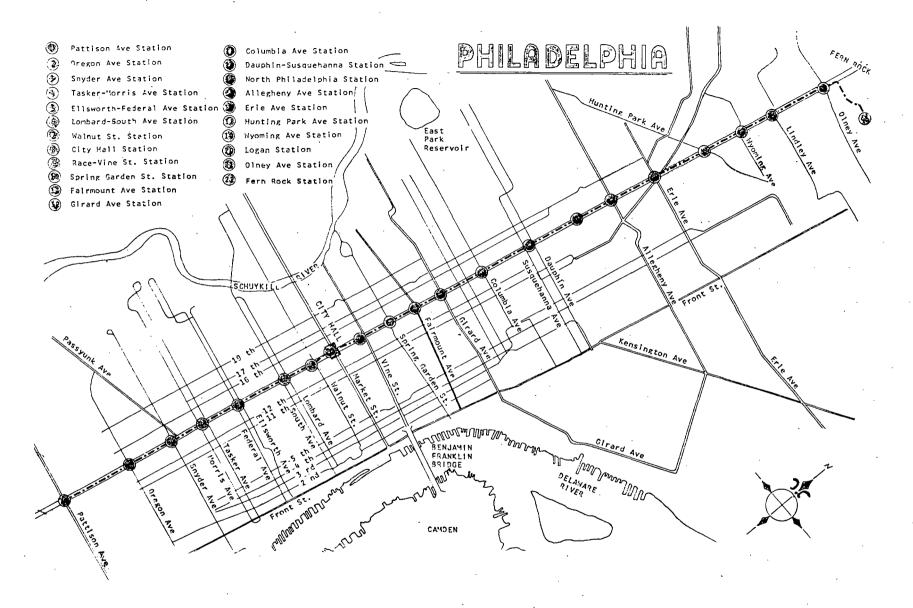


Figure 1–1. The SEPTA Broad Street Subway System

D-2

2.0 TEST PROCEDURES

Pretest

- 1. Mount all required sensors
- 2. Calibrate Instrumentation System
- 3. Brief Test Crew on Test Operations

NOTE:

One vehicle is instrumented for noise measurements, avoid other than normal conversation.

Test

- Operate the vehicles in a simulated revenue service,
 i.e. maintain the given schedule.
- Provide a nominal 10 second door opening at each scheduled stop.
- 3. Provide voice commentary on instrumentation recording during progress of test.
- 4. Maintain a manual log of events during the test run, correlated to the instrumentation system records.
- 5. Monitor various preselected data channels to ascertain validity of test run.
- 6. The Test Controller will terminate the test if:
 - (a) An extended delay or train shutdown occurs
 - (b) One or more required data channels malfunction

(c) The test vehicle is not operating properly Advise Test Controller of any abnormal operations or events that occur during the test run.

3.0 INSTRUMENTATION

The SOAC Instrumentation System was used for this series of tests. This system is described in detail in Volume VI of State-of-the-Art Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center, Final Test Report, UMTA-MA-06-0025-75-6, January 1975. A synopsis is included below.

3.1 Ride Qualities, Structural and Performance Tests

Electrical signals from the vehicle mounted transducers are conducted by cables to an interface panel which is connected to an instrumentation console containing two magnetic tape recorders, two light beam oscillographs, a time code generator, a temperature recorder and signal conditioners. Any 28 selected test parameters can be recorded on tape and displayed on the oscillographs. In addition, wheel speeds may be recorded directly on the oscillographs; total power is recorded on tape and displayed on a mechanical counter. The time code generator provides signals that are recorded on both tape and the oscillograph. The oscillographs provide quick-look data to evaluate test progress and results during testing (See Figure 3-1).

3.2 Noise Tests

The instrumentation used for noise measurement consisted of a 1" condenser microphone with battery operated cathode follower and a 1/4" single channel tape recorder.

D-4

SOAC INSTRUMENTATION CONSOLE

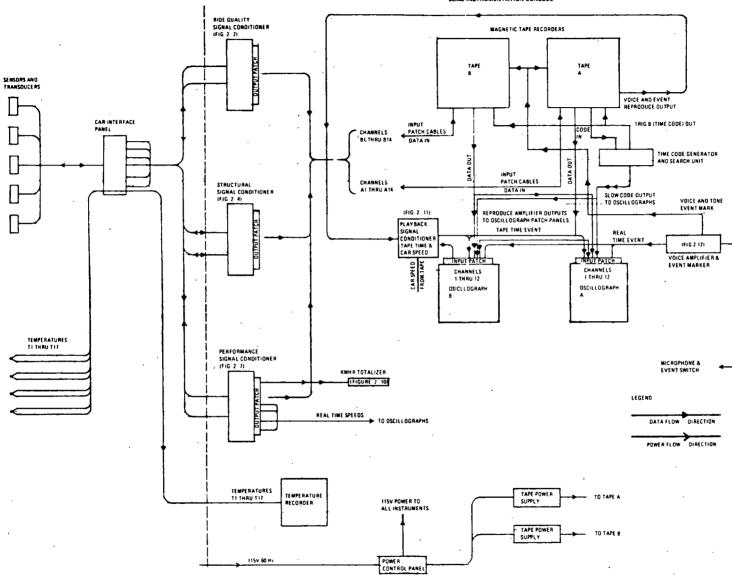


Figure 3-1. SOAC Instrumentation System Block Diagram

D--5

4.0 <u>DATA</u>

The parameters recorded during the property tests are described in Tables 4-1 and 4-2. The definition of the parameter measurements is contained in Appendix A, Standard Outputs for SOAC Property Tests.

Data was recorded for the roundtrip routes noted in the Test Description Section. All of the data was recorded on analog tapes and processed to provide three types of outputs.

Time History Charts Station Summary Tables Frequency Histograms

4.1 Time History Charts

A slow chart speed strip-out of certain parameters is included in this report. The purpose of these charts is to provide an indication of the maximum levels of parameters during various phases of the run. The complete run is described on the charts including station stops and any particularities that occurred. A series of time histories at a high chart speed is included to illustrate the cyclical nature of the data. These charts are a single time frame for all parameters and are representative of the worst case conditions exhibited for a particular test run.

Intermediate parameters, such as a weighted (filtered) car body acceleration are shown on some charts.

4.2 Station Summary

A summation or summary of specific parameters is made by each station stop. These include test running time and distance for comparison to the property's schedule. Power consumption, motor duty cycle parameters are also summarized by station to indicate the relative sizing of the SOAC propulsion with respect to operations on the property. Station stops and maximum speeds are also shown as another indicator of vehicle operation in a scheduled service environment.

D-6

PZ	ARAMETER		STANDARD	OUTPUTS	
DESIGNATION NO.	DESCRIPTION	RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
301	Longitudinal Acceleration	<u>+</u> 0.25 g's	AP/A	Format(3)	Format(4)
302	Line Voltage	0 to 1000 VDC	LVD/A	None	
303	Line Current	0 to 2000 ADC	LCD/A	None	-
304	No. 1 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	-
305	No. 1 Truck Armature Current	0 to 1000 ADC	MACD/A	None	RMS-MAC/A
306	No. 1 Truck Field Current	<u>+</u> 50 ADC	MFCD/A	None	RMS-MFC/A
307	No. 2 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	-
308	No. 2 Truck Armature Current	0 to 1000 ADC	MACD/A	None	- ·
309	No. 2 Truck Field Current	<u>+</u> 50 ADC	MFCD/A	None	-
. 310	"P" Wire Current	0 to 1.00 ADC	CS/A	None	Format(3)
317	Total Power Consumption	l Pulse/0.1 KWHR	PCC/A	Format(2)	Format(2)
315	Speed	0 to 80 MPH	VS/A	Format(3)	Format(4)
318	Brake Cylinder Pressure	0 to 100 psig	BCP/A	None	-

Table 4-1. SOAC Revenue Service Data List A

D-7

	P	ARAMETER		STANDARD	OUTPUTS	
D	ESIGNATION NO.	DESCRIPTION	RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
	101	Front Truck, Forward Axle, Righthand Wheel Journal Box Vertical Acceleration	<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
	102	Front Track, Forward Axle, Righthand Wheel Journal Box Lateral Acceleration	<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
	103	Front Truck, Forward Axle Lefthand Wheel Journal Box Vertical Acceleration	<u>+</u> 20 g's	AJ/A	Format(3)	-
ר גו	115	Mid Car Centerline Vertical Acceleration	<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1), (3)
	116	Mid Car Centerline Lateral Acceleration	<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1), (3)
	120	Forward Car Centerline Vertical Acceleration	<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1)
	121	Forward Car Centerline Lateral Acceleration	<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1)
	219	Truck Frame Upper Strain Gage	<u>+</u> 6348 psi	STP	Format(3)	Fromat(4)
	220	Truck Frame Lower Strain Gage	<u>+</u> 6348 psi	STP	Format(3)	-
	221	Pitch Angular Acceleration	+ 1.5 Rad/sec/sec.	ACA/A	Format(3)	Format(4)
	222	Roll, Angular Acceleration	\pm 1.5 Rad/sec-sec.	ACA/À	Format(3)	Format(4)
	223	Yaw, Angular Acceleration	+ 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
	-	Interior Sound Pressure	40 to 120 dB(re 2 x SP/A	10-5ŊM ²)	NL/A(1)	NL/A(2)

Table 4-2. SOAC Revenue Service Data List B

D--8

4.3 Frequency Histograms

3.

These distributions are an indication of the ratio of time that a parameter is at a particular level with respect to the time to complete a roundtrip scheduled service run. These parameters may be used to describe how the vehicle was driven, the track conditions, and how the vehicle responded to these conditions.

5.0 DATA DISCUSSION

Vehicle operation was such that while operating southbound from the Fern Rock Station, the instrumented car, SOAC No. 2, was leading. A positive longitudinal acceleration value on the time history chart is startup. For the northbound run vehicle start-up is a negative value on the longitudinal acceleration time history.

As defined in Section 4, there are three forms of data. These forms are discussed below with respect to three categories:

(1) Operation

How the vehicle was operated and maintained schedule.

(2) Environment

Track and truck conditions

(3) Response

How the vehicle responded to the operational environment.

Figures 5-1 to 5-13 present the frequency histograms for the SEPTA tests. Figure 5-14 is a sample of the Interior Noise Level time history. The remaining time history charts are shown in Figures 5-15 through 5-25. Table 5-1 is a summary of some of the test parameters and is taken from the histograms and time history charts. Tables 5-2 and 5-3 are the Station Summaries with power consumption.

5.1 Operation

The Station Summaries show that the SOAC maintained the SEPTA schedule and even ran early. As noted on the Summaries, station stop times were too short, and possibly influenced the early run time.

The maximum acceleration rate for the SOAC at SEPTA is shown on the time histories to be 2.73 mph/sec. This value is within the SOAC specification.

The Station Summaries show 14 percent of the trip time was spent in a station. This is comparable to the speed frequency histogram which shows 22 percent of the trip time in the 0 to 5 mph band. The 8 percent difference would be the time spent with the vehicle moving at 5 mph or less. This is a high ratio of low speed running.

The Station Summaries show the power consumption for the SOAC to be 136 KWHR for the roundtrip. For the scheduled distance of 20 miles this is 6.8 KWHR/mile. For the measured distance of 22.5 miles, it is 6.1 KWHR/mile.

The RMS armature current indicates the relative sizing of the SOAC propulsion system with respect to the test route. The SOAC motors have a continuous rating of 175 hp (460 amps), and a one hour rating of 230 hp (600 amps). The roundtrip required 281.5 amp (RMS) or 61 percent of the continuous rating. Consistently the most severe cycle is the Logan to Wyoming Street run which required around 370 amps.

5.2 Environment

The journal accelerations and truck frame stress were to be used as an indicator of track conditions. Unfortunately, the vertical journal box accelerometer failed prior to the test and this data was not obtained. In addition, the truck frame stress gage was destroyed prior to this test and this data is also missing.

The summary values for the journal lateral acceleration are shown in Table 5-1. The 50th percentile is a statistical quantity and is read as 50 percent of the time the journal lateral acceleration is between <u>+</u> 3.4 gs. The 95th percentile is read similarly. The "nominal" value is the 50th percentile for vehicle moving time.

5.3 Response

Ride Roughness and Noise Levels are parameters which are related to "human responses". Ride Roughness is a ride comfort rating of vibration levels, and Noise Level is a hearing comfort rating of sound pressure levels. The parameters are described in the Standard Output Section of this report. A summary of the values for the SEPTA tests is shown in Table 5-1.

A summary of the car body acceleration levels is also shown in Table 5-1. From the time history charts it can be seen that the 7.5 hertz is the dominant vertical vibration frequency.

Interior Noise Level data was taken in the middle of the non-instrumented car at a seated person's ear level. The original engineering tests at TTC indicated that this is the quietest point in the car. The statistical quantities derived from the data are:

L(99)	L(90)	L(50)	L(10)	L(1)	L(EQ)
64 dba	66	68	75	82	72

SEPTA

Table 5–1. Summary Values for SOAC Operating on the CES Airport Line

х.	50TH %	"NOMINAL"	95TH_8	MAXIMUM
Journal Box Vertical Acceleration (G)	(DATA	CHANNEL MALFU	NCTION)	-
Journal Box Lateral Acceleration (G)	<u>+</u> 3.4	<u>+</u> 3.8	<u>+</u> 9.25	-
Truck Frame Stress (PSI)	(DATA	CHANNEL MALFU	INCTION)	-
Forward Car Vertical Acceleration (G)	<u>+</u> .022	<u>+</u> .026	<u>+</u> .071	<u>+</u> .197
Mid Car Vertical Acceleration (G)	<u>+</u> .019	<u>+</u> .022	<u>+</u> .068	<u>+</u> .209
Forward Car Lateral Acceleration (G)	<u>+</u> .015	<u>+</u> .018	<u>+</u> .047	<u>+</u> .222
Mid Car Lateral Acceleration (G)	<u>+</u> .015	<u>+</u> .018	<u>+</u> .038	<u>+</u> .163
Longitudinal Ride Roughness (GRMS)	.004	.005	.014	.080
Forward Car Vertical Ride Roughness (GRMS)	.011	.013	.043	.100
Mid Car Vertical Ride Roughness (GRMS)	.012	.014	.050	.115
Forward Car Lateral Ride Roughness (GRMS)	.007	.009	.029	.118
Mid Car Lateral Ride Roughness (GRMS)	.004	.005	.017	.090
Pitch (RAD/Sec-Sec)	<u>+</u> .140	<u>+</u> .150	<u>+</u> .190	<u>+</u> .119
Roll (RAD/Sec-Sec)	<u>+</u> .125	<u>+</u> .140	<u>+</u> .230	<u>+</u> .932
Yaw (RAD/Sec-Sec)	<u>+</u> .138	<u>+</u> .146	<u>+</u> .190	<u>+</u> .173

Table 5–2. S	Station Sun	ımarv I
--------------	-------------	---------

.

	STATION	5	SCHEDULE	TE	ST	POWER CO	ONSUMPTION					
NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)	
LIM.I	Fern Rock	. 0	0	0	0	0	0	0	0	0	0	-
20 30 ²	Olney Avenue	.68	3.0	.74	3.25	3.09	4.15	104.6	27.8	19.2	20	
, 16 ³	Logan Street	.62 1.3	2.0	.69	2.12	1.47	2.14	185.4	22.7	15.6	30	
40 ³ 40 ⁴	Wyoming Avenue	.38 1.68	2.0	.40	1.08	2.84	7.07	368.0	28.5	12.0	39	
40	Hunting Park Ave.	.45 2.13	1.0	.55	1.18	4.10	7.44	377.6	27.5	10.0	43	
40 40	Erie Avenue	.60 2.73	2.0	.72	2.18	3.59	5.02	257.2	28.0	18.0	38	
40 ⁷)	Allegheny Avenue	.53 3.26	2.0	.58	1.45	3.05	5.24	277.2	29.7	10.8	42	
40	North Philadelphia	.41 3-67	1.0	.52	1.32	3.62	7.03	328.7	29.1	9.6	40	
409	Dauphin Street	.58 4.25		.66	1.46	3.43	5.18	314.9	25.1	14.4	42	
/ 10	Columbia Avenue	.58 4-83	1.0	. 67	1.41	4.29	6.45	359.2	26.9	12.0	44	
30	Girard Avenue	.51 5.34	2.0	. 59	1.53	2.Ì1	3.58	257.0	23.6	9.6	32	
25_{12}^{2} 35_{12}^{2}	Fairmount Ave.	.33 5.67		.37	1.19	1.98	5.43	286.8	28.6	9.6	28	
1 4	Spring Garden St.	.28 5-95	1.0	. 35	1.07	2.00	5.66	331.3	28.3	9.6	34	
35 ⁻¹³ 20 ⁻¹⁴	Race - Vine Street	.38 6.33	1.0	.43	1.33	1.81	4.24	270.9	24.1	20.4	34	
25-15	City Hall	.35 6-68	2.0	.41	1.57	1.98	4.80	197.2	28.9	13.2	22	
· 20 16	Walnut Street	.25 6.93	1.0	.30	1.15	2.00	6.77	256.7	30.8	13.2	28	
45-17	Lombard Street	.33 7.26	2.0	.38	1.46	1.81	4.75	217.7	28.9	10.8	22	
18	Ellsworth Avenue	.56 7.82	1.0	.62	1.32	3.71	5.98	351.4	27.2	10.8	43	
45 ¹⁰ 39	Tasker Avenue	.44 8.26	1.0	.51	1.31	3.70	7.29	351.2	28.3	12.0	43	
41 20	Snyder Avenue	.39 8-65	2.0	.45	1.58	2.59	5.79	266.8	25.8	12.0	34	
21	Oregon Avenue	.51 9.16	2.0	.60	1.32	3.62	6.07	339.3	27.3	12.0	44	
NO 22	Pattison Avenue	.86/0.02	- 2.0	.81	2.95	5.16	6.33	275.4	28.2	12.0	40	
				тс	TALS	61.95	5.46	278.7	27.4			

TEST RUN SUMMARY

	SCHEDULE	TEST
Distance	10.02	11.35
Time	34.0	33.23
Block Speed	17.7	20.5
Station Dwell	30.0	12.7
Station Spacing	.48	.54

D-14

34.0

	STATION		SCHEDULE	TE	ST	POWER C	ONSUMPTION				
NO.	NAME)ISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)
4.5	Pattison Avenue	0	0	0	0	0	0	0	0	0	0
• • •	Oregon Avenue	.86 /0.9	f 1.0	.85	1.80	4.13	4.85	280.0	28.0	14.4	44
453	Snyder Avenue	.51 U.3	9 2.0	.63	1.42	3.39	5.39	291.1	28.5	10.8	44
<u>4</u>	Tasker Avenue	.39 /1.7	8 2.0	.42	1.34	2.47	5.88	248.4	31.0	12.0	36
455	Ellsworth Avenue	.44/2-2	~ 1.0	.53	1.26	3.77	7.14	342.1	29.0	12.0	45
453455	Lombard Street	.56 /2.7	8 1.0	.62	1.42	4.08	6.55	324.9	27.4	13.2	46
257 257 358 259 10 351 351	Walnut Street	.33 13-1	/ 2.0	.39	1.44	2.18	5.53	197.0	32.5	14.4	28
3_8	City Hall	.25/3.7	۲.0	.10	1.37	1.53	5.16	207.1	26.8	19.2	24
فحرر	Race Vine Street	.35/3.7	2.0	.40	1.26	2.76	6.96	269.4	31.9	12.0	34
10	Spring Garden Street	. 38 14.0	9 1.0	.41	1.14	3.32	8.20	312.8	30.2	12.0	34
11	Fairmount Avenue	.28 14-3	7 1.0	.35	1.13	3.32	9.59	318.7	32.0	13.2	38
3.2	Girard Avenue	.3314-7	^{,6} 1.0	.38	1.24	2.56	6.65	281.2	29.0	13.2	33
$4s^{-12}_{13}$ $4s^{-14}_{14}$	Columbia Avenue	.51 45-2	2/ 2.0	.57	1.41	3.83	6.74	305.8	27.7	15.6	44
43 <u>–</u> 14	Dauphin Street	.58 <i>45-</i> 7	7 9 1,0	.67	1.45	4.44	6.69	347.8	27.7	12.0	45
<i>رپ -</i> 15	North Philadelphia	.58 /6.3	37,2.0	:69	1.83	4.22	6.15	284.1	23.2	12.0	45
⁴⁴⁵ 16	Alleghany Avenue	.41 /6.	75 1.0	.51	1.42	3.90	7.66	328.5	30.1	15.6	46
4517 · 4518	Erie Avenue	.53 /7.3	,	.59	1,59	4.42	7.48	307.4	29.7	13.2	46
⁴³ 18	Hunting Park Ave.	.60 / 7.		.70	1.67	5.12	7.32	309.6	29.6	14.4	46
4519	Wyoming Avenue	.45 / 8 .	36 2.0	.51	1.41.	3.01	5.93	299.4	27.3	14.4	45 '
$40^{-20}_{-43}_{-21}$	Logan Avenue	.38 /8.7		.43	1,19	3.70	8.52	369.0	29.0	15.6	42
21	Olney Avenue	.62 / 9		.71	1.72	5.49	7.69	291.0	26.1	15.6	45
1522	Fern Rock	.68 20.0	4. 3.0	.64	, (3.07)	2.59	> 4.06	100.0	27.5	16.8	15
		`		тс	TALS	74.23	6.69	284.4	28.6		

