

# First Article Transit Bus Test Plan



U.S. Department  
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**Urban Mass  
Transportation  
Administration**

Office of Technical Assistance  
Office of Bus and Paratransit  
Systems

Prepared by:  
Battelle  
Columbus Laboratories

October 1983



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**FIRST ARTICLE TRANSIT BUS TEST PLAN**

to

**DEPARTMENT OF TRANSPORTATION/UMTA  
Office of Bus and Paratransit Systems**

October 28, 1983

by

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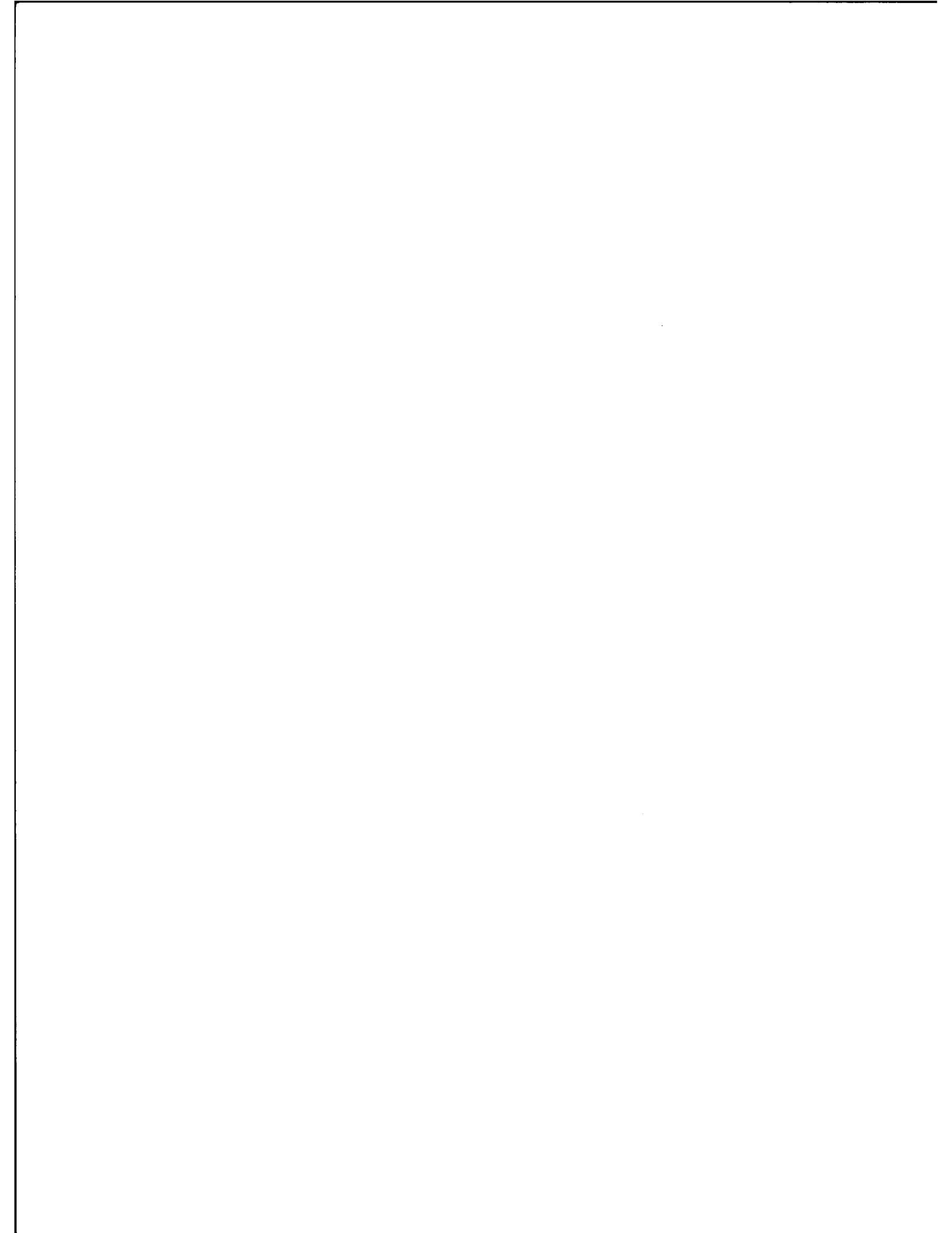
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16. Abstract <p>This report presents a series of nonrevenue and revenue tests that can be specified by a bus purchaser when a manufacturer offers a First Article Bus. First Article Bus is defined in detail to include production transit buses that feature new major components or designs that have not been used in revenue service in the United States.</p> <p>Included in the report are an analysis of interviews with eight bus manufacturers and transit authorities, the thinking of APTA's Bus Technology Liaison Board, and the conclusions of the researchers.</p> <p>The Appendix to the report is a "First Article Nonrevenue and Revenue Bus Test Plan for 35-Foot and 40-Foot Transit Buses" that could be added to transit authority procurement packages. It includes seven nonrevenue tests and three revenue tests.</p>					
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## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