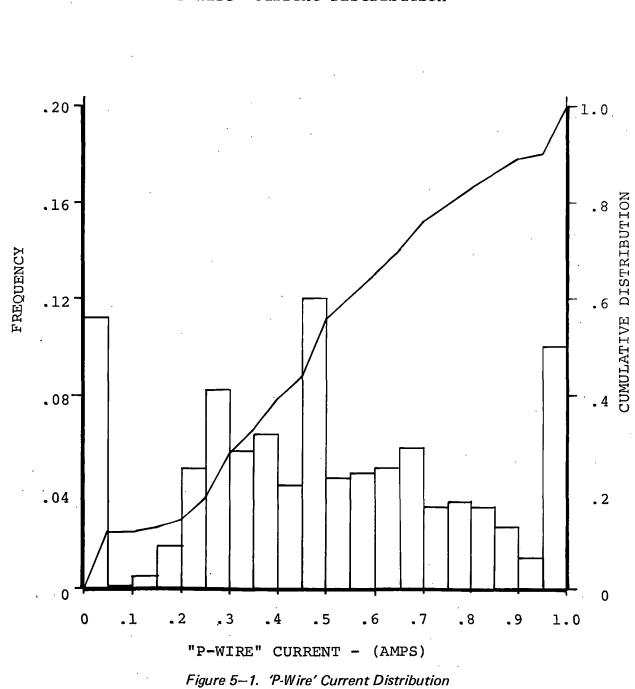
Table 5–3. Station Summary II

D--15

TEST RUN SUMMARY

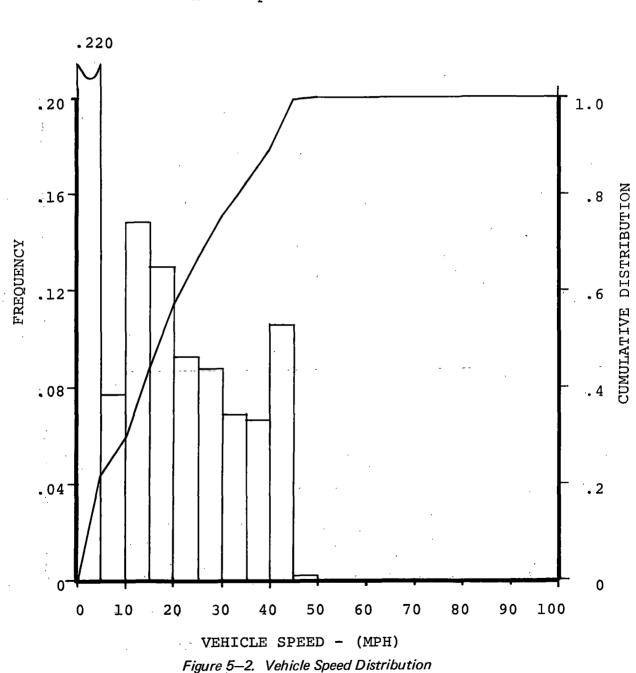
	SCHEDULE	TEST
Distance	10.02	11.10
Time	33.0	31.58
Block Speed	18.2	21.1
Station Dwell	30.	13.9
Station Spacing	.48	.53



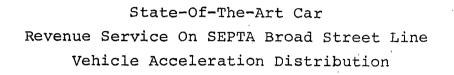


State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line "P-Wire" Current Distribution

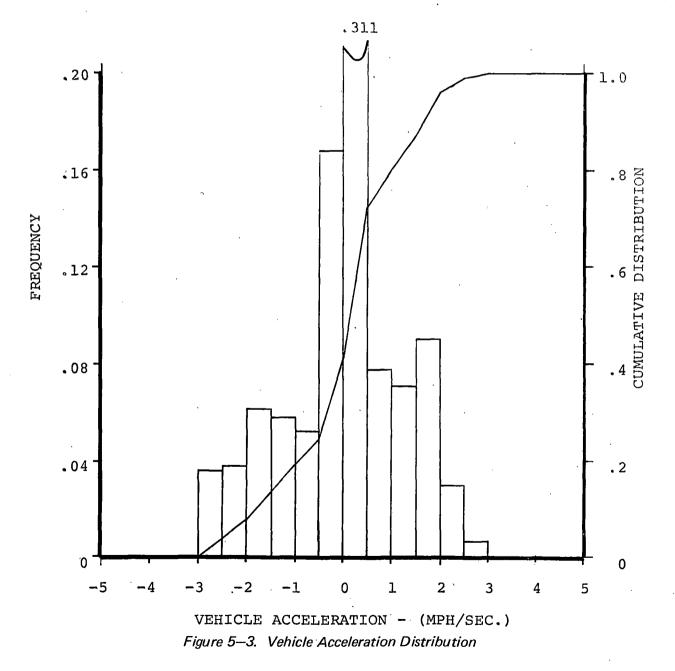
D--16



State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line Vehicle Speed Distribution



ŝ



; D–18

State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line Journal Box Lateral Acceleration Distribution

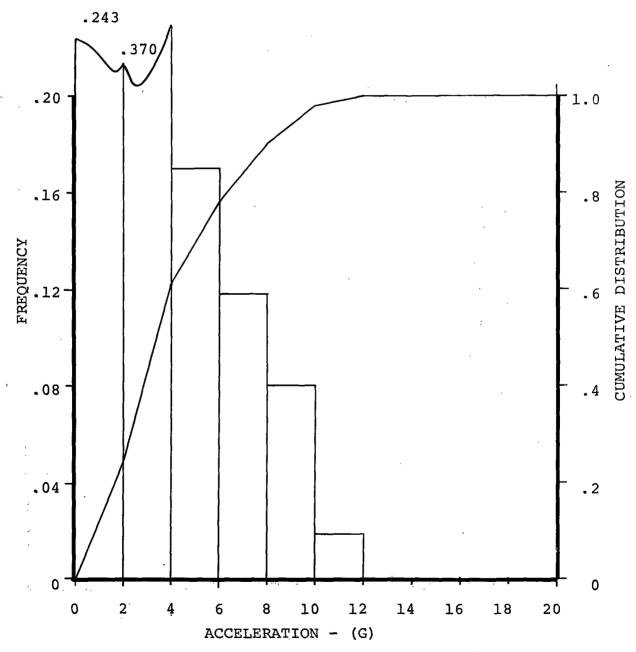
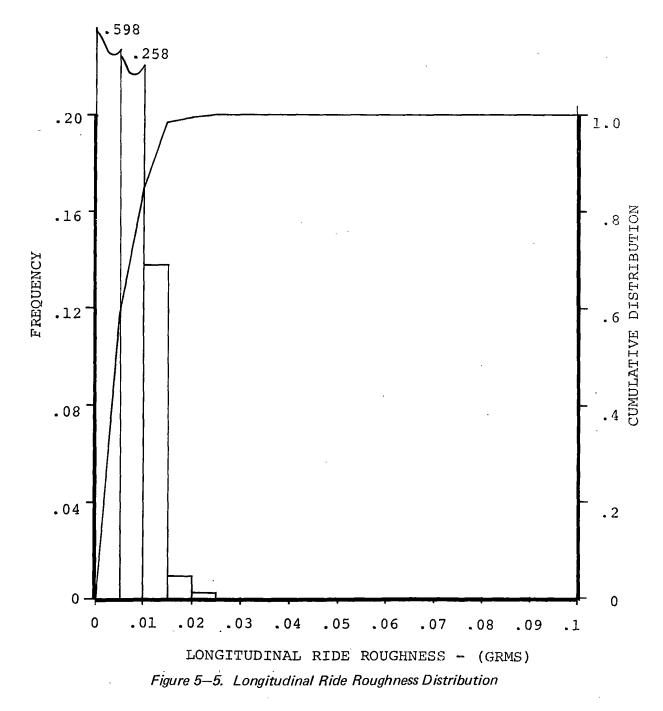
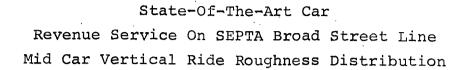
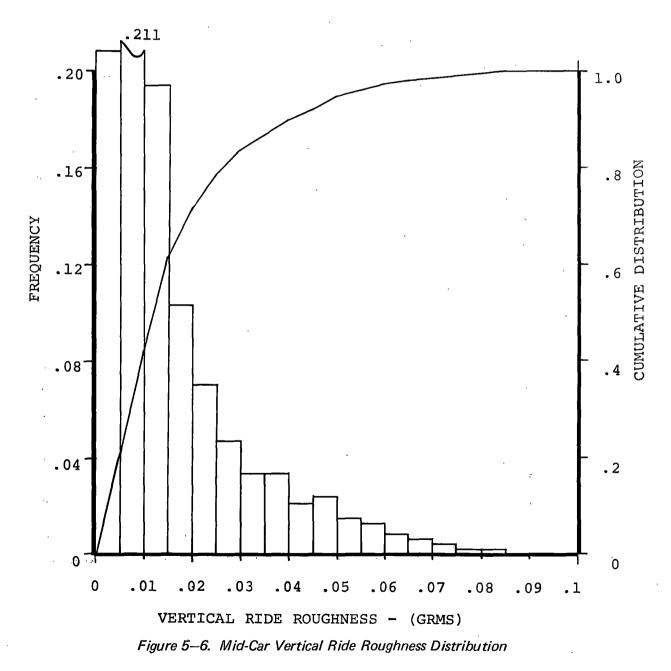


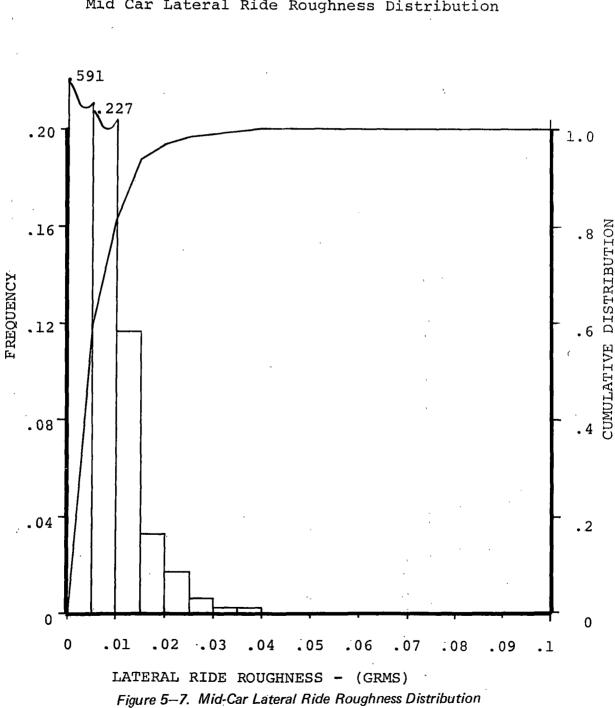
Figure 5–4. Journal Box Lateral Acceleration Distribution

State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line Longitudinal Ride Roughness Distribution



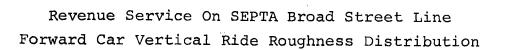




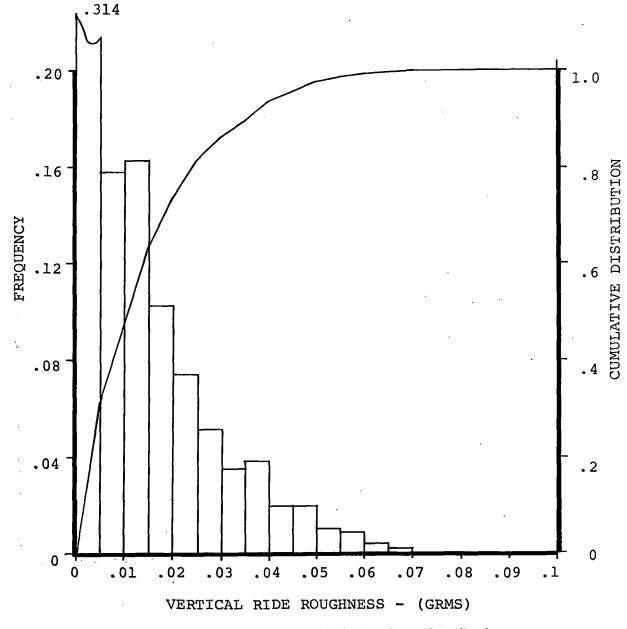


State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line

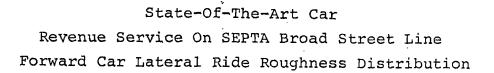
Mid Car Lateral Ride Roughness Distribution



State-Of-The-Art Car







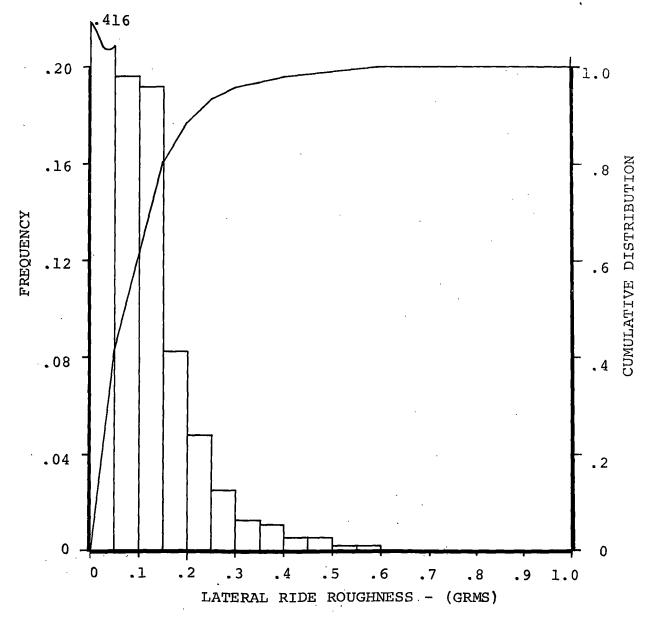
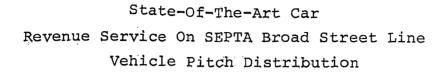
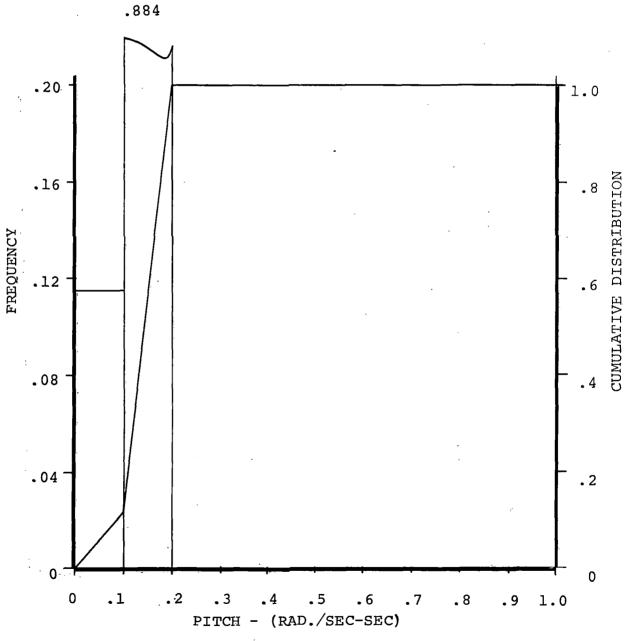
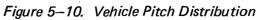
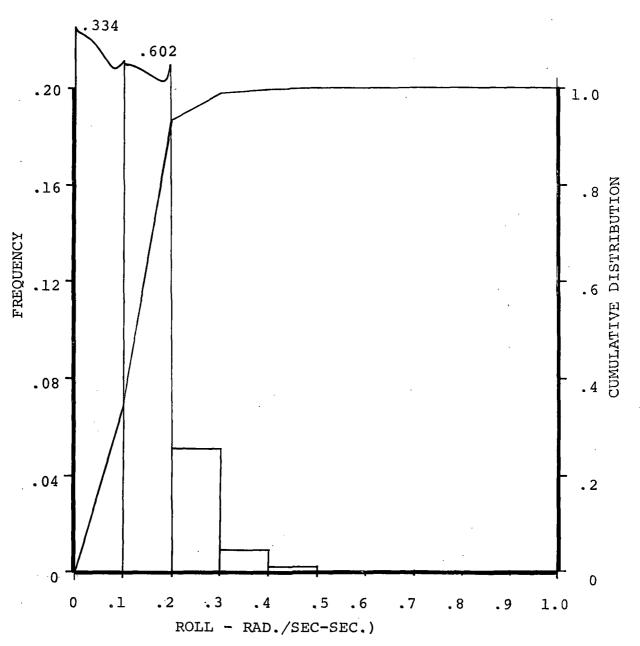


Figure 5–9. Forward Car Lateral Ride Roughness Distribution





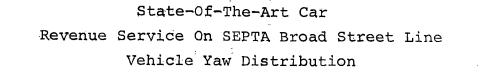




State-Of-The-Art Car Revenue Service On SEPTA Broad Street Line Vehicle Roll Distribution

Figure 5–11. Vehicle Roll Distribution

______D____26



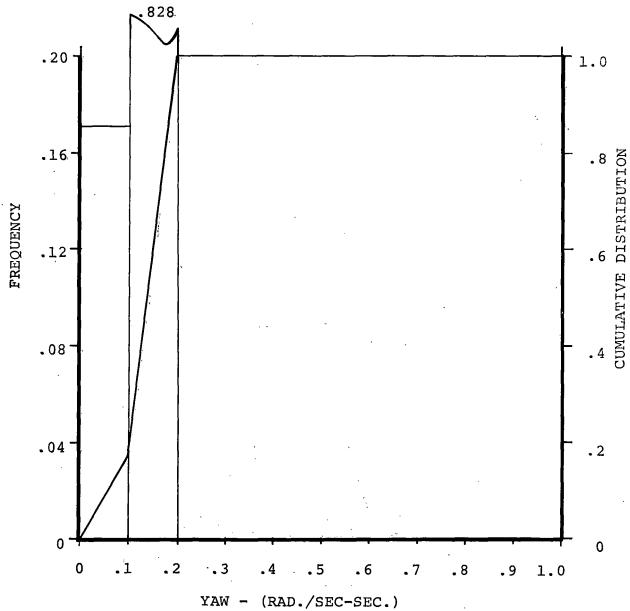
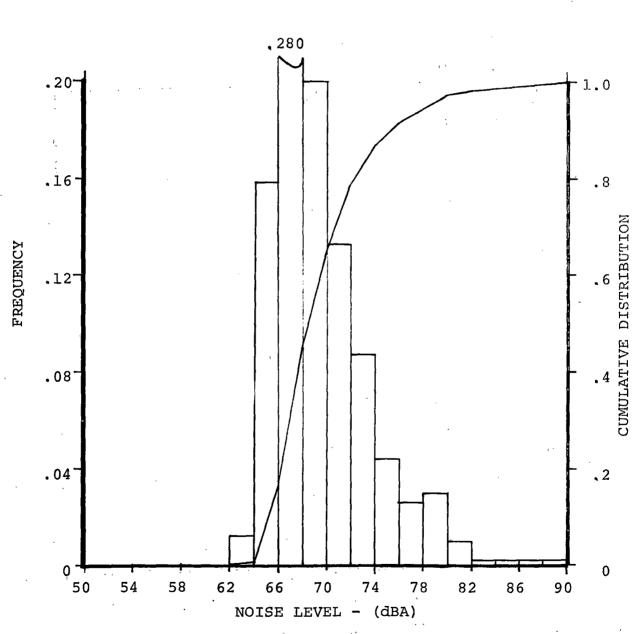
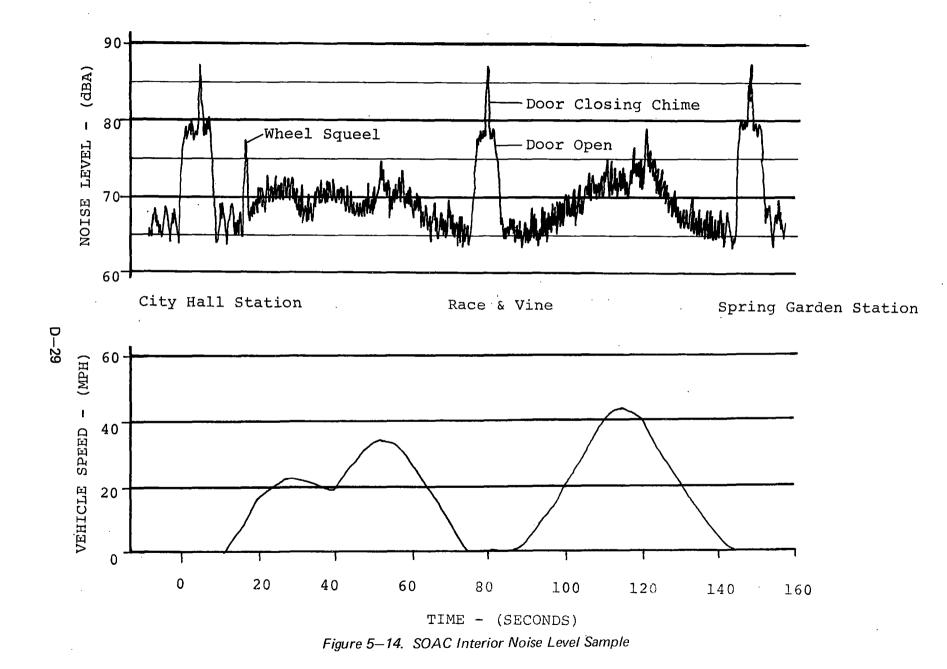


Figure 5–12. Vehicle Yaw Distribution



State-Of-The-Art Car Revenue Service On The SEPTA Broad Street Line Interior Noise Level Distribution

Figure 5–13. Interior Noise Level Distribution



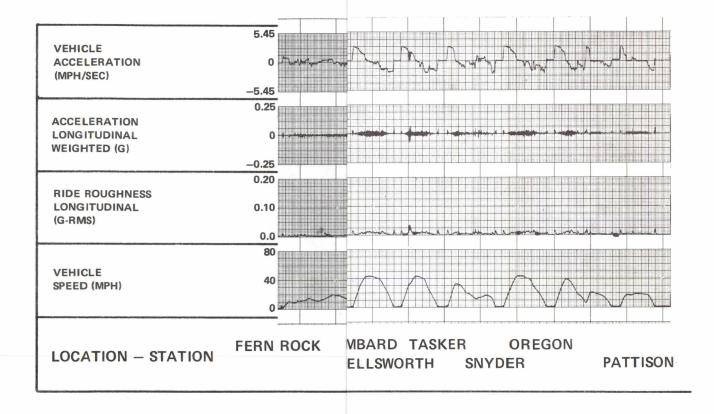


Figure 5–15. Vehicle Accele

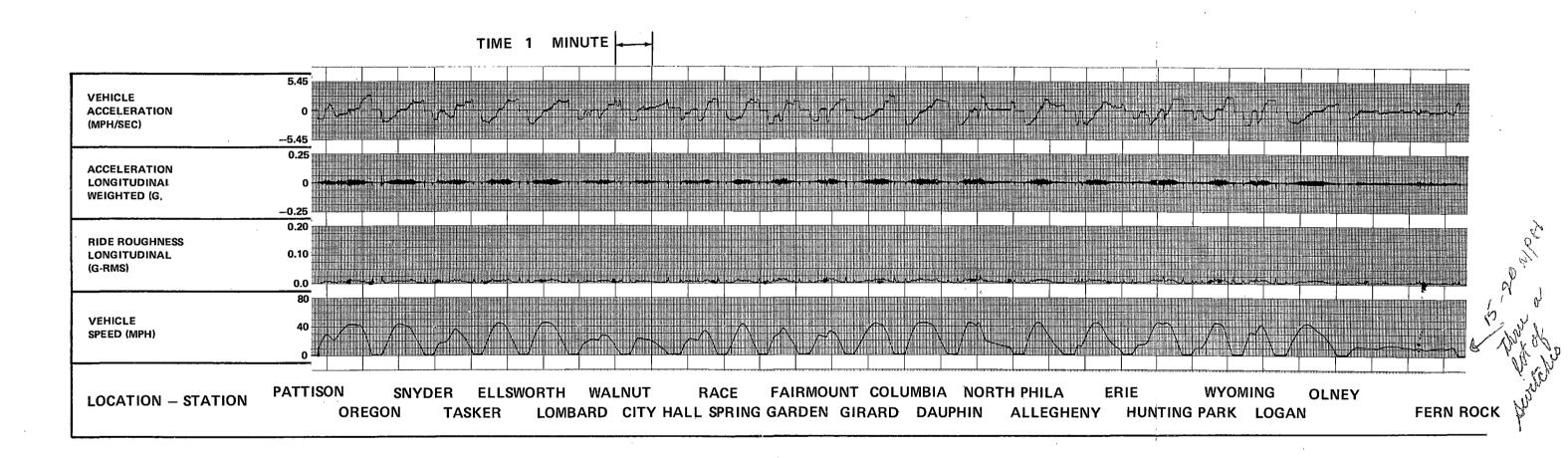


Figure 5–16. Vehicle Acceleration and Speed Time History Chart (P–F)

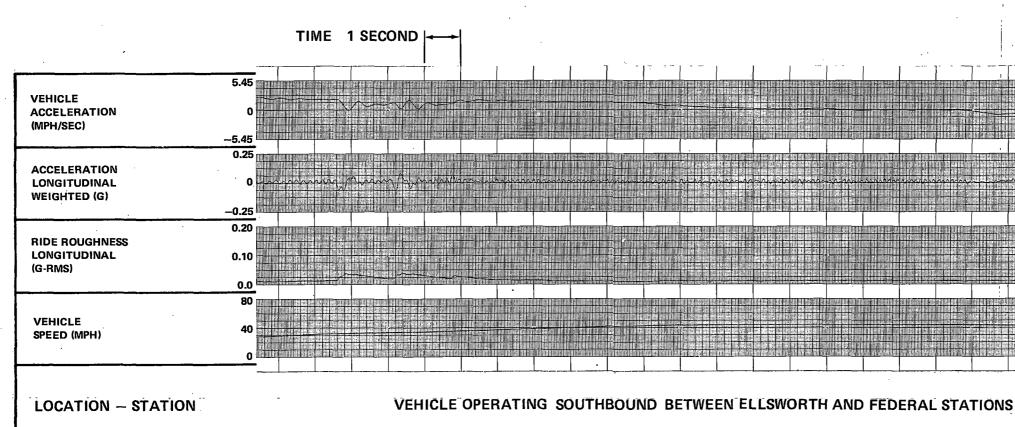


Figure 5–17. Vehicle Acceleration and Speed Time History Chart (~)

				14 I.I. I.I.I.I.I.I.I.I.I.I.I.I.I.I.I.I.I			
				ELEMAN			
				HANNA			
				THEFT			4
				SI A FI FI FI			
				166			_
		ill		И			
the second second second second second second second second second second second second second second second se				ł			
	And and a second s			i	1		
		and the second s		Ę		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
				1	l		
				l			
		t		l	l	Ī	t
			1		-		
		I		1	l		
				Ľ	1		
E	-	I		j	ſ		
A I AND A I I I I I I I I I I I I I I I I I I	and the second sec	ARRENT AND AND ARREST OF A R.		l	ľ		
				l	1		
				1			
				H	1		
				1			
				ŀ			
	_						
				I	I		
	· · · · · · · · · · · · · · · · · · ·				ľ		
and and a second		and the party of t					
			1				
	a de la desarra de la dela dela dela dela dela dela de			L			
					1		
			1	Y			
					Ē	A REAL PROPERTY AND A REAL	
ľ							
		TALL IN THE OWNER WATER AND IN THE OWNER WATER AND IN THE OWNER WATER AND IN THE OWNER WATER AND IN THE OWNER W					
		and a second second second second				and a state	
						And the same	

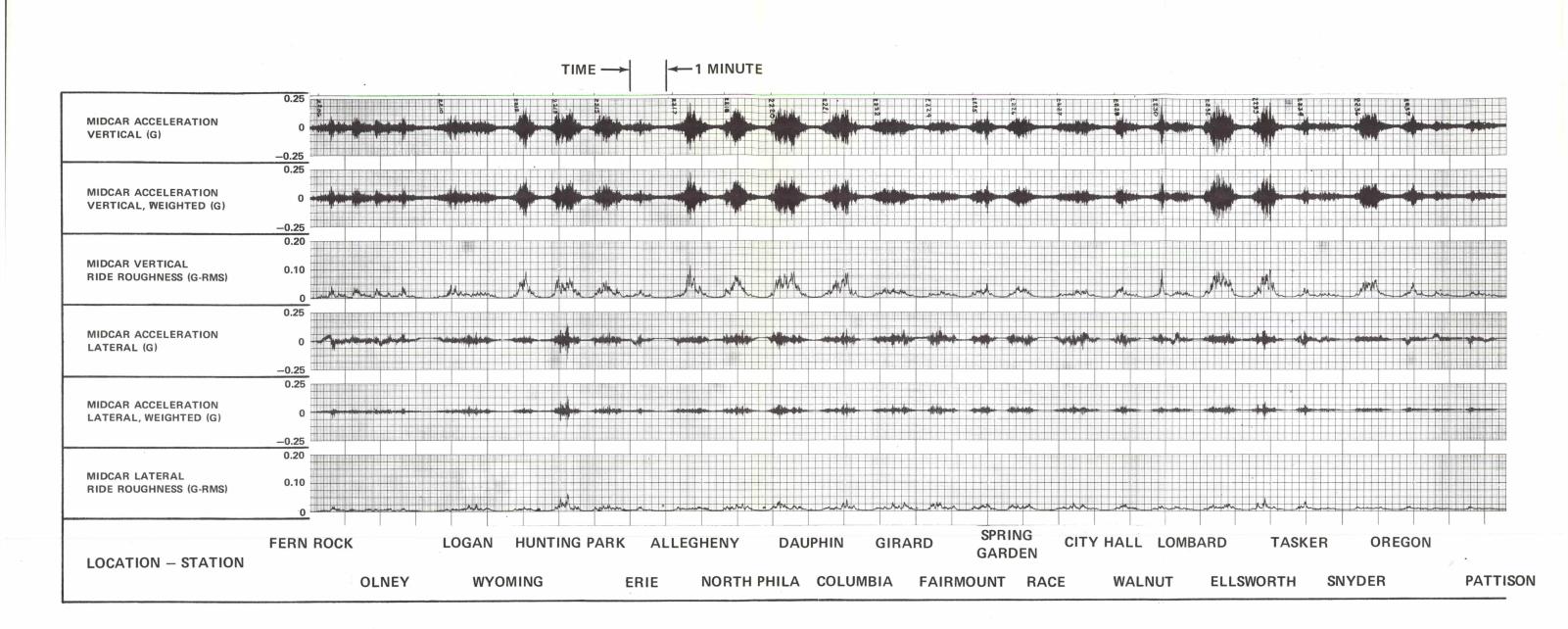
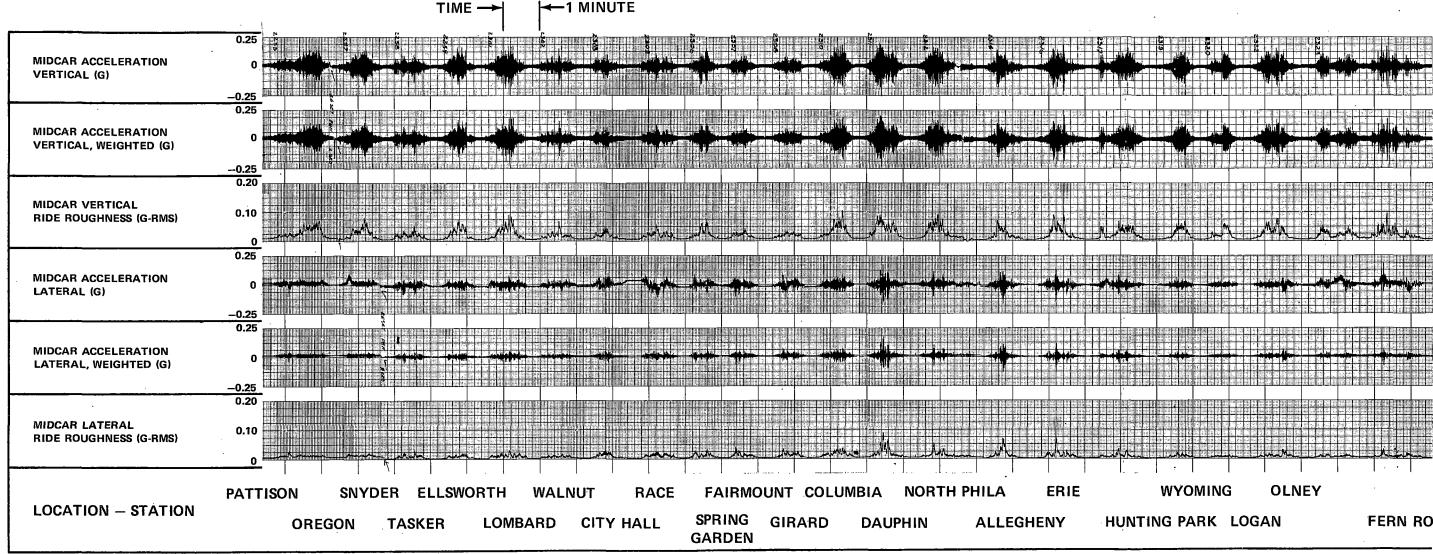


Figure 5–18. Mid-Car Acceleration Time History Chart (F–P)





FERN ROCK

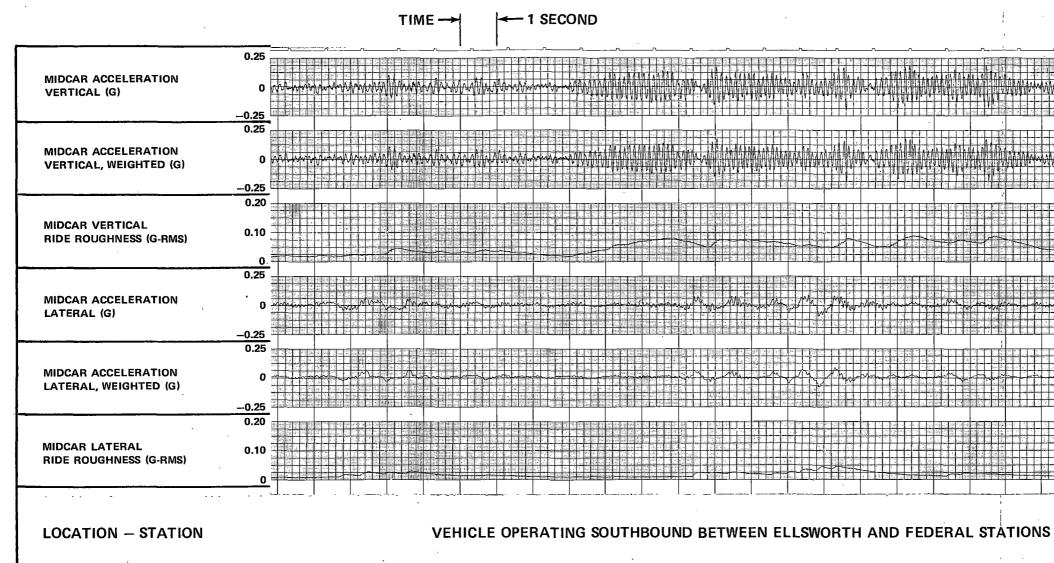


Figure 5–20. Mid-Car Acceleration Time History Chart (~)

	_				_	<u> </u>		_		_	۰		_			÷		_		-3	c		_		-	1			_
				i	1				151 14 -		-							ł			-	1	1						
		1.3	-	F -		2		-		-	1	iĄ		1		t			ħ		1	4	Ľ	I		T.	1		
h	A	J.	h	M	ł	h	þ/	Ā	ł	A	N	H	#	H	H	H	H	4	Щ	14	١.	1	ļ¦;	H	H	H	H	A	h
	Ľ	Ĺ	L					Ľ	Ľ	-	Ľ	Ľ	Ħ	Į,	ŧ	Ľ	Ţ	İ	Ŭ	Ħ	Ħ	Ħ	lt	ţ١	ł¥	Ľ	ť	Ľ	ľ
-		1		-15	 1,e		1		ç.,		-	ŀ		ŀ-	+-	-	-	μ			1		ŀ	╞╴	+	┢	ŀ		ł
		1.7.12	1		lare a								<u>۔</u> ۲	-	-				1	100.0				T	1	1		<u></u>	t
	····	L			1		E.				r	[ŀ				Ľ.	1	┢	1	Г	1				Г	Ŀ	ŀ	╀
1			F	-	-	-	L	F						-	-	Ļ	1	-	ļ.	1	-	Ī				-		-	ļ
ļ,	A	W		1.1	V	A	h	'n	<u>, /</u>	A		A				h	ľ		ĥ		h				M	h	H	h	h
T	Π	-	Γ	M	V	2	-	M	ĮV	μ	Ň	V.	Π	Π	Ų	Π	Щ				П	ľ	I	į	Π	μ	Ų	ľ	h
		-	t	÷			t	E		1		-	ľ	ľ	E		ł	-		i i	H	1	Ť	ľ		Ŀ			
		(6	ſ	3		.		<u>.</u>	62			1.1		1			1	<u>í</u>				<u> </u>	ſ	£	C	ſ	(l
								-	L										L							_	_		
-	-	-	-	-		-	-	F		1	-					-	H							+	-	ŀ	ŀ	-	ŀ
						ŀ				Ľ		Ē		E	E	E	1			ġ.						É	t		t
		1	1			i.		H		-	-	-	F.	1	-								-	┝	┝	t	-	ŀ	ŀ
-		5					-							~	E	Ľ								Γ	۰.	Ē	Ľ	Þ	ŀ
			1.7	11.1			F	F	-	F	F	۲	-				1.7					Б.		┝	-	-			
				Γ					-					Γ					Γ					Γ					f
									6.6		÷																		
1						_							· ·	1	1			-							-				
			5			~		~		· . ·			L	5	Ľ			L	J.		L		Ŀ	L		t			
~	ſ								m		٢.			Ŀ	1~	17		Ľ	1	١* 1	1	ı.	٢.	T٣	1 -	1			ľ
			r	Ľ	5.			L 3	6 d	E • •		£ 3	() I	6.	1	-	-		(7	1	+		1	1.	t		-	
																										Ē			Ē
				1													: :												Ē
				1												1.1	: :												10.00
				1												1.1	- - 												2000 C 10 C
				1												1.1						1							
				1												1.1						1							
				1												1.1						1							
				1												1.1						1							
																1.1						-							
																1.1						-							
																1.1						-							
																1.1													
																1.1													
																1.1													

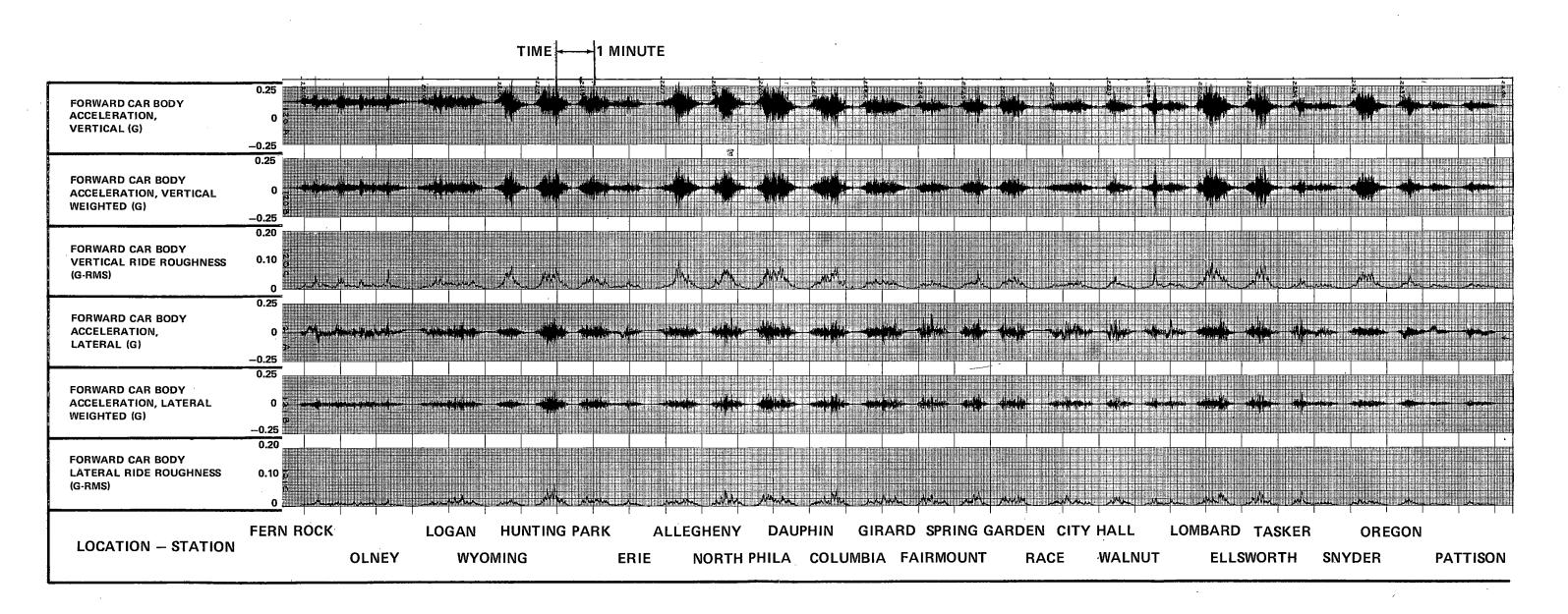
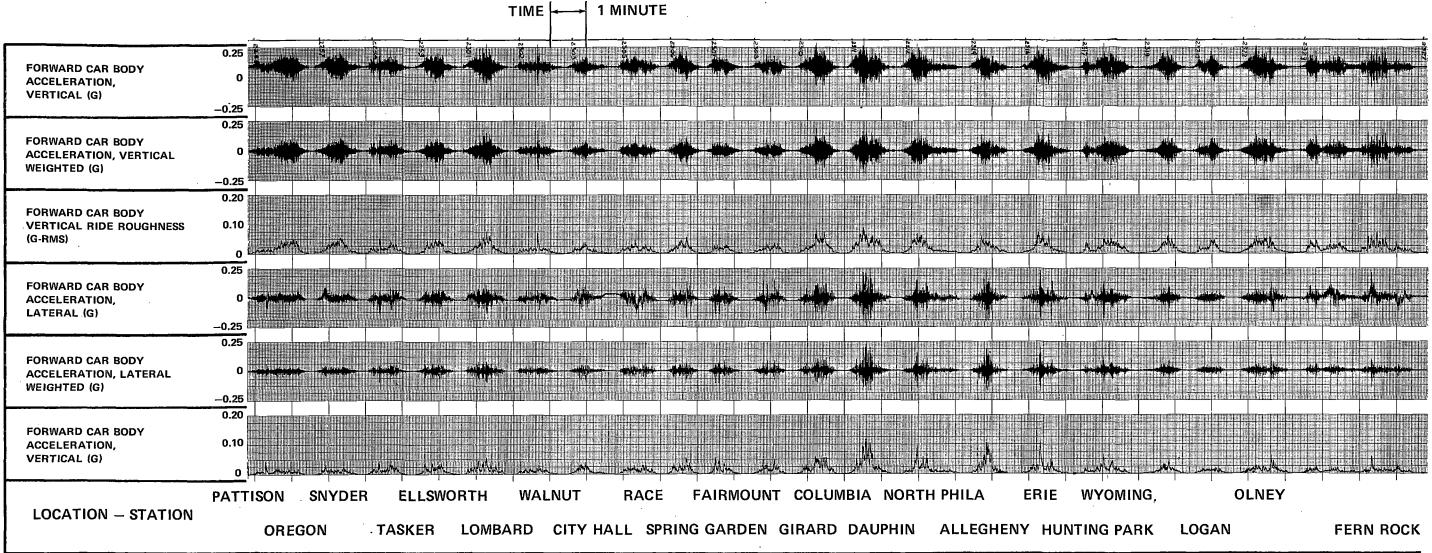
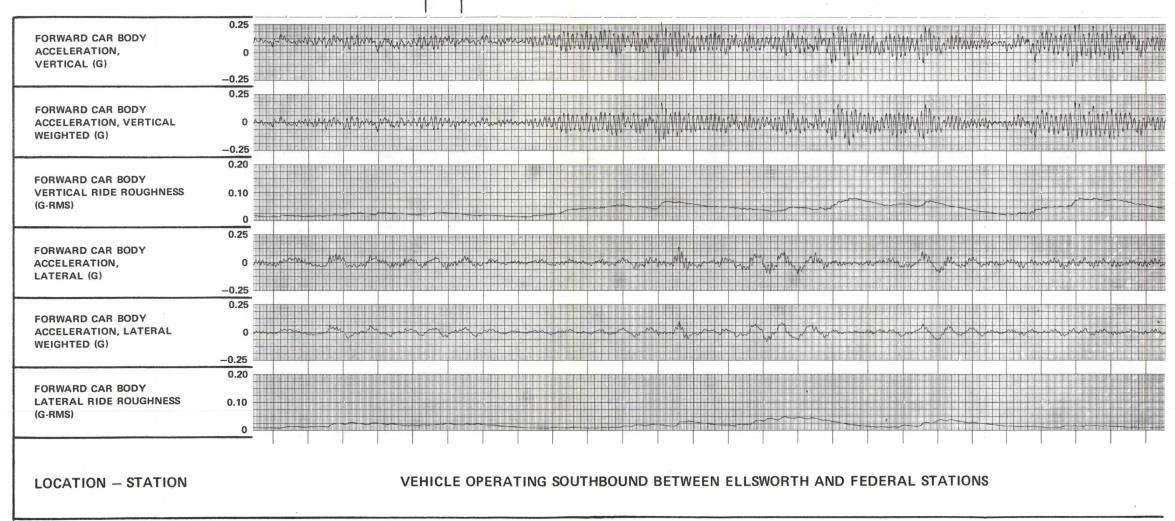


Figure 5–21. Forward Car Acceleration Time History Chart (F–P)









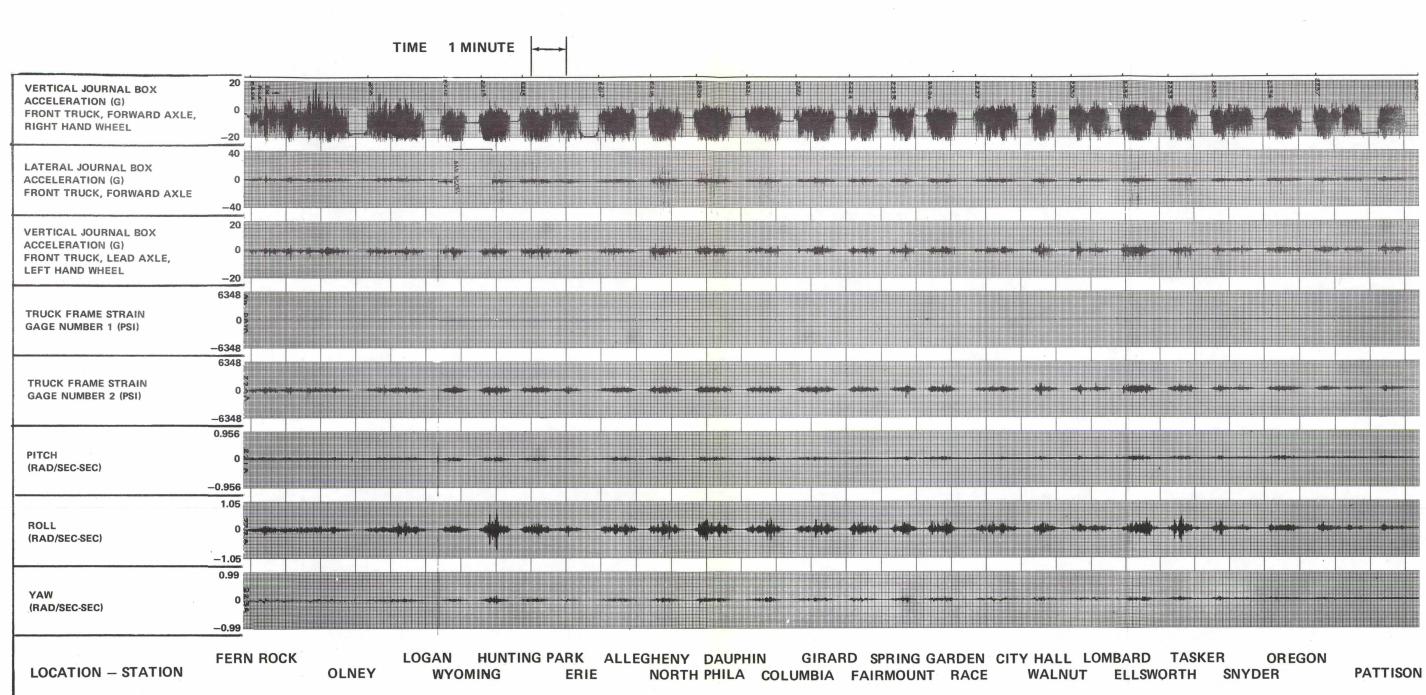


Figure 5–24. Journals, Truck Stress, and Angular Acceleration Time History Chart (F–P)

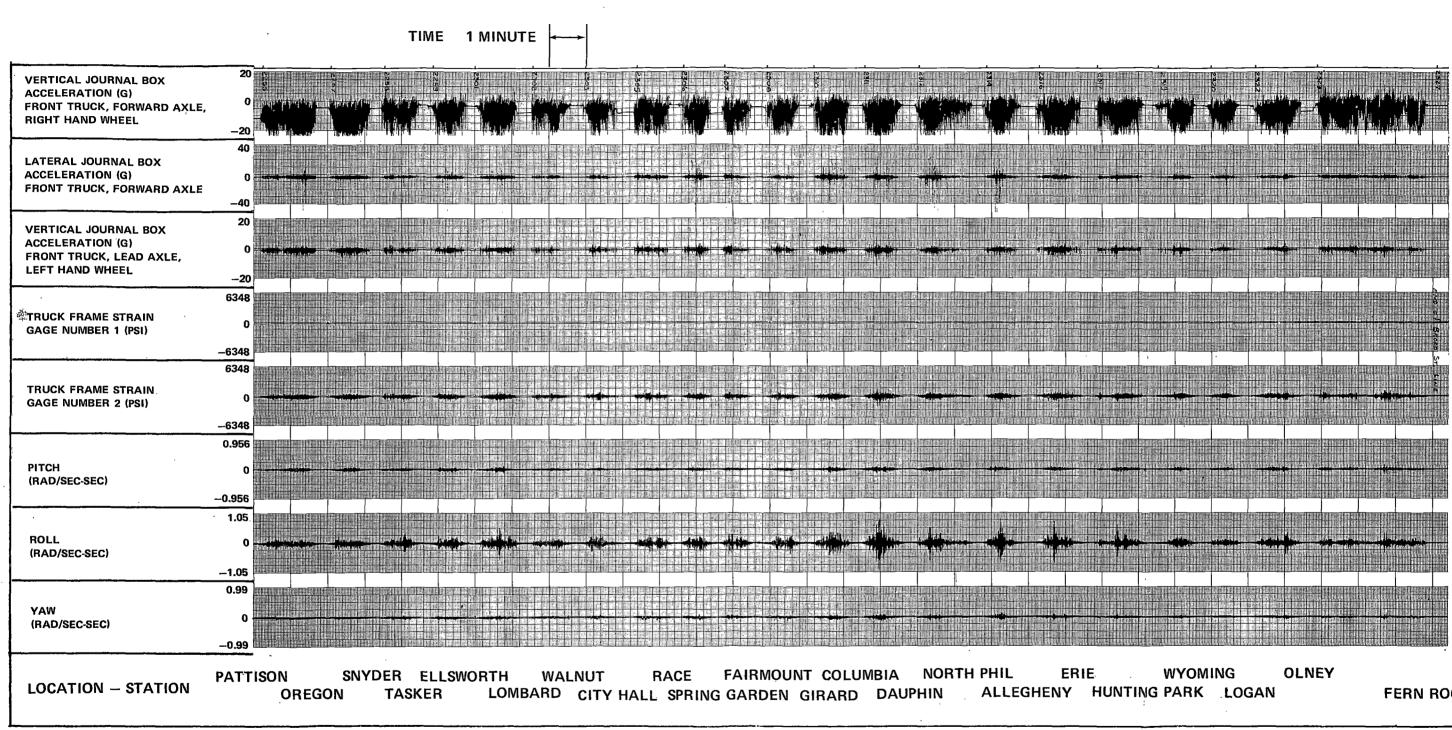


Figure 5–25. Journals, Truck Stress, and Angular Acceleration Time History Chart (P–F)

FERN ROCK

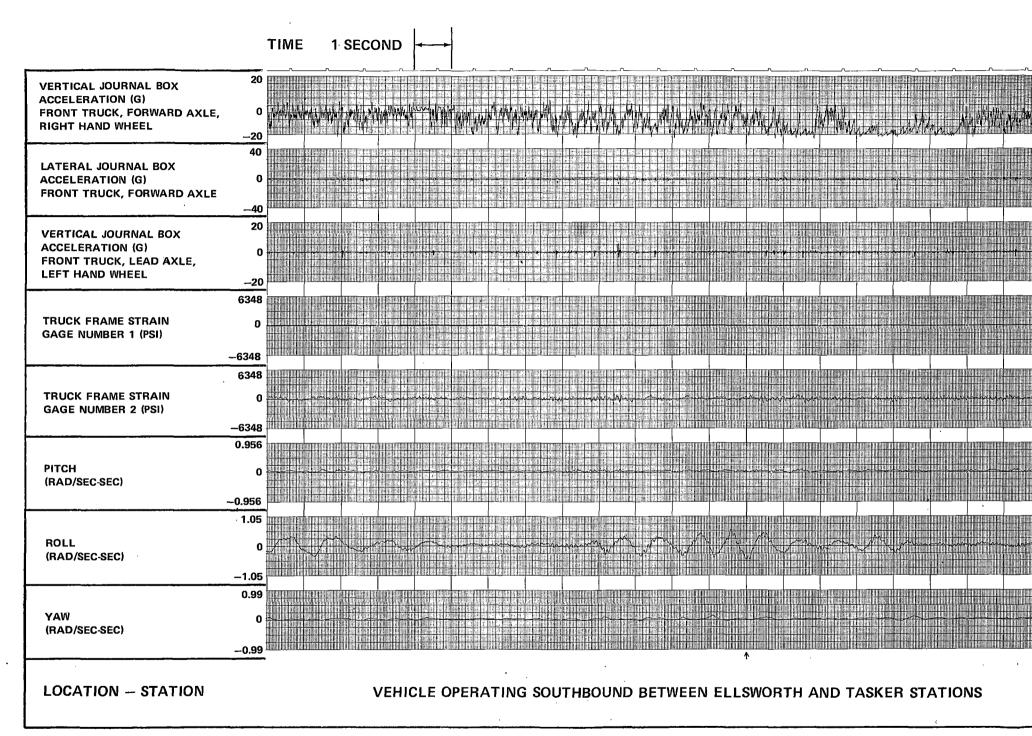


Figure 5-26. Journals, Truck Stress, and Angular Acceleration Time History Chart (~)

			_	_		-	_	-	_	_	_	_	_	_	-	-	 -	-	_	_	_	-	_	 	_	_	_	-	n	 	 _	_	-	_	 	_	h	 	 	_	 	 	r	_	 	
L											Ł											1						A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK A TANK				The second second second second second second second second second second second second second second second s														And a second sec
																																							and the second s							
																		the second																												
					The second s																																									

APPENDIX E TESTING AT LINDENWOLD, N.J.

1.0 TEST DESCRIPTION

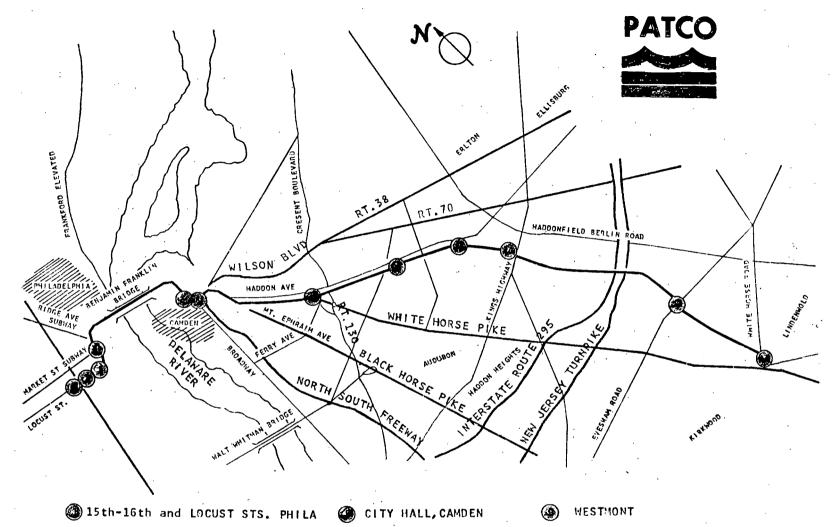
At the conclusion of the SOAC Operational Test and Evaluation Program, ending in Philadelphia on the SEPTA lines, a proposal was instituted to operate the SOAC on the PATCO Lindenwold Line for an extended period. The opportunity arose to perform the SOAC Simulated Revenue Service Tests on the PATCO lines as the details of the proposed extension were being firmed and prior to the removal of the instrumentation system from SOAC following the SEPTA tests.

1.1 Test Site

The PATCO Lindenwold line is 14.1 miles long with 11 stations. It has scheduled service time of 22.5 minutes. The route originates in Lindenwold, New Jersey and runs elevated and at grade level westward to Ferry Avenue. Beyond Ferry Avenue the line is subsurface through Camden, surfaces to cross the Delaware River via the Ben Franklin Bridge and becomes a subway again, terminating at 15th and Locust Streets in Philadelphia. The surface and elevated sections of the route in New Jersey have a 70 mph track speed limit.

1.2 Test Operations

The tests were scheduled for and accomplished during the early morning of May 1, 1975. The test plan was incorporated into a program to verify the SOAC car clearances on the Lindenwold Line and to move the vehicles from SEPTA property to the PATCO Lindenwold Shops. The tests were performed as soon as the clearance runs were completed. As with previous tests, the vehicle operation was entirely under the control of PATCO personnel during the tests. The requirements to provide normal schedule service and to provide a door opening on the car side opposite to a station platform were maintained. As noted below, the test time and operation were sufficient and no significant events occurred which would invalidate the tests.



E--2

15th-16th and LOCUST STS. PHILA
12th-13th and LOCUST STS. PHILA.
BROADWAY, CAMDEN
9th -10th and LOCUST STS. PHILA.
FERRY AVENUE, CAMDEN
8th- and MARKET STS PHILA.
COLLINGSWOOD

WESTMONT
HADDONFIELD
ASHLAND

(LINDENWOLD

Figure 1–1. The PATCO Lindenwold Line

2.0 TEST PROCEDURES

Pretest

- 1. Mount all required sensors
- 2. Calibrate Instrumentation System
- 3. Brief Test Crew on Test Operations

NOTE:

One vehicle is instrumented for noise measurements, avoid other than normal conversation.

Test 🔬

- Operate the vehicles in a simulated revenue service,
 i.e. maintain the given schedule.
- Provide a nominal 10 second door opening at each scheduled stop.
 - 3. Provide voice commentary on instrumentation recording during progress of test.
 - Maintain a manual log of events during the test run, correlated to the instrumentation system records.
 - 5. Monitor various preselected data channels to ascertain validity of test run.
 - 6. The Test Controller will terminate the test if:
 - (a) An extended delay or train shutdown occurs
 - (b) One or more required data channels malfunction

(c) The test vehicle is not operating properlyAdvise Test Controller of any abnormal operationsor events that occur during the test run.

E-3

3.0 INSTRUMENTATION

The SOAC Instrumentation System was used for this series of tests. This system is described in detail in Volume VI of State-of-the-Art Car (SOAC) Engineering Tests at Department of Transportation High Speed Ground Test Center, Final Test Report, UMTA-MA-06-0025-75-6, January 1975. A synopsis is included below.

3.1 Ride Qualities, Structural and Performance Tests

Electrical signals from the vehicle mounted transducers are conducted by cables to an interface panel which is connected to an instrumentation console containing two magnetic tape recorders, two light beam oscillographs, a time code generator, a temperature recorder and signal conditioners. Any 28 selected test parameters can be recorded on tape and displayed on the oscillographs. In addition, wheel speeds may be recorded directly on the oscillographs; total power is recorded on tape and displayed on a mechanical counter. The time code generator provides signals that are recorded on both tape and the oscillograph. The oscillographs provide quick-look data to evaluate test progress and results during testing (See Figure 3-1).

3.2 Noise Tests

The instrumentation used for noise measurement consisted of a 1" condenser microphone with battery operated cathode follower and a 1/4" single channel tape recorder.

E-4

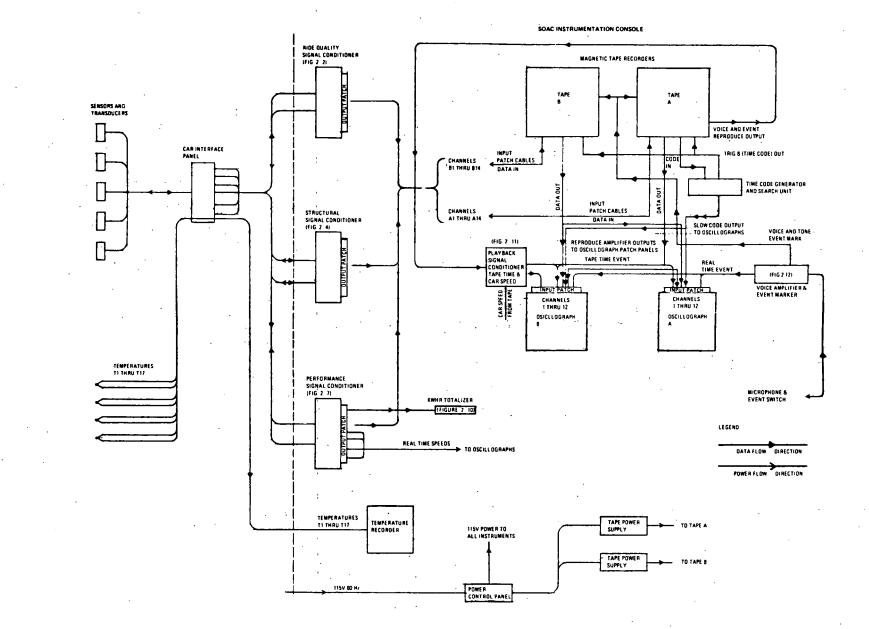


Figure 3–1. SOAC Instrumentation System Block Diagram

т | 5

4.0 DATA

The parameters recorded during the property tests are described in Tables 4-1 and 4-2. The definition of the parameter measurements is contained in Appendix A, Standard Outputs for SOAC Property Tests.

Data was recorded for the roundtrip routes noted in the Test Description Section. All of the data was recorded on analog tapes and processed to provide three types of outputs.

Time History Charts Station Summary Tables Frequency Histograms

4.1 Time History Charts

A slow chart speed strip-out of certain parameters is included in this report. The purpose of these charts is to provide an indication of the maximum levels of parameters during various phases of the run. The complete run is described on the charts including station stops and any particularities that occurred. A series of time histories at a high chart speed is included to illustrate the cyclical nature of the data. These charts are a single time frame for all parameters and are representative of the worst case conditions exhibited for a particular test run.

Intermediate parameters, such as a weighted (filtered) car body acceleration are shown on some charts.

4.2 Station Summary

A summation or summary of specific parameters is made by each station stop. These include test running time and distance for comparison to the property's schedule. Power consumption, motor duty cycle parameters are also summarized by station to indicate the relative sizing of the SOAC propulsion with respect to operations on the property. Station stops and maximum speeds are also shown as another indicator of vehicle operation in a scheduled service environment.

		Table 4–1. SOAC R	evenue Service Data List	t A		
	PJ	ARAMETER		STANDARD	OUTPUTS	
	DESIGNATION NO.	DESCRIPTION	RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
	301	Longitudinal Acceleration	+ 0.25 g's	AP/A	Format(3)	Format(4)
	302	Line Voltage	0 to 1000 VDC	LVD/A	None	-
	303	Line Current	0 to 2000 ADC	LCD/A	None	-
E7	304	No. l Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	-
7	305	No. 1 Truck Armature Current	0 to 1000 ADC	MACD/A	None	RMS-MAC/A
	306	No. 1 Truck Field Current	+ 50 ADC	MFCD/A	None	RMS-MFC/A
	307	No. 2 Truck Armature Voltage	0 to 1200 VDC	MAVD/A	None	_
	308	No. 2 Truck Armature Current	0 to 1000 ADC	MACD/A	None	-
	309	No. 2 Truck Field Current	+ 50 ADC	MFCD/A	None	-
	310	"P" Wire Current	0 to 1.00 ADC	CS/A	None	Format(3)
	317	Total Power Consumption	l Pulse/0.1 KWHR	PCC/A	Format(2)	Format(2)
	315	Speed	0 to 80 MPH	VS/A	Format(3)	Format(4)
	318	Brake Cylinder Pressure	0 to 100 psig	BCP/A	None	-
		· ·				

	Table 4–1.	SOAC	Revenue	Service	Data	List A
--	------------	------	---------	---------	------	--------

Table 4-2. SOAC

PARAMETER

DESIGNATION NO.	DESCRIPTION
101	Front Truck, Forward Axle, Righthand Wheel Journal Box Vertical Acceleration
102	Front Track, Forward Axle, Righthand Wheel Journal Box Lateral Acceleration
103	Front Truck, Forward Axle Lefthand Wheel Journal Box Vertical Acceleration
115	Mid Car Centerline Vertical Acceleration
116	Mid Car Centerline Lateral Acceleration
120	Forward Car Centerline Vertical Acceleration
121	Forward Car Centerline Lateral Acceleration
219	Truck Frame Upper Strain Gage
220	Truck Frame Lower Strain Gage
221	Pitch Angular Acceleration
222	Roll, Angular Acceleration
223	Yaw, Angular Acceleration
-	Interior Sound Pressure

•

Ш 1 8

۰.

Revenue Service Data List B

х.	STANDARD	OUTPUTS	
RANGE	RECORDED	PRESENTED	PRELIMINARY ANALYSIS
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AJ/A	Format(3)	Format(4)
<u>+</u> 20 g's	AĴ/A	Format(3)	-
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(1), (3)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRV/A(1)
<u>+</u> 0.25 g's	AC/A	Format(3)	RRH/A(l)
<u>+</u> 6348 psi	STP	Format(3)	Fromat(4)
<u>+</u> 6348 psi	STP	Format(3)	-
+ 1.5 Rad/sec/sec.	ACA/A	Format(3)	Format(4)
\pm 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
\pm 1.5 Rad/sec-sec.	ACA/A	Format(3)	Format(4)
40 to 120 dB(re 2 x SP/A	10-51 y M ²)	NL/A(1)	NL/A(2)

4.3 Frequency Histograms

These distributions are an indication of the ratio of time that a parameter is at a particular level with respect to the time to complete a roundtrip scheduled service run. These parameters may be used to describe how the vehicle was driven, the track conditions, and how the vehicle responded to these conditions.

5.0 DATA DISCUSSION

The instrumented car, SOAC No. 2, was operating in the forward direction when running westbound. A positive longitudinal acceleration on the westbound time history charts is vehicle start-up.

As defined in Section 4, there are three forms of data. These forms are discussed below with respect to three categories:

(1) Operation

How the vehicle is operated and maintained schedule.

(2) Environment

Track and truck conditions.

(3) Response

How the vehicle responded to operational environment.

Figures 5-1 through 5-14 present the frequency histograms for the PATCO tests. Figure 5-15 is a sample of Noise Level Time History. The remaining time histories are presented in Figures 5-16 through 5-27. Table 5-1 presents a summary of some of the test parameters taken from the histograms and time histories. Tables 5-2 and 5-3 are the Station Summaries with power consumption.

5.1 Operation

The Stations Summaries show that the SOAC was able to maintain the PATCO schedule reasonably well. The SOAC run was 10 percent longer than the schedule. It should be noted that the station stops were shorter than scheduled. The maximum acceleration was 2.73 mph/sec. and the maximum braking rate was 3.3 mph/sec. A light rain wet the rails and induced a few wheel spin/slides on the open portion of the route.

The Station Summaries also show that 9 percent of the travel time was spent in a station. This compares to the speed frequency histogram which shows 13 percent in the 0 to 5 mph band. The differential 4 percent is the time ratio of vehicle moving below 5 mph. The rest of the speed histogram shows a substantial proportion of time in the 35-40 mph and in the 65-70 mph bands.

The "P-Wire" histogram provides some information on how the SOAC was driven. Twenty-four percent of the time was spent in requesting the maximum acceleration from the propulsion system. The 9 percent station time is reflected in the p = 0 distribution value. The relatively "flat" distribution of the braking request (p .45) is probably attributable to the drivers attempts to ease the vehicle slides.

The power consumption for the roundtrip route was 204.7 KWHR. For the scheduled distance of 28.2 miles, this is 7.3 KWHR/mile. For the measured distance of 31.3 miles, it is 6.5 KWHR/mile.

The RMS armature current indicates the relative sizing of the SOAC propulsion system with respect to the route. The SOAC has a continuous rating of 175 hp (460 amps) and a one hour rating of 230 hp (600 amps). The roundtrip armature current was 395.7 or 86 percent of the continuous rating. The most severe cycle occurred between Westmont and Collingswood stations (510 amps).

5.2 Environment

The journal accelerations and truck stresses are to be used as indication of track conditions. A summary of these values is shown in Table 5-1. The 50th percentile is a statistical quantity and is read as 50 percent of the trip time the journal box vertical level is between \pm 0.6 gs. The 95th percentile is read similarly. The nominal value is the 50th percentile for the time that the vehicle is moving.

The truck frame strain gage was destroyed prior to the PATCO tests and this data was not available.

5.3 Response

Ride Roughness and Noise Levels are parameters which are related to "human responses". Ride Roughness is a ride comfort rating of vibration levels and Noise Level is a hearing comfort rating of sound pressure levels. These parameters are described in the Standard Outputs section of this report. A summary of the Ride Roughness values is presented in Table 5-1. Interior Noise Level data was taked in the middle of the non-instrumented car at a seated person's ear level. The original engineering tests at TTC indicate that this is the quietest point in the car. The statistical quantities derived from this data are:

L(99)	L(90)	L(50)	L(10)	L(1)	L(EQ)
62	64	66	77	89	74

Journal Box Vertical Acceleration (G) Journal Box Lateral Acceleration (G) Truck Frame Stress (PSI) Forward Car Vertical Acceleration (G) Mid Car Vertical Acceleration (G) Forward Car Lateral Acceleration (G) Mid Car Lateral Acceleration (G) Longitudinal Ride Roughness (GRMS) Forward Car Vertical Ride Roughness (GRMS) Mid Car Vertical Ride Roughness (GRMS) Forward Car Lateral Ride Roughness (GRMS) Mid Car Lateral Ride Roughness (GRMS)

Pitch (RAD/Sec-Sec) Roll (RAD/Sec-Sec) Yaw (RAD/Sec-Sec)

Ε -13

	. 6		
50TH %	"NOMINAL"	95TH %	MAXIMUM
<u>+</u> .6	<u>+</u> .64	<u>+</u> 1.88	<u>+</u> 4.00
<u>+</u> 1.0	<u>+</u> 1.1	<u>+</u> 1.94	<u>+</u> 4.50
	(DATA CHANNEL	MALFUNCTION)	
<u>+</u> .018	<u>+</u> .020	<u>+</u> .070	<u>+</u> .250
<u>+</u> .021	<u>+</u> .022	<u>+</u> .072	<u>+</u> .225
<u>+</u> .019	<u>+</u> .021	<u>+</u> .075	<u>+</u> .141
<u>+</u> .017	<u>+</u> .019	<u>+</u> .054	<u>+</u> .084
.005	.005	.018	.058
.019	.021	.044	.140
.019	.021	.041	.090
.012	.013	.029	.083
.006	.006	.015	.035
<u>+</u> .140	<u>+</u> .145	<u>+</u> .190	<u>+</u> .285
<u>+</u> .108	<u>+</u> .116	<u>+</u> .199	<u>+</u> .315
<u>+</u> .103	<u>+</u> .112	<u>+</u> .190	<u>+</u> .141

۰ ب ۰

.

•

		STATION		SCHEDULE	TE	ST .	POWER C	ONSUMPTION			STOP	MAX.
	NO.	NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	TIME SECONDS	SPEED (MPH)
15								•				
28	1	15th & Locust St.	0	0	0	0	0	0	· 0	0	0	0
	2	12th & Locust St.	.28	1.0	.25	.85	2.83	11.15	466.6	30.2	13.2	38
95	[.] 3	8th & Market St.	.65	2.5	.75	1.95	4.78	6.00	356.6	31.1	12.0	32
2.35	4	City Hall-Camden	2.35	5.0	2.66	5.37	15.82	6.01	316.3	29.6	12.0	38
3 2 S	5	Broadway	.15	1.0	.30	1.34	2.65	8.75	282.9	27.8	10.0	18
1	6	Ferry Avenue	2.16	3.0	2.35	2.82	13.86	5.90	373.9	21.8	10.0	72
14	7	Collingswood	1.61	2.0	1.76	2.13	11.93	6.77	451.9	23.5	12.0	72
	8	Westmont	1.05	1.0	1.15	1.65	10.08	8.78	467.3	24.9	12.0	72
	9	Haddonfield	.87	1.0	.96	1.51	8.70	.9.10	510.2	27.9	12.0	70
	10	Ashland	3.19	3.0	3.52	4.12	22.75	6.46	437.7	22.3	10.8	72
	11	Lindenwold	1.79	3.0	1.95	2.60	12.45	6.38	393.9	22.4	12.0	72
					тс	TALS	105.85	6.70	397.8	26.0		
		TEST RUN SUMMARY										

. --

-

.

.

.

-

SCHEDULE	TEST
Distance14.10Time22.5Block Speed37.6Station Dwell30.Station Spacing1.28	15.65 24.34 38.6 11.6 1.42

~

STATION	- 44	SCHEDULE	TI	ST	POWER C	ONSUMPTION				
NAME	DISTANCE (MILES)	TIME (MINUTES)	DISTANCE (MILES)	TIME (MINUTES)	KWHR	KWHR/MILE	I-ARM (AMP-RMS)	I-FLD (AMP-RMS)	STOP TIME SECONDS	MAX. SPEED (MPH)
Lindenwold	0	. 0	0	0	0	0	. 0	0.	0	0
Ashland	1.79	. 3.0	1:97	2.40	12.39	6.29	441.1	23.3	14.4	70
Haddonfield	3.19	3.0	` 3.49	3.75	19.44	5.58	416.8	20.6	18.0	70
Westmont	.87	1.0	0.99	1.55	9.58	9.66	498.8	26.2	16.8	68
Collingswood	1.05	1.0	1,17	1.75	11.08	9.44	510.7	28.5	10.8	70
Ferry Avenue	1.61	2.0	1.69	1.87	8.92	5.27	406.9	21.1	10.8	70
Broadway	2.16	3.0	2.42	3.15	12.74	5.26	365.0	20.9	12.0	70
City Hall-Camden	.25	1.0	.25	1.24	1.68	6.72	248.6	27.7	14.4	20
8th & Market St.	2.35	5.0	2.61	4.95	15.17	5.80	311.4	27.9	12.0	40
12th & Locust St.	.65	2.5	.74	1.92	5.23	7.08	349.5	30.3	13.2	37
15th & Locust St.	.28	1.0	.31	.99	2.62	8.55	413.3	28.5	13.2	29
		· .	т	DTALS	98.85	6.32	393.5	25.1		

Table 5–3. Station Summary II

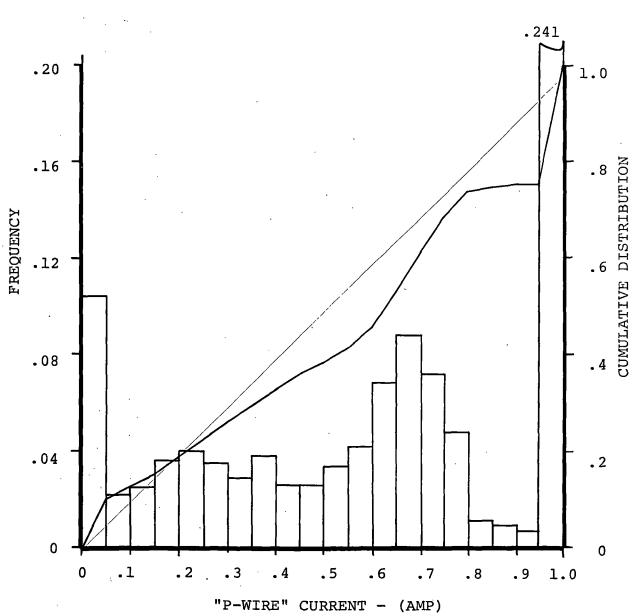
TEST RUN SUMMARY

•	SCHEDULE	TEST
Distance	14.10	15.64
Time	22.5	23.57
Block Speed	37.6	39.8
Station Dwell	30.	13.6
Station Spacing	1.28	1.42

6.54

1-

E–15



State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line "P-Wire" Current Distribution

Figure 5–1. 'P-Wire' Current Distribution

State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line Vehicle Speed Distribution

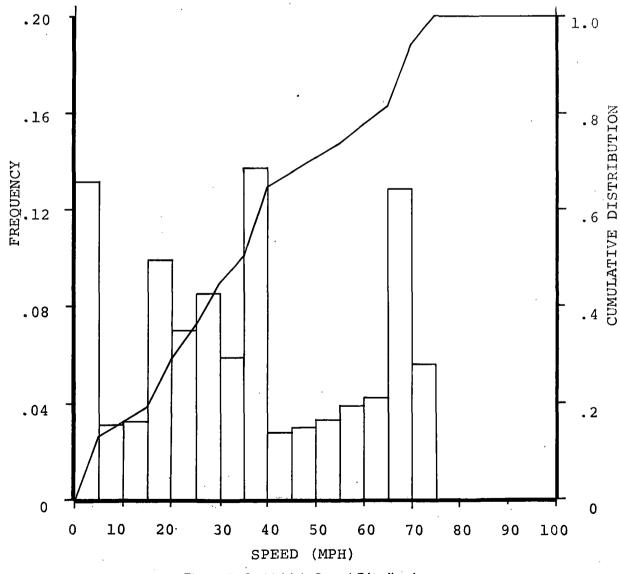
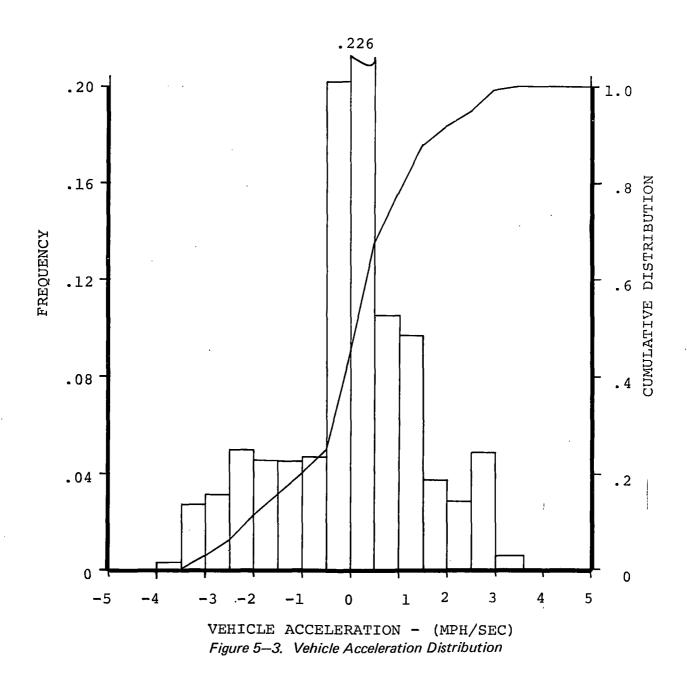
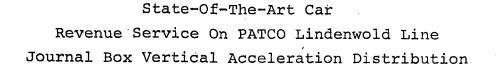


Figure 5–2. Vehicle Speed Distribution



State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line Vehicle Acceleration Distribution



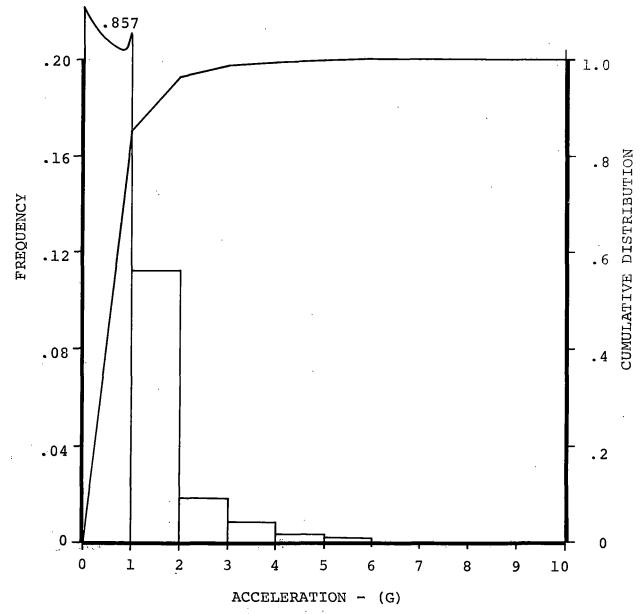
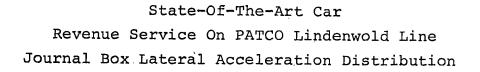
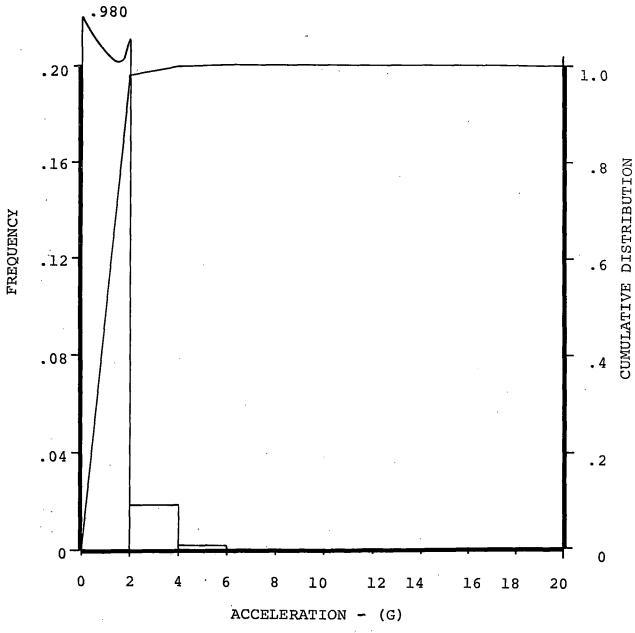


Figure 5-4. Journal Box Vertical Acceleration Distribution

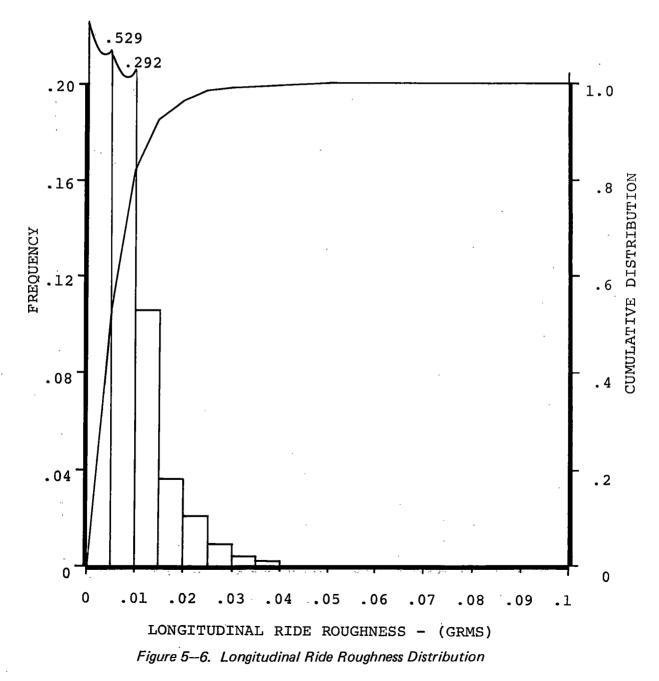




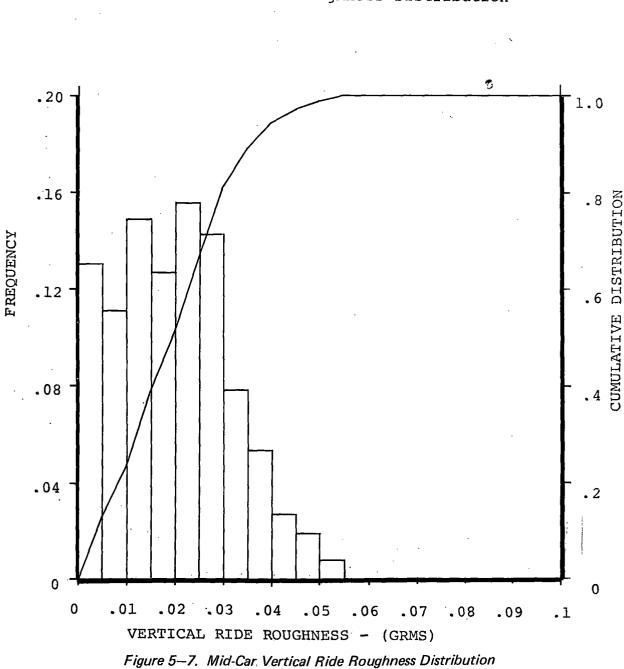


State-Of-The-Art Car

Revenue Service On PATCO Lindenwold Line Longitudinal Ride Roughness Distribution

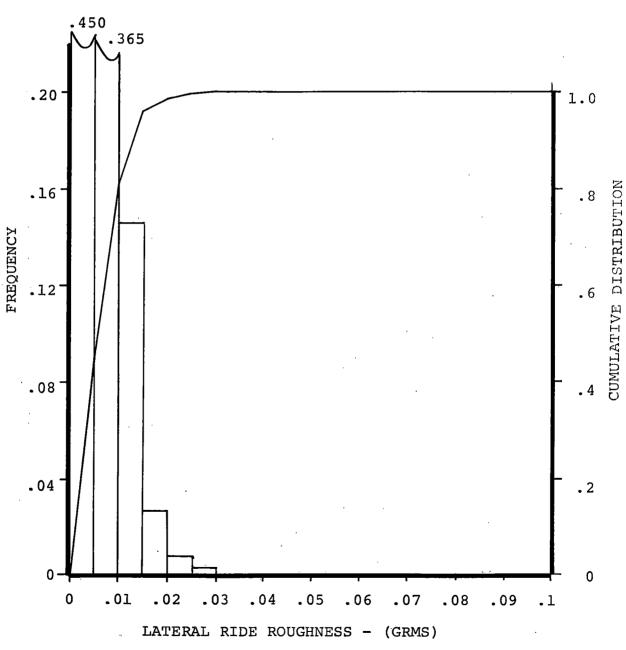


E--21



State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line Mid Car Vertical Ride Roughness Distribution

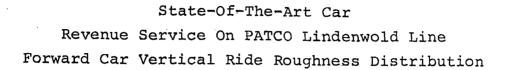
E--22

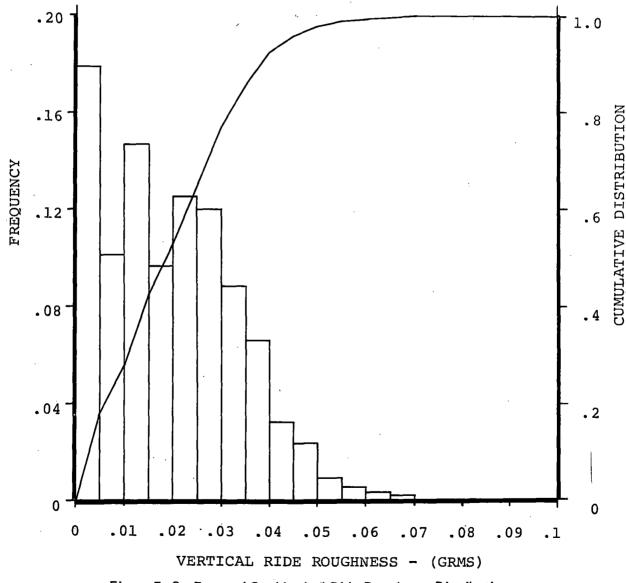


Revenue Service On PATCO Lindenwold Line Mid Car Lateral Ride Roughness Distribution

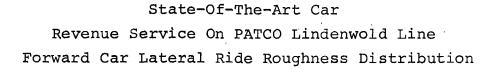
State-Of-The-Art Car

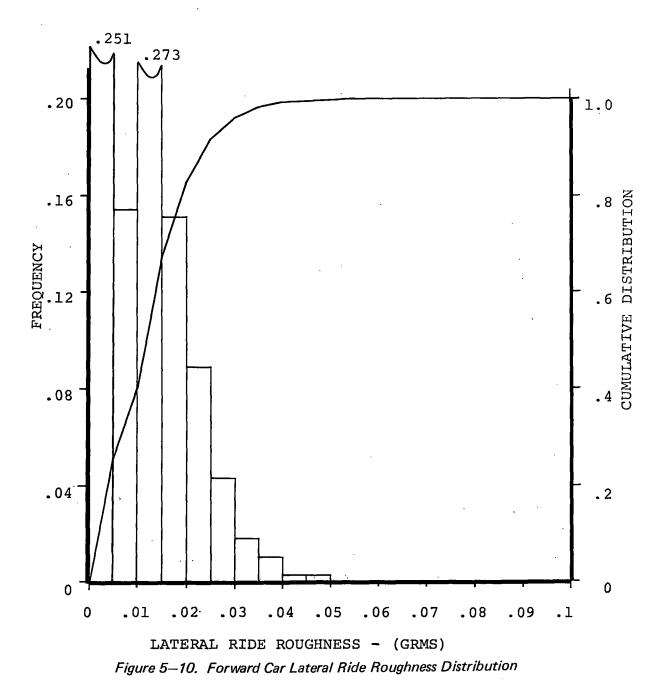
Figure 5-8. Mid-Car Lateral Ride Roughness Distribution

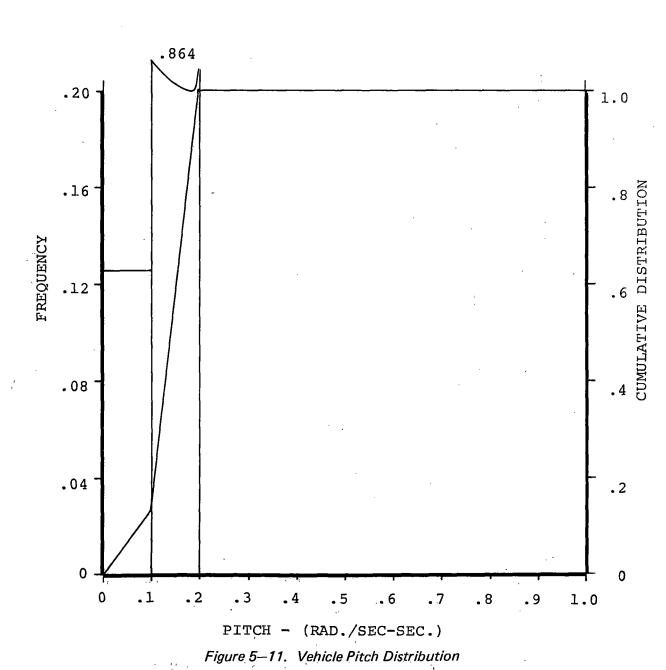




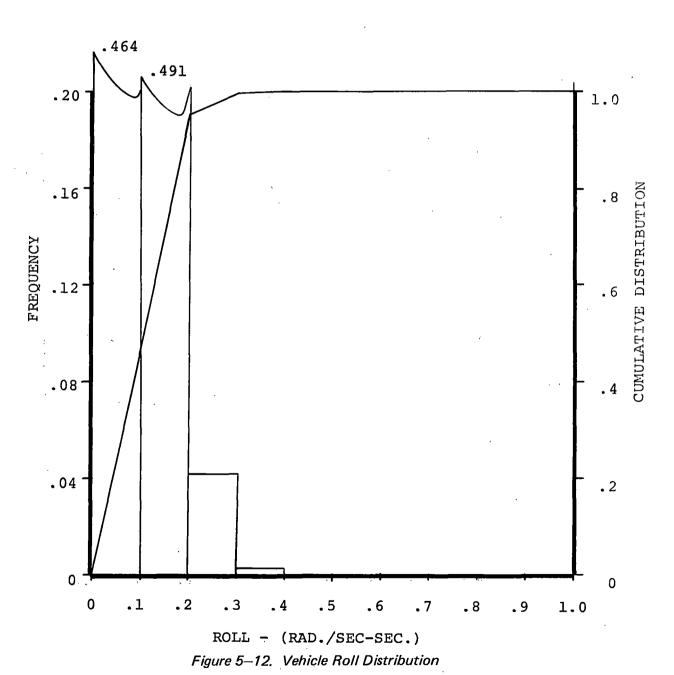




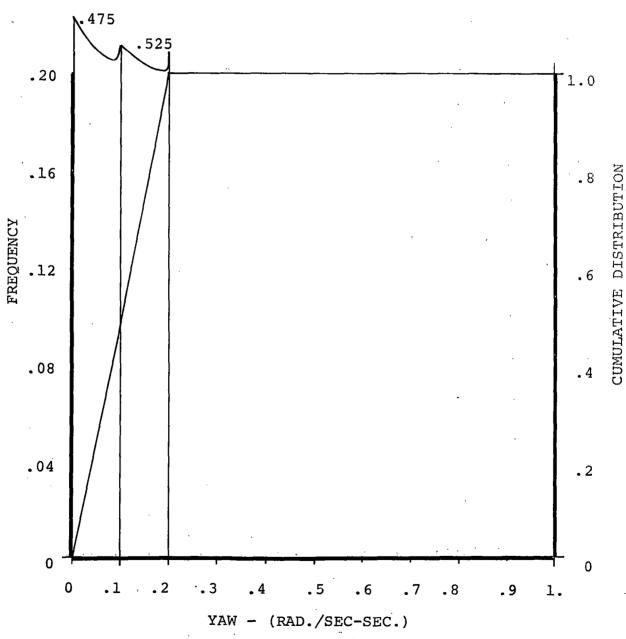




State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line Vehicle Pitch Distribution



State-Of-The-Art Car Revenue Service On PATCO Lindenwold Line Vehicle Roll Distribution



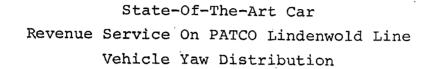
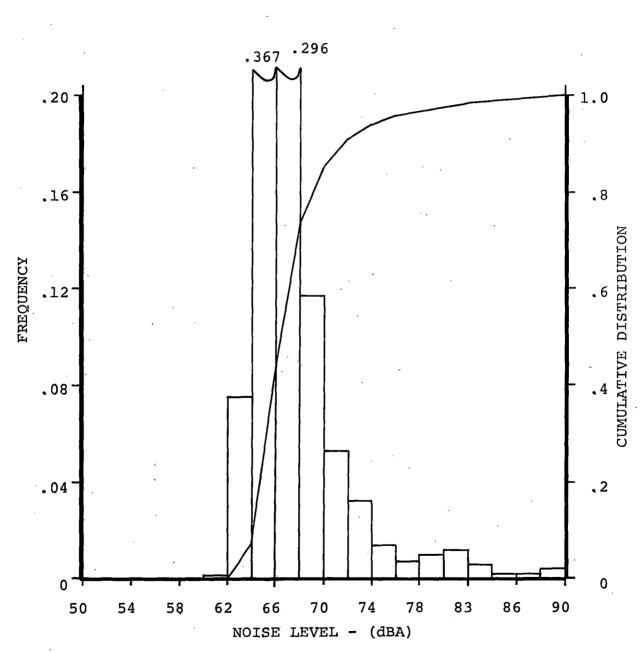


Figure 5–13. Vehicle Roll Distribution

E--28



State-Of-The-Art Car Revenue Service On The PATCO Line Interior Noise Level Distribution

Figure 5-14. Interior Noise Level Distribution

· E-29

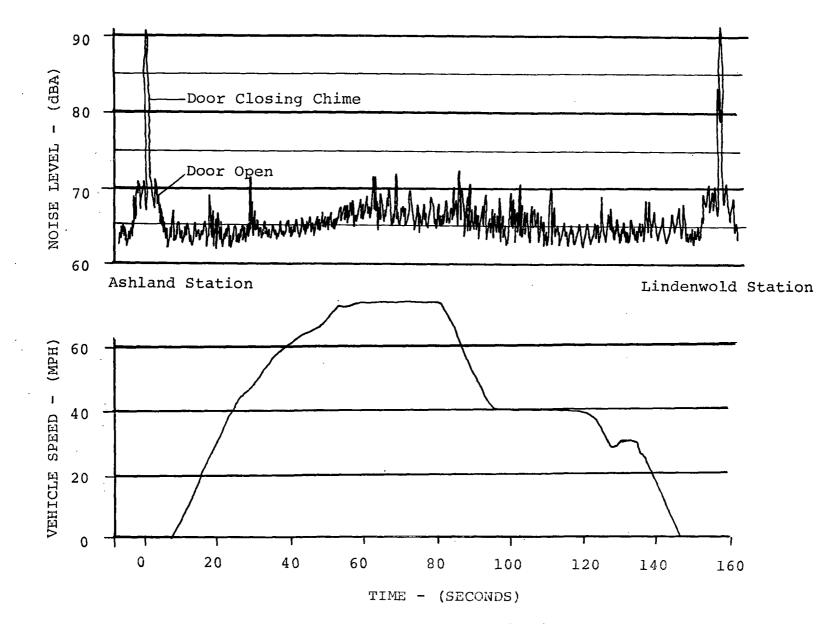


Figure 5–15. SOAC Interior Noise Level Sample

E-30

.

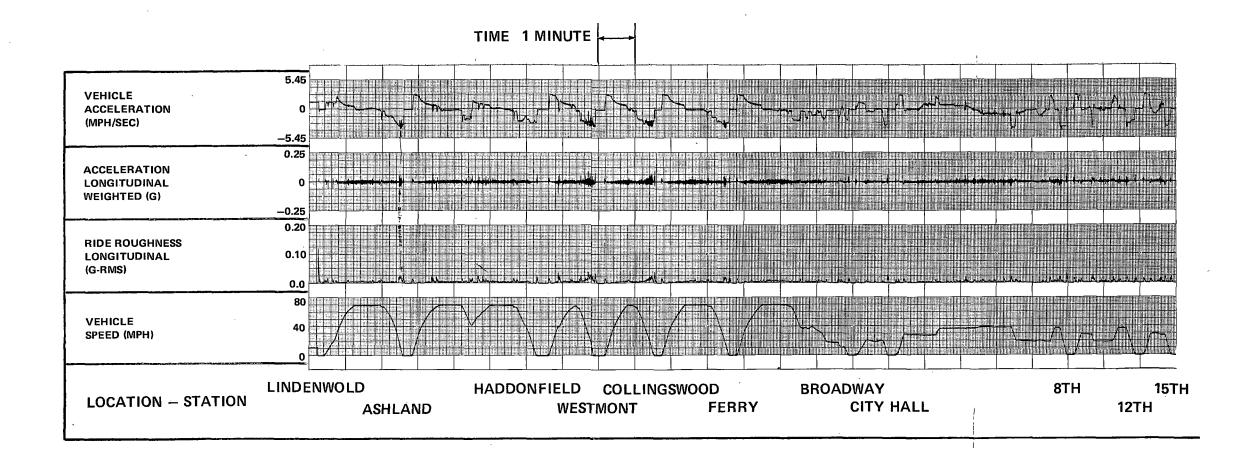


Figure 5–16. Vehicle Acceleration and Speed Time History Chart (L-15)

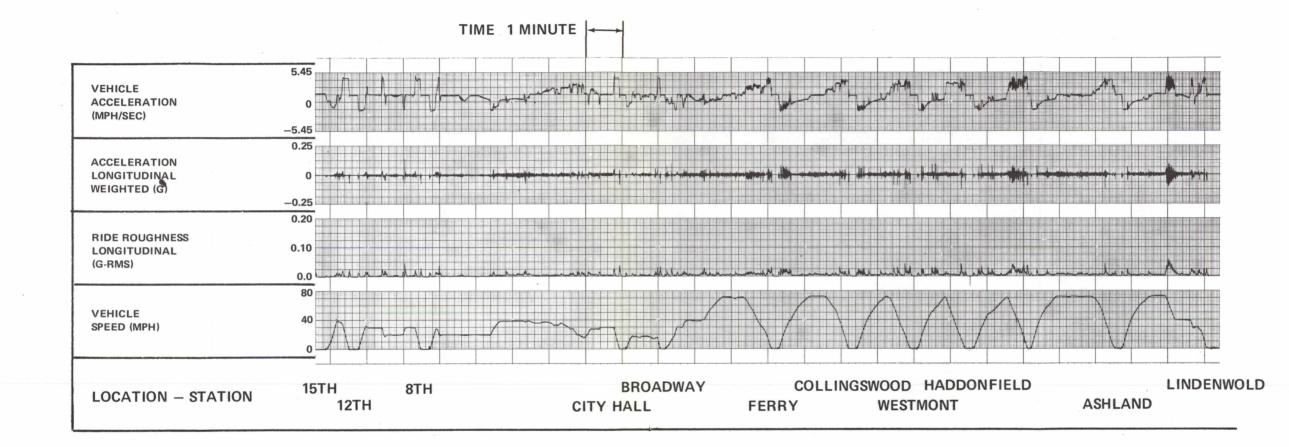


Figure 5–17. Vehicle Acceleration and Speed Time History Chart (15-L)

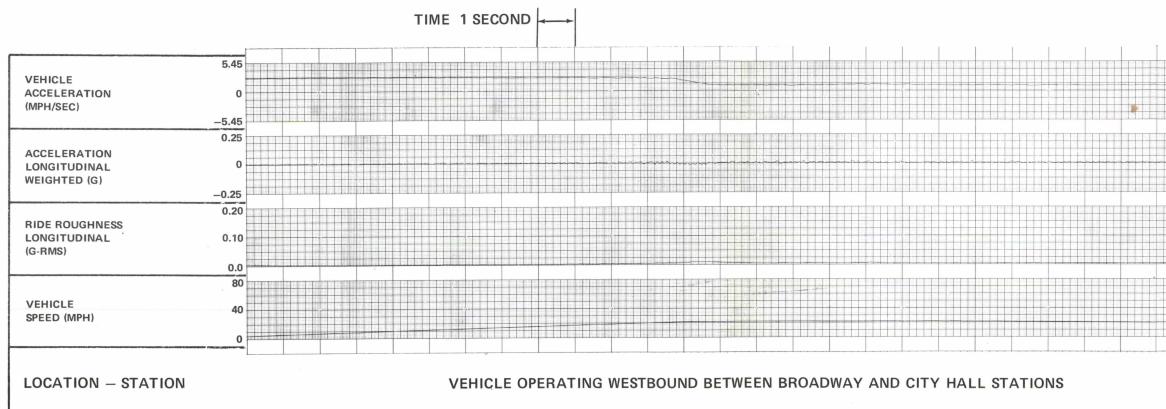


Figure 5–18. Vehicle Acceleration and Speed Time History Chart (~)

				17504	
	-			04	
			0		
				-	
			1		
				-	
				0	
				2.	
			>		
				115	
		-			
a set fully a set					

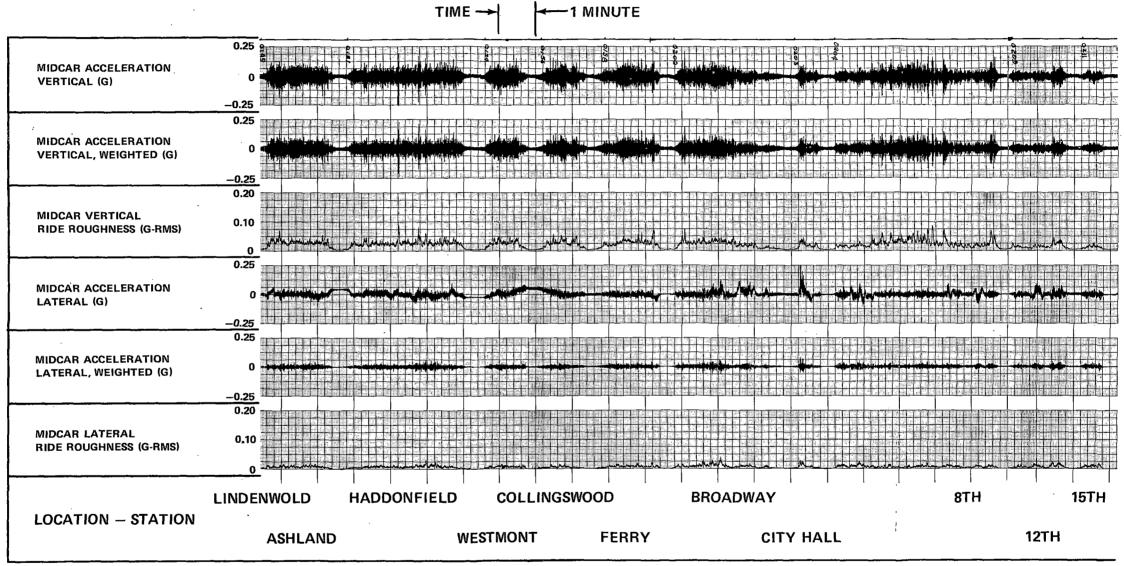


Figure 5–19. Mid-Car Acceleration Time History Chart (L-15)

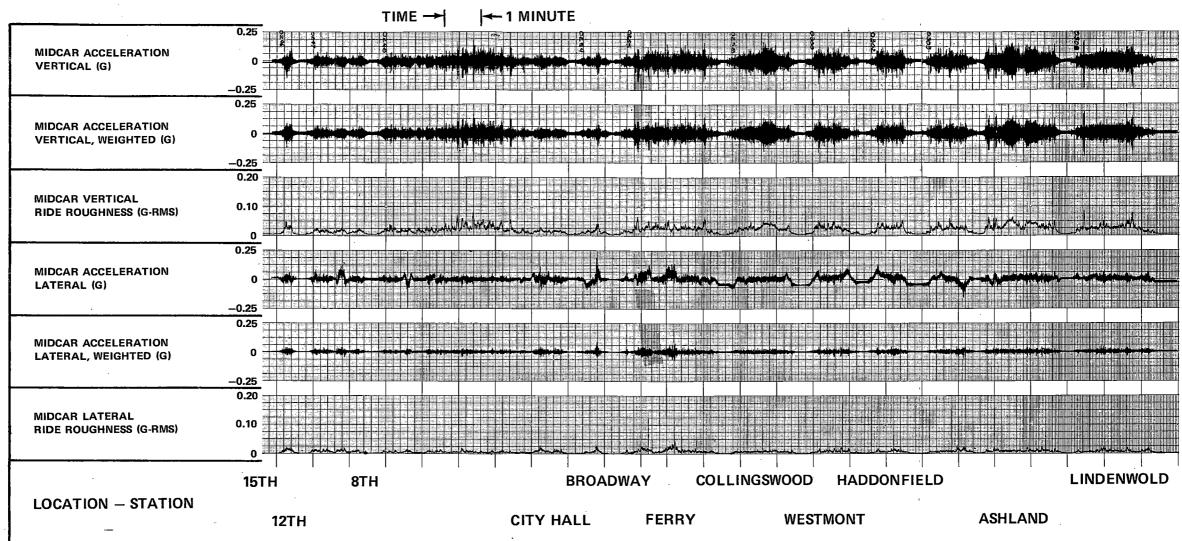


Figure 5-20. Mid-Car Acceleration Time History Chart (15-L)

E--39

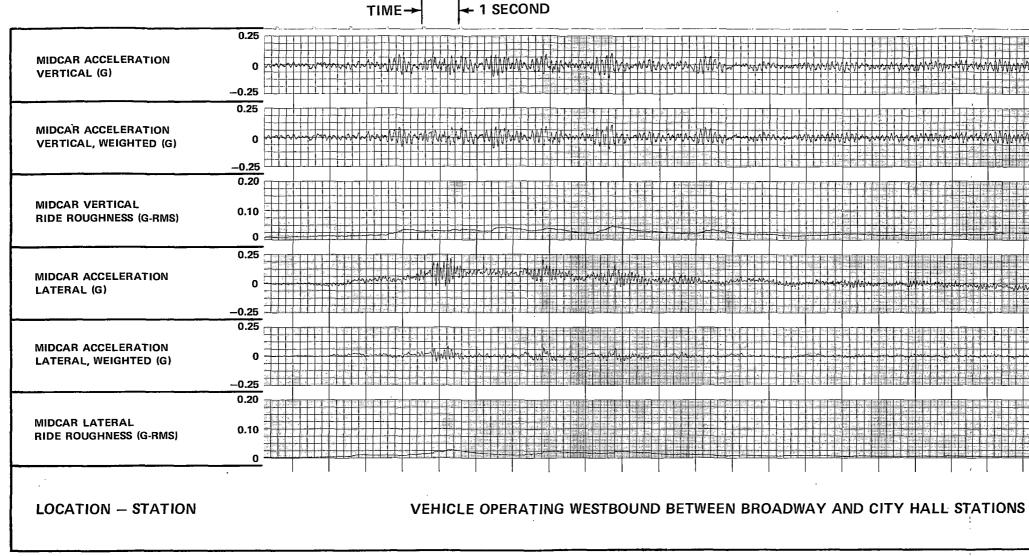
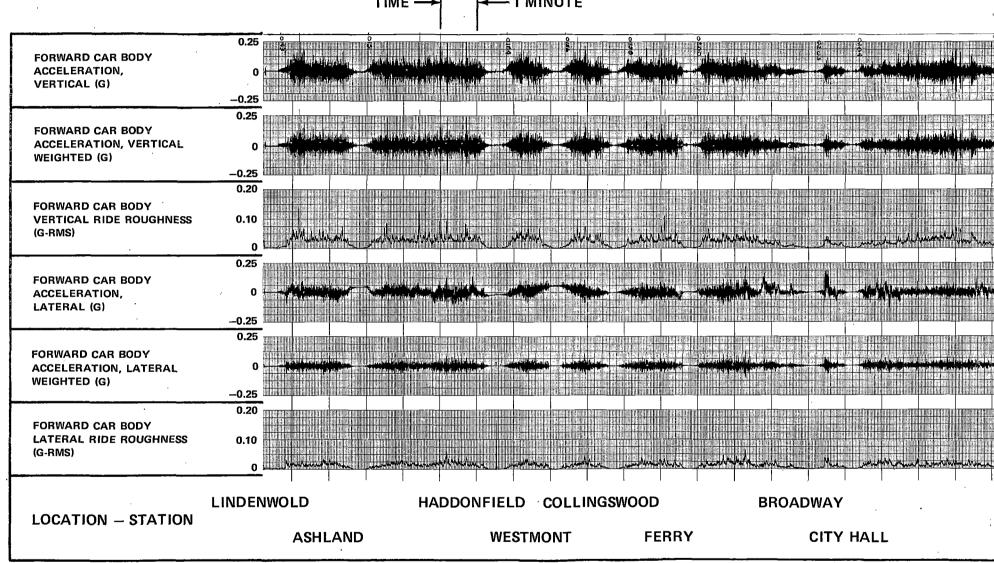


Figure 5–21. Mid-Car Acceleration Time History Chart (~)

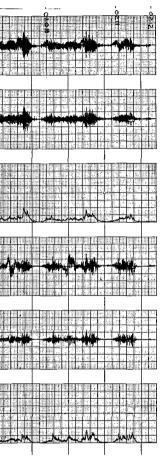
																	11.										_				1	
-	4	ż,		1	2.7						-					-			L											-		+
+	1	1	٨Ì	ļ.,						-				-	-		1.1	-	-	¥				-		-		L		-	1	
M	đ	A	Ĥ	h	hr	Ą	1		-	h	₩	А	M	ł	₩	Ą	v	W	h	٧	Y٦	٨,	1	Ν	1	V	Ċ1	۲	٧V	۲	Ŧ	ń
+	٣	Ч	-			1.1	-	<u>.</u>	-	17		-		-	h	2.1												t			T	
1	t	1			1	-		1	1													1.57	12			10						
													11																			
1																					Ŀ					1						
-	-				120				11	150			1940	1975									1	E	1111				155	an:		
-	╉	-	-	1	1.1	111		-		1				-	-	. r			-	-	-	-		-			-		+	-		-
÷	Ť	1		1	-	-	÷	ŀ		ŀ	t	1	-	-	F		÷.	۲÷			-						t				t	4
10	h	N	ā			Л	÷.			١.	5.		Ľ.				••••	Ĺ,				ii .	1	1	te			t,				1
η	4	ŋ	rΨ	Ų,	Ą٩	Y	٧	r			V		1	1	Ľ	ŵ	4	Y		¥	٣	۲v	Ľ				1		Ť			
M																11	÷.		. 1			-										
																				1												
4		Шł		40														. :	:0		ш			i li		1	, iii			ii	4	
		η					100		118	187							019				hr	1		60	DU	┢	m	J	T	T		Π
						1				t	1		Ľ											T						t		
	: I .													L			12					÷.,			Π							
							2		14							hi					Į.											
1						-	į.														Ì.											1
		_				÷.,						-																			4	
	+	-																			Ļ			Ц.		-					ł	
-				90				110			F	11		1.00		1211		Hi.	80	μni		1111	0111	Litt	0.00		1:111			196	Ŧ	
T						1011								Lin							Γ									198		
	77		5		×		~					<u>ا ا</u>	3	-												~						
					×	~	v						3	<u>,</u>	-5					12					5	5			~			
	77		, 10 J	- V			v					— I (2	Ŷ						12		- X				5			~			
	77		, 10 J		~	~	~	2		<u>م</u>			2	2						2		- X					1.		~			
	77		, 10 J		~	~	v	2		<u>م</u>			2	2						2	<u> </u>								~			
	77		, 10 J		~	~	×	2					~													S S S S S S S S S S S S S S S S S S S			6			
	77		, 10 J		~	~	v	2		· · · · · · · · · · · · · · · · · · ·			~																7		4	
	77		, 10 J		~	~	~	2					~	24						ž –						S S S S S S S S S S S S S S S S S S S						
	77				~	~	~	2		· · · · · · · · · · · · · · · · · · ·																			2			
							•						~																2			
						~																										
							•						~																			
							•																									
							•																									
							•																									



- 1 MINUTE TIME -----

Figure 5–22. Forward Car Acceleration Time History Chart (L-15)

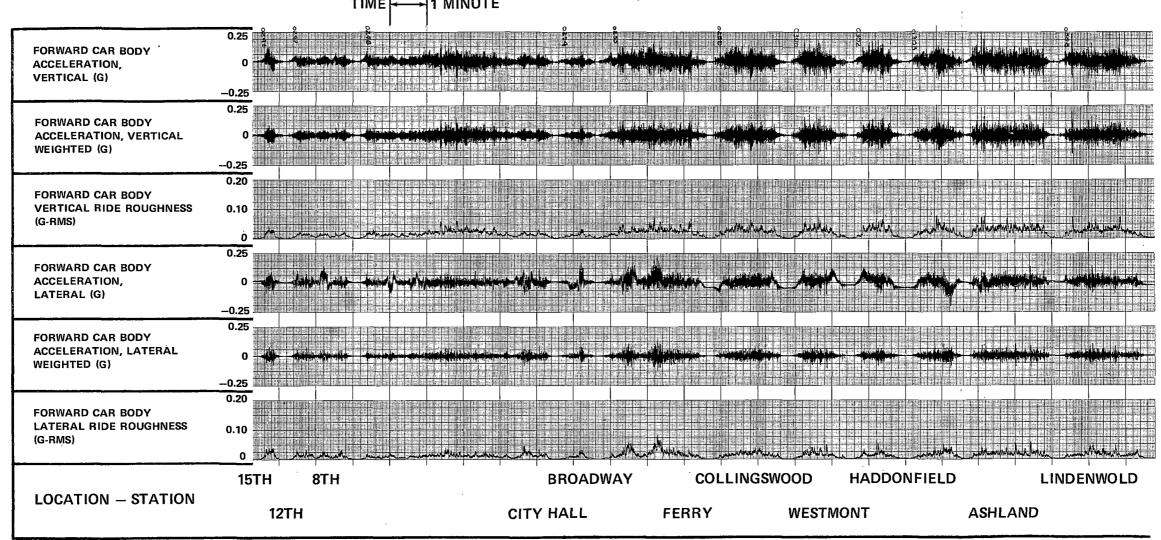
E-43



8TH

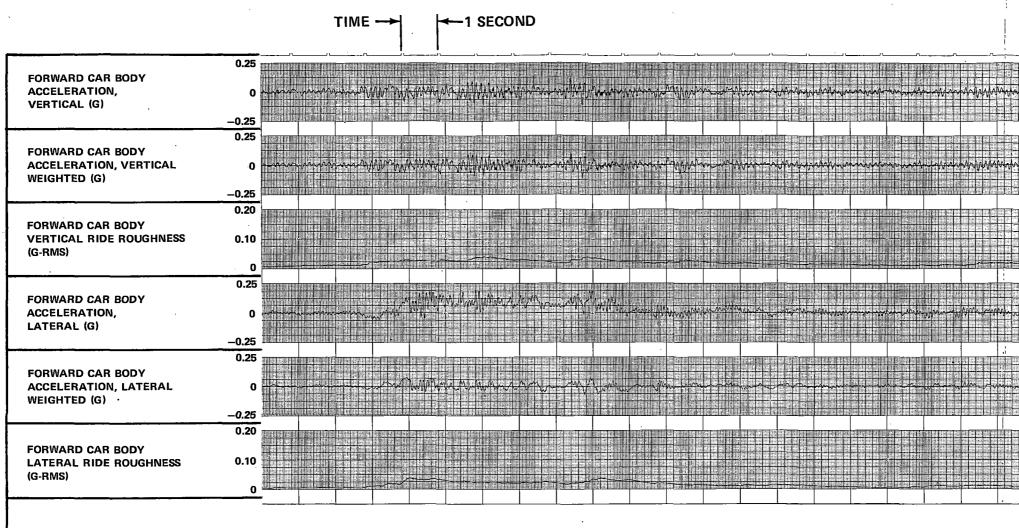
15TH

12TH



TIME 1 MINUTE

Figure 5–23. Forward Car Acceleration Time History Chart (15-L)



LOCATION - STATION

VEHICLE OPERATING WESTBOUND BETWEEN BROADWAY AND CITY HALL STATIONS

Figure 5-24. Forward Car Acceleration Time History Chart (~)

_	_	n					~_				_	n				_	~_			_		r_						_	_	_
																			2111		12071					2112			-	1.1.1
	H																				Щ	Ш	Ш	1			Щ	1		1
							11															Щ				Щ	Į.		IJ	įĮ,
							10					811				111				-	11		Ш		Щ	Щ		Ш	i l	
J,	4		- 4		A	6	~			.,	Λ.			<u>م</u>	<u>ب</u>						чI	ц,	Ц	Ц.	4	4	L	Ļ	4	
1			З		~ •	Ľ.,		1		9.1		٢. ٩							1	- 1	1	n		Ш		Ш				
			Ŀ.,							1													Ш							
			21					Ε.,			1		ЪЩ.									50						L		
																														j,
																							Г							
							1													_			١.	_						
														1			I	Ш						I				Τ		Π
			···;		1	2.5			1				1	1									Π					T		l
T			÷.,	1.00				14										11.1				Ť	III	h			h	1	Π	Î
T			1.	1		1	~	Ŵ	, A				1							,			Į.			14		t		i
ť	1	-	r٩	٣	A	ሎ	1	Ŵ٧	2	PH	ř۲	7	M	٣	۲Y	5	n.	۲ř	Ĩ.		Υ	tr/	ì	T	í		t	ſ	Ĩ	ġ
ł				÷		+-	H	-			4	٨	v	^	F	~	liii	H.	H.			H	ř	t		•		t	ŧ	đ
ł	-		-		111			-							h		Hil	Hł	÷				H	t			H	ŧ	H	Ť
ł		1			-	Ľ					H				H	H	H		H			H			H		fili	╬	H	4
÷	9.		ini.	ini		<u>(</u>	шî:	110			1111	96		1 111	EUO)	68	MA	023	uli	g.,	111	ΥΠ	ηđi	uti	i i i	нi	1:0	(fi)	Щ	th
																							L						J	
a.			_						1									1.01		1.17	1111	m	I					-		æ
1	ä		i.										Ш				Ш	μ£				Ш	Щ	H.	1		Ľ	1	Ш	4
1		÷.,	in:															11				Ш		4				1	Ш	1
		1	1		1			L			r i						H.	li i				Ш	Ш	١Ū			H	1		Í
T																1.16	1111	100	1.000	12.12		333	1118	HH:		101	B	314	11	ΗĒ
T													1									П	Ĭ		H			1		ł
1		10	а,											141							111			I				il		đ
I																					L.		Πī			雦		İŤ	Ш	tt
t	i,					-					t iii	-					iπ	Hii		ħH.	iii)							١		đ
<u>.</u> с	1H	hii	100	1.11	1	1640		٣			hili	1,772	1	100	1112	1111	riili)	m	(i-i	eпī	10.8	un	10	UF E		eff	-	a	нП	±۲ ا
																							L							ı.
æ	- 11		-		Leż	die:	lo:		1			1:11		Ž	E	1.01			Hite:	Dec.	1111	HP	h	DD:	÷	HUD.	1111	æ	HI.	h
1	1					ſ	H	F	H		μ	Ш		H	ł	H	Ш	Щ	H		÷.	H	Ш		i.	Щ	H.	H	H	Ű
1										L				H	H			Ш	Ш	Щ,			Ш	Ш	1	U.	Ш	ĮĮ,	Щ	ļ
1					L	L			1		L		L	L	Ľ	Ľ	11	Ш				Щ	Ш	Щ	Щ	Ш		1	Щ	ļļ
	ų				1	1	Ë							Ļ	L	U						Щ			μİ	Ш	Ш	ĮĮ,		1
1		34	m	3	<u> </u>	m.	W.	۲Ŵ	hr	Α.		يريا	ŀ,	7			٣	Ē		- C	11		Ľ			Ш	Ш	1	Ш	1
1						1	190	E.																	ill			Ш	1	1
I	1					L		E	Ľ						L			h				Ш	Ш	Π	I		f	Ø	l	U
			171																									Π		1
			<u> </u>					1-		-			Г					1					T						-	Г
													1										1							L
			1414					18									E	m	r III	FIII		Ш			m	HT.	10		H	h
					F	1	t	12									1	II.	h			H		H	ť	H	H	Ħ	tt	H
	-				F						t				F	t				H				H			ľ.	H		H
ł	H	H		ŀ-	ŀ		1		1			H	-	1-	ŀ							н		H	н	H		ł	l.	Ĥ
ł	Y	2	-	بر بر	r	-	÷	4	to	ł	-	-	٣	۲	p.	h	-	H	-		-	h		H	4	H	+-	╉	1	H
1	4	H		H		ĺ-		-	÷	F	-	H	ŀ			H	H		H			Щ	Ш	4		H			#	H
	1							L		-			1	1								Щ		4			Į.	Щ	Щ	Į.
1	đ		1						1-			ht											1		Ľ.			1	1	L
1	fii			L	L	L				1	L						لللل					il!	ψ		l			#	I	l
		1	1					[[1	ſ					ſ						1	í.
_	_		L	_	_		_	L	_				L		_			L		_	_	_	L					_		-
T						F											III	m				П	Π	П	Π		П	ſ	П	1
t			Ť.																			ll	T	i i	Ť	T.	f	t	I	ţ
t	Î																	tii		17	T.	ťł	T	f.	ii		ff	t	İ	đ
t	i.	1.1					F)	F								l.	H	١f				H	Ш	H	Ű		tt	H	H	ű
ł		H	÷					-	t								H					H					f.	H	H	å
ł			H					-						f		H	H	H		H		Ш	Ш		H	H	H	4	H	₿
1					H			ŀ					H		H	H		Ľ.		H		μŧ	Щ	H)	ų	H	1	H	н	붜
1			-	-							L.			H	L	H	Ľ.		H			Щ	Ш					Щ	Щ	
	i i i	μr.		-	F.			F			1		E	1	1	0	11	##		1	m	Hil	₩₩	11	iii	iii	1	Į.	Щ	Щ
																		1					1							
			1					1					1					1					1							£.
-	_																													

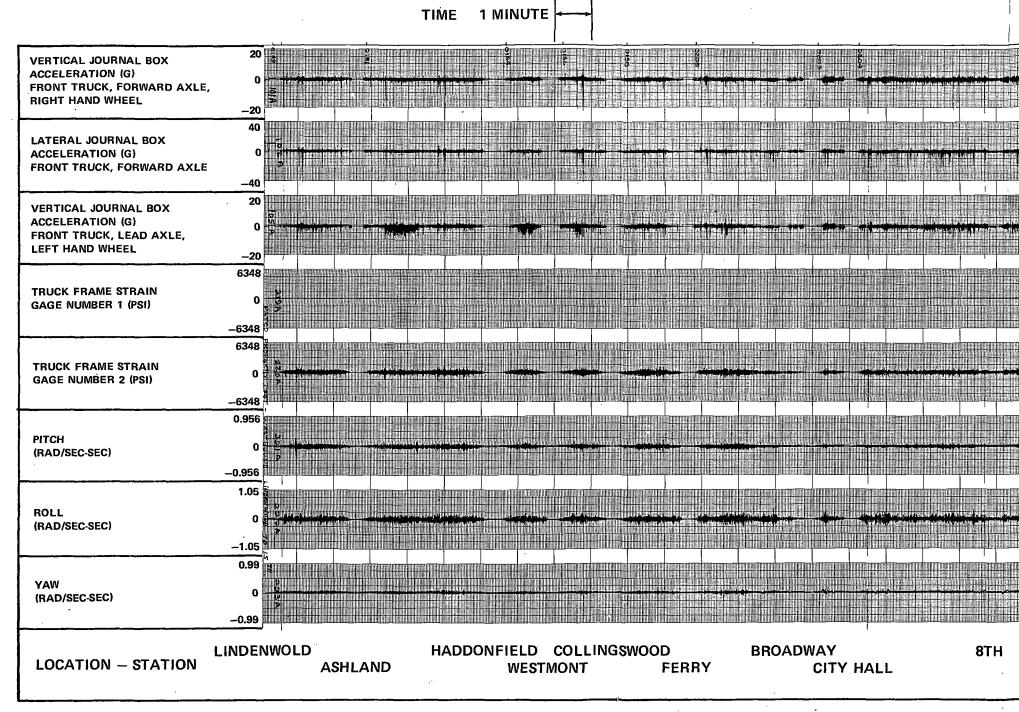


Figure 5-25. Journals, Truck Frame, and Angular Acceleration Time History Chart (L-15)

E--49

	_										_		_		_		_						_	_		
				b.			Π		D			m	ſ	1	Π	Щ	I			ľ	9	T	Π			I
				6										1.1								ť	ł			
	戙	l.						7				H	Į	ų				ļ								
	1								1	1.14			l	Π	1	Ì		Ť	l	ľ			ľ	Ē	l	
															1	Π			I					1		
			Γ						_				н							1						
					I			Ш				Ľ	ł			ľ	H	I		h	ł		ł	1	5	
																	1					Ť		l		
	a i								1				I				9			-			1		Π	
	I				Γ				ļ				ļ		1		1	ľ					Ţ		ľ	
				U							Π	l	Ű	ľ			l	H		Ű	Ű	Í	Í	Í	ĺ	
			ŀ				i.								ł											
						I								ļ	1						ļ					
			lii		ĮĮ,	Ľ	17						1			ľ	Ť	ij	Π	l	I	I	I	Ī	l	
	- 				211				141			1		ł						₩	1					
						Γ									-										l	
													l		l					Ш					ľ	
			ł				2	ł					ł		1					ł						
				Ш					Π				ļ	Ņ		\mathbb{P}					H				l	
					ľ											h		Í		l				l		
			H					Н					ļ			H	ł							Н	i	
		Щ								L		Ĥ	1	1		H			1	II.	ľ	1	í	M	ľ	
								Ш					ļ							ij	1					
													1							L						
				ļ.													ļ	ļ	ĮĮ		ļ				ļ	P
								ľ				l	1						I				ļ	t	l	
		1.91	1:31	1111	1111	112	1Т	1111	1.61		T.::	111	п	ш	191	£33	аfi	111	81 E		Ыŧ	111	112		183	
																			h			-				
	ij	ļ		Į.	W,				Į.	l.		į,	ļ	h		Į,	Ŵ	l	Ü	Ŵ	ļ	ļ	4	H	ļ	
			L				•	L					l							1						_
									H			H				₩	ł									
														l		I	ļ				Ť.		ļ		ļ	ļ
									Li.				ì		Î					h				Ť		
		Н	4												ľ										1	
			Ĭ										Ψ		Ē					Ш						
	nar.	THT.		1111		1111		L		ma		-	ļ	107	 111	HT			T			m	æ			
	H		₩					₩	H		H			╟									∥	H		
			П																							
	Ш	1		T	144	i		n.	4	11	đ		Ĭ		7	4	I.I	ſ	I	ľ	l	h	Ĩ	1	i	
								a a a a a a a a a a a a a a a a a a a	-						ł	間面	l	ł						i		1
			Ш				▥					I	Ĩ	U	T	l		ſ	ſ	Ψ	Ĩ	1	1	1	ľ	Ī
	1970							100	True	1011	m	mii	$\frac{1}{10}$	Бя	ni)	TH:	m	He	-	h	ю		ш		m	r.
			₩	₿	₽				┞	ľ	║	\parallel	l	╂	Щ		╢			╢			╢	H		
									H				1			H	ľ	Ĥ	I	1	M		T	Ĩ		ľ
					Γ		ľ	ľ		ľ		l	Ű	Ĩ	1	ľ	I		Í	Ì	ļ		ľ	1		Ì
	H			ŀ	ŀ	ľ	L	H	H			₩			ļ		╢				ļ	H	ł	ľ	ľ	ł
·) · · ·	Ú						ļ	III)		L,			Π	Q	Ŧ	0	I				I	Ĩ	ſ	III.	Í	Ĺ
										1					'											

15TH

12TH

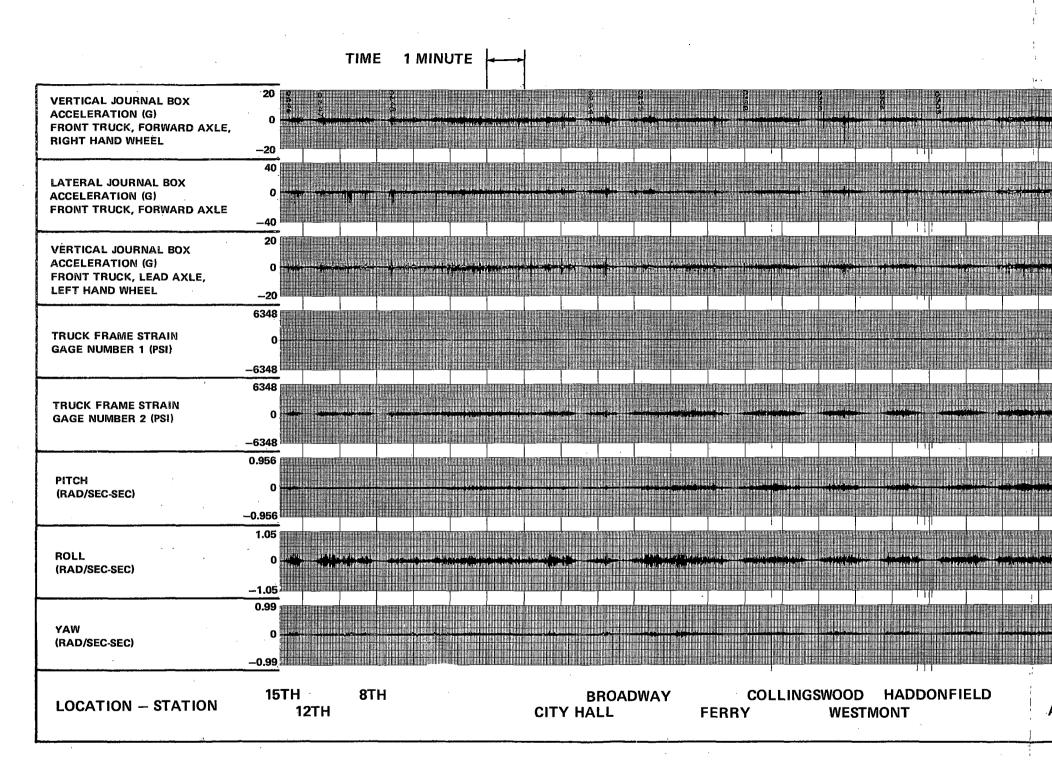


Figure 5–26. Journals, Truck Frame, and Angular Acceleration Time History Chart (15-L)

E-51

				i																		1																							ļ	1		5	
							Ì					5		Î					i		Ï		1		l	ļ											l												
Ķ		ļ	l		ļ				ļ					1	1	i			ļ			1	ļ		ļ	11		1	1		f	į	į	H	ļ	H	ļ		ł	1	ļ	ť		1			l		Î
Ï	Ï	Ì	h	ļ	i	1	ļ	l	2	ł	ļ	l	ľ	H	ł	ł	1	ļ		l	l	l	l			ł	l	1	ł	ļ		ł			l	ļ	l	ł	į	ļ		Ï	ł	l	l	Ï	t	Ì	i
I	ļ			i		-						1				ļ							ļ		ļ	ļ		ļ	ļ			-					Ì			ļ				l					
fl	1	1	ł	1	1	ļ	ļ	ļ	ŧ	(H	4	#	ŧ	f	Ħ	±	Ħ	Í	f	1	1	đ	ł	I	Ħ	₫	1	1	Í	#	1	1	đ	Ű	IJ	4	<u>ff</u>	1	Ē	ţ	1	Ħ	#	t	<u>t</u>	Ľ	#	ti	1
_	_							J														_		_		_				_			_	_	_		_	_	_			_						_	
ļ							1			I		I	I			į					ĺ		l												ļ														
ľ			H		ł													l	Í		Ð				l								Ï	l		i	H										1		8
l	l	Ì	l	l					Ì	l				Ì	Ì		ļ	ĺ			l	ļ		U		ļ	l	į	ł,			ļ	l	Í	l	l	l	ļ	Ľ	ļ	ļ		İ		Ï	ij	ĺ		
l			l			J	ļ		1	l		1	l	ì	l				Ì		I	1	1			Î	j	1111		l		ļ	l	ſ	Ĩ.	I		Î	ľ			ļ			þ	ļ		ľ	ĺ
															Ì		l							i				1	Ĭ			ļ							ŀ										l
l			l		ï											l		l						l												Ì	I				ļ						Ï		i
-																							Ī													1	22												-
п	m	н	Æ		F	Æ	R	Ŧ	Е	Ħ	H	1	B	Ŧ	E	Ħ	5	E	Ŧ	R	Ð	Ŧ		'n	1	÷	Đ		E	Ŧ	H	E	π	H	E	,	п	æ	Б	8	Ð		H	П	-	Đ	Đ	H:	Đ
	ļ		Í	Í	i	l		ļ		Í		ļ	ļ	Í	ĺ	ľ	l	ţ	ļ	Ì		l	ļ	l	Ē	į				ļ	ļ	Ì	Í	l	ļ	ļ	Í	Í	Í	ij	titt		ĺ	l	ļ	1	ļ		
ļ	Ì	İ	Í	ĺ	Í		Ì	Í		Í		Í	Í	Í	Í		1	İ		l	111	Ì		ļ	l	ļ			ĺ	İ	l	l	ĺ	Í	ļ	i	l	ľ	Í	ļ	Ì		Í	ĺ	ļ	l	l	l	ļ
H	ł	l	l	ļ	ł	ļ	ŀ	1		l	IJ	l		ļ	Į	l	Ĩ	2	l	ļ	ļ		ļ	i	ť	l	1	l		l	ļ	l	ri M	l	ļ	1	ļ	ļ	Ļ	ļ	ł	ļ	ļ		t	ĺ	ļ	l	
I	1		ĺ	ĺ	10000						l			1	Í		l	ĺ	Í		ľ	1		l		Í						ĺ	É	Î	l			l	H	ĥ	i	l	l		ľ	ĺ	l		ł
ľ	ĺ	Ú	İ	ĺ		Í	Í	l	Í	l	l		Í		Í	ĺ	į	l	ĺ			l	Í	Í		l	l	1					İ	İ	Ï	ij	l	l		í	i	1	ĺ	Í	Î	ĺ	l	Í	ĺ
			l	l	Ì		ĺ	ļ		l	1		l	1	l		ĺ				Í	I	ļ	1	Í	ſ	ĺ	1				ĺ	1		ľ	I	I	1	l	ĺ	ĺ	ļ	l		í	Í		ľ	ĺ
								ļ																																									
8	Ð		ļ	B	ļ	l	B	ļ		I		l	I	ļ	F	l	ļ	ļ	I	ļ	ļ	ļ		1	þ	ļ	ļ	Ŗ	ł	R	P	þ	Ĥ	ſ	l	Ţ	I	ļ	I	ļ	ļ	ļi	1		ļ	ļ	ļ	I	ſ
			ļ	ļ	ļ		ļ	ļ	ĺ	ļ	ļ	ļ		ţ	İ	ļ	Ī		ļ	ļ	ļ		ļ	ļ	ļ	ļ	ļ			ļ		ļ	ļ	ľ	ļ			ļ	ļ	ļ	J		Í		ļ			I	
Í	Í	Í	1		1	l	l	1	Í.		Í		Í	Ì			Í	ĺ			ĺ	Ĥ			í		ĺ	ł			l	İ	l	1	Í	l	Í		1	l	t H		1	1	ļ	ĺ	ļ		É
ľ	1	Í		Í	1	Í	ĺ	ļ	1	lÍ	l		Í	1		Í	ij	1	ĺ	ĺ	l	Ï	Í	İ	i	ľ	i	1.000	Í	l	ĺ	ĺ	i	İ	j	ij	ij	1	ü	ļ	ì			j	Ħ	ļ	t	Í	f
l	i		Í	t	Í	1	Í	Í		Í	Í		1	Í	Í	Ì	İ	Í	Ì	i	ť	l		į		l	İ	1.1	Í	l	İ	Í	Í	Í	Í	İ	ĥ	Í	Í		Î		Í	l	ij	I	l	I	
l	tini i		l	1			ľ	ļ	l		ļ		ļ			ļ	I				I			l		ļ				l	l	ļ	ľ	ľ	ļ	ł	ľ	Í	l	l			ĺ						
đ	۳Ĵ	É	1	Ē	ŧ	Ľ	É	1	É	Ħ	ij	É	#	ť	Ħ	i i	ŧ	ŧ	Ľ	1	#	#	1	#	Ħ	Ħ	1	ŧ	Ħ	Ħ	t	#	ti	1	#	#	ľ	#	Ħ	IJ	ŧ	j,	ŧ	Ľ	#	1	1	t	Ê
		_		_	_				Ļ					-							_																L		.,		•								
		1		ł			l	l		ĺ			Į		I	Ï	ļ								1111111		l			Ú		Į	İ	ļ					ĺ	l	I				ļ	İ		1	1
l	f		1	ĺ	ĺ			ĺ	ĺ	1				Í	İ	t	į	11111	Í	İ	Í	ţ	l	1	ļ	1	Í			ļ				l	ł	Ű	l	1	1		Í		H		í	Í		1	1
l	ł	Í	t	l	Í	l	ĺ	ĺ		l	l		İ	Í			ļ		1	ľ	l					l					l	l	į	ţ	ļ	l	t	ļ	ľ	ţ	1	İ	ľ	l	l	i	İ		
1		1		ſ	ļ		Î	ĺ	i i		l	Í		l	ĺ				l	ĺ	1			l	l	l		Î	l		ł	ĥ		ĺ	ļ		l	Í	ľ	ĺ	1	ĺ	l	H		1			ļ
ļ	l	Í	l	ſ	ļ		l	ļ	-		Í		ĺ	f	İ	Í	Í	Í			1	Í	ļ		ĺ	ĺ	fi i i	Í	Í	ļ	ļ	l		ľ	ļ	Í	ľ		ļ	ľ	ĺ	l			ľ	f	ł		ļ
Î	10100	Í	ĺ	l			ľ	ĺ		l		l		1	Í	1			ĺ				ļ	ĺ	ĺ	Í	1			l		Ì	Ï	l	i	ľ		Ĩ	Í	ĺ		Ì	ĺ		f	Í		Í	Í
		Î	Î		Î	Î	Î	1	ſ	Î																	ĺ									1	ſ							Î					
		1	1	Đ		Ħ	₽	Į	ŀ	Ħ	₽	I	p	I	₽	P	₽	I	Ħ	₿	1	ŧ		H	₽	T	Ŧ	I	l	Ⅲ	1	0	1	ŧ	E	ł	3	#	8	ŧ	ł		Ħ	n	P	ł	H	8	f
ļ	l	ĺ		ļ	į	l		į		i	i	ĺ	į	j	l	İ	ĺ	Í	ĺ	1		l	J		Î			ĺ		ļ		į		t	ĺ	ļ	ļ	Í	l			l	į	ľ	ij			Í	ĺ
	ļ		I		ĺ			ĺ		l	l		ĺ	í	Í		Í		I	ĺ	Í	Í	ĺ	1	Í	ſ	ĺ	I		ĺ	ļ	1	1			l	1		Í	ĺ	1		ļ	ĺ	ĺ	Í		Í	ĺ
ļ	ļ	l	l	ļ	ļ	I	l	l		l	1			ļ	ĺ	l	i	ļ	l	l	1	1	l	ļ	ļ	ţ	ļ	l	ł	ļ	ļ	j	į	ļ	ļ	ļ	H	l	H	ł	ł		l	B	ļ	l		ľ	I
	-	Ì	l	f	ł			Í		Í	İ			í	Í	ĺ	Í		ľ		ł	Ì		Í	Ì	ļ		ĺ		Í	1		Í	i		ł		Í	l	Ì	Í	ľ	l	İ	l	İ		Í	ł
ļ	1	ĺ	ļ		ļ		ĺ	l	f	ļ		ĺ	ļ	Ĩ	Í	ļ	ĺ	ſ	ļ	ĺ	Į	ſ	ĺ		Í	Î	Ĩ			l	ļ	ĺ	ļ	ļ		l		ļ	ļ	ĺ	Ĩ	ſ	ļ	ĺ	ſ	Į	ſ	ĺ	Í
	ž		1	ĺ	ſ	Ħ	ĺ	ĺ	l	1	ť	l	Í	ĺ	1	l	f	ĺ	l	ŧ	ļ	ŧ	ļ	#	Í	I	ŧ	ļ	Ħ	1	Í	ĺ	8	ĺ	1	Ę	H	1	ŧ	ŧ	l	ŧ	1	ŧ	ſ	1		l	É
																																				l													
ļ		9	1	ļ		ĺ	ļ	1111			l			ļ	ļ	ļ	ļ	Į	ļ		Į	ļ	l		ĺ	l	ļ		l	ļ		ļ	ļ	l	ļ	ļ	-	l	I			ļ	ļ	I	ļ	ļ		ļ	I
ļ					1			I					ĺ	1							Ī						1					ĺ		f	ļ				I	l						1		ĺ	ĺ
ļ		l	Í	Í	į	ł	l	ĺ		Í	l	l	l	1	l		l		1		I	ļ		ļ	Ï	ļ	ł	ł	ł	l	I	ļ	ļ	Į		l		l	l	ļ				J		1	ł		ł
I	ļ	ĺ	ĺ		ļ			ĺ		ĺ	Í	l	l	ļ	ľ	l	ĺ			[ļ	ļ		ļ	ļ	ņ	ļ	ļ	l	1	l	l	Ì	ĺ	1	I		l	p	l	ľ	Í	l	ļ	I	ļ	ļ	ļ	ļ
l	Í	Í	l	l			ĺ	l	Í		ĺ			ľ	l		1			l	-			ļ	ļ	ł				l	ĺ	ĺ	l	l	l		H		ľ		1				l				ĺ
l		ſ	₿	f			f	ļ	Tiere a	l	f	ſ	Í	I	1	ĺ	1	ĺ		ļ		ń	I	1	l	l	f			∥	ĺ	ĺ	H	l	ĺ	ĺ		l		ľ	ł	ľ		ļ	Í	ŧ	l	Í	Í
#	6	Ĥ	£	8	đ	H	H	1	ŕ	ff	1	ti i	f	ŧ	ť	*	t	ŧ	t	t	±	H)	Ï	#	t	±1	1	đ	Ħ	4	ť	f	4	f	*	#	ť	#	f	ť	£	t	f	t	#	1	f	±Ĺ	ŝ
								j									.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				P		ļ	Ļ			P										Ļ				r					7			Ŧ
l	l		l		Í	I	l	Í	ĺ	Í	l			1	ľ		l	ľ		l	Í	l		╢	ĺ	ĺ	f			l		l		l	l	ł	H		l	l	Í	Í			ł	1	ľ	Í	Ē
ł	l		l	1	ļ	ł	ļ	ļ		l	l	ľ	l	t		ļ	ł	1		ł	f			l	ľ	f	1		H		ŀ			╢	l			I	ť	ł	ļ		ł	ł	1	1	ł		ł
l	l	l	ţ	t	ţ	t	ļ	Í	t	t	ļ	ľ		ţ	Í	ļ	ť		1	t	ţ		l	ţ	ţ	Í	ĺ	ľ	Ì	t	Ì	Í	ij	t	İ	l	Í	t	ť	l	Í	ľ	l	ţ		ļ	ļ	Í	ļ
Í	ļ	Í	I		ĺ		ſ	l	ſ	Í	ĺ	ſ	Í	ĺ	ſ	ĺ	l	Í	Í	ĺ			J	Í	ļ	ļ	ĺ	Í		Í	ĺ	Í	I	ĺ	Í	Í	ļ	ļ	f		Í	Í	ļ	ſ	Í	ĺ	Í	Į	ĺ
			l	þ	1		l		1	₿	ĺ		f		₿	l	ļ			1	1		l	1	ĺ	l	ł	l		╢	l	ľ	ł	l	ľ			H	þ	ĺ	l		ł	l	ļ	I			ļ
				£	ŧ	ú	ŧ	4	É	ŧ	ŧ	ŧÉ	t	4	11	d	1	ú	4	ŧ	ť	ŧĤ	ŧ,	#	ł	4	4	ŧĒ.	а	11			41	1ŝ	æ	d)	ш	11	1Í	1									

LINDENWOLD

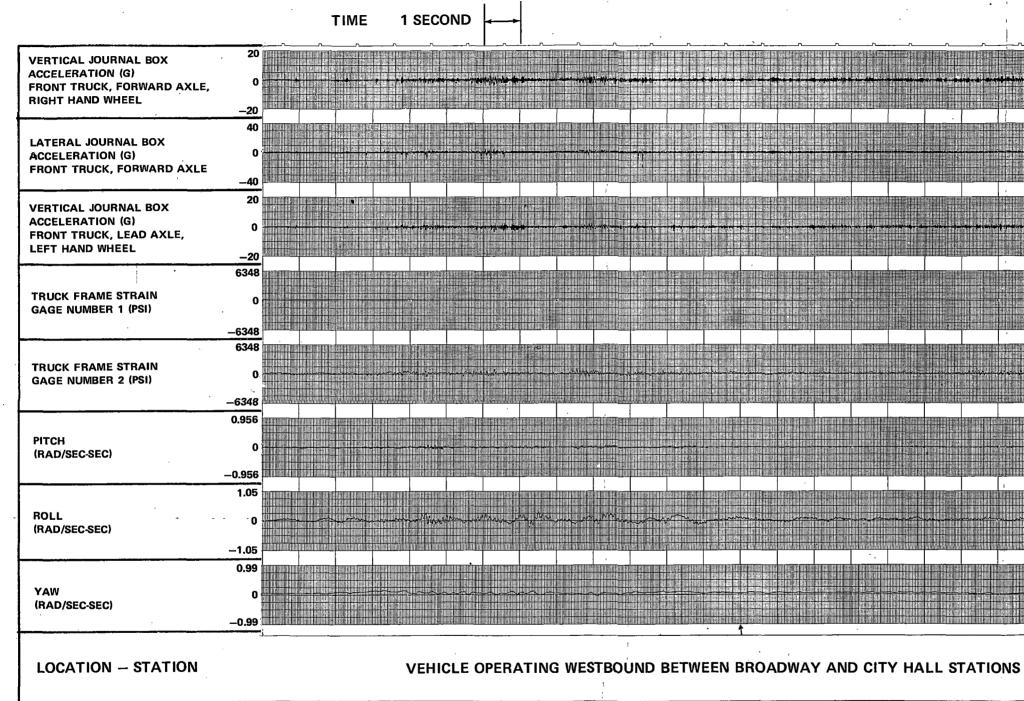


Figure 5–27. Journals, Truck Frame, and Angular Acceleration Time History Chart (~)

	•