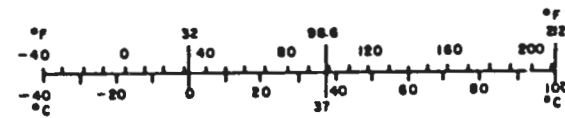
Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.96	liters	l
gal	gallons	3.8	liters	l
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

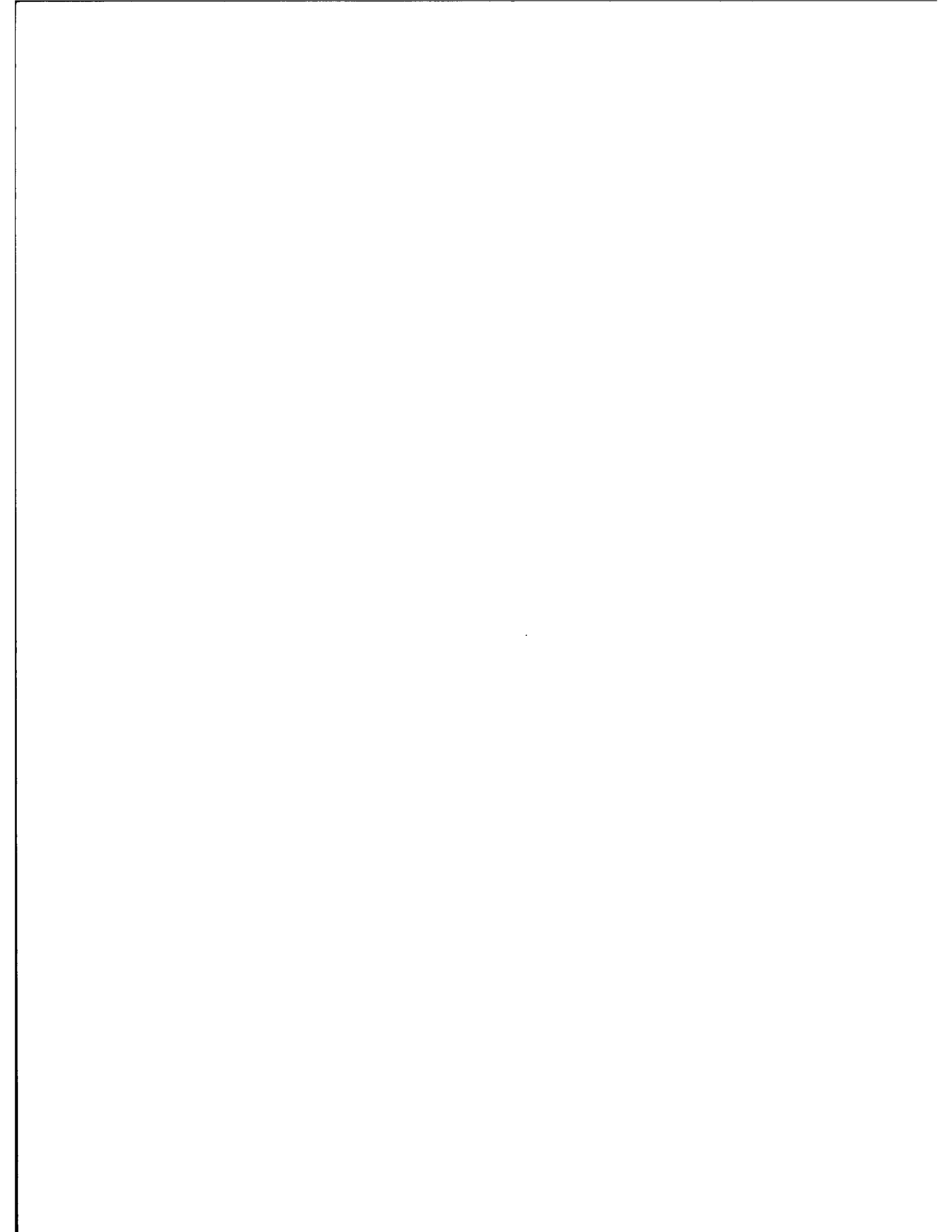
\*1 in = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Misc. Publ. 288, Units of Weights and Measures, Price \$2.25, SO Catalog No. C13.10.288.



### Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	36	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F







## EXECUTIVE SUMMARY

The transit bus industry has recognized that new critical components, new bus designs, and new bus manufacturers entering the United States market could make it difficult for transit authorities to evaluate bids. In recognition of the American Public Transit Association (APTA) Bus Technology Liaison Board's (BTLB) concern about new products and new manufacturers, the Urban Mass Transportation Administration's (UMTA) Office of Bus and Paratransit Systems has performed this investigation and prepared the test plan which forms Appendix A of this report. An approach to use of this plan by transit bus manufacturers and transit authorities is suggested in the report.

The contractor for preparation of the "First Article Nonrevenue and Revenue Test Plan for 35-Foot and 40-Foot Transit Buses" was Battelle's Columbus Laboratories. The task plan was predicated on maximum use of transit industry experience and based on information, opinions, and draft critiques obtained from the

Bus Technology Liaison Board  
Central Ohio Transit Authority (COTA)  
Chicago Transit Authority (CTA)  
Metropolitan Atlanta Rapid Transit Authority (MARTA)  
New York City Transit Authority (NYCTA)  
Southeastern Michigan Transit Authority (SEMTA)  
GMC Truck and Coach Division  
Grumman Flxible Corporation, and  
Neoplan USA Corporation.

The excellent cooperation of all of these organizations is greatly appreciated.

The plan is based on interviews of the technical managers from the transit authorities and bus manufacturers and draft review by several of the interviewees and by the BTLB as a group. The task was performed during the period from May 1982 to October 1983 with excellent cooperation from the transit industry.

Appendix A is written in such a way that it can be included in a transit authority's bid package and be deemed valid when the transit authority and manufacturer agree that a bid bus is a First Article Bus.

The test plan is for standard heavy-duty 35-foot and 40-foot transit buses but could be modified or used in-part for procurement of either small or articulated buses.

The test plan in Appendix A is prefaced by a statement of the intent of the test plan and the definition of first article.

The nonrevenue tests are:

- Structural Strength and Distortion
- Acceleration/Gradeability/Top Speed
- Braking
- Handling and Stability
- Fuel Economy
- Interior Noise and Vibration, and
- Exterior Noise.

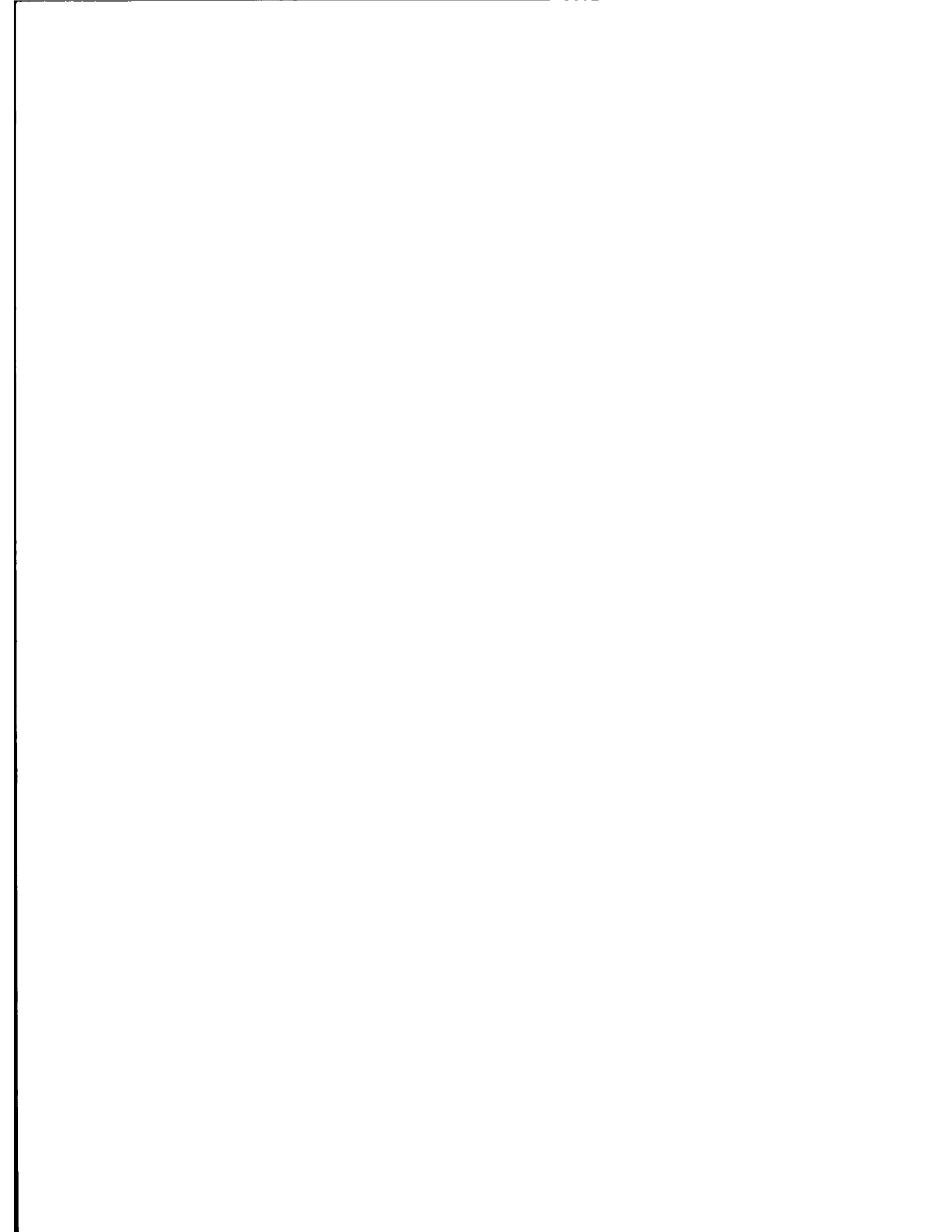
The revenue tests are:

- Structural Durability
- Service Reliability, and
- Equipment Reliability, Maintainability, and Life.

The report is organized with a description of the technical approach or methodology in Section 2. Results, including comments and suggestions based on the interviews and BTLB review, are included in Section 3. The specific conclusions are based on study of all of the industry inputs and are included in Appendix A.

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## 1.0 INTRODUCTION

Concerns have been raised by the transit industry regarding the life, safety, and performance of "new" buses being delivered to U.S. transit authorities. Recognizing these concerns the Urban Mass Transportation Administration (UMTA) has completed this study and prepared this whole bus test plan to aid transit authorities and bus manufacturers in recognizing and dealing with the problems associated with purchase and introduction of a "new" or First Article Bus into revenue service. The study and the resulting test plan were initiated by the American Public Transit Association's Bus Technology Liaison Board's (BTLB) detailed discussion of bus subsystem and whole bus testing and their desire to establish criteria for acceptance of new equipment.

This report describes the activities in assisting the BTLB and includes discussion of the information obtained and considered in developing test plans. The results of the study including the intent of the test plan, the definition of a First Article Bus, and the test plans form Appendix A.

First Article Buses are the first ten buses off the production line that are built for delivery to a U.S. transit authority and:

- (a) Are of a new design that has not been used in revenue service in the United States, or
- (b) Include any major change in configuration or components critical to sustained revenue operation that has not been evaluated and proven acceptable in U.S. transit service.

The final decision on whether or not a bid bus is a First Article Bus and what tests would be performed would be reached by agreement between the transit bus manufacturer and the transit authority purchasing the bus with no third-party involvement.

## 2.0 TECHNICAL APPROACH

The technical approach to this task was to use the best thinking of the BTLB and as many other interested transit industry organizations as possible. It included analysis of transit bus test requirements and industry practices by our staff and in-depth interviews with transit bus manufacturers and transit authorities.

A description of our work plan was prepared for distribution to the selected transit bus manufacturers and transit authorities. The description included preliminary definitions of several critical terms, described our approach, and listed several questions to be discussed with the selected organizations. The description was used as a starting point for discussions and forms Appendix B of this report. This section of the report is organized on the basis of the approach described in Appendix B.

### 2.1 Review of New Product Testing of Automobile and Truck Manufacturers

This brief study was based on Battelle's experience with automobile, truck, and military vehicle manufacturers and discussions with people in new product development in these industries. Each product segment has different development approaches based on production volume and customer requirements. The general opinion is that for small volume production of land vehicles it is more cost efficient to build in factors of safety (overdesign) than it is to perform all of the tests that would be required to assure the life and durability of a vehicle. The authors understand this thinking, but concur with the transit industry that new transit buses and new manufacturer's products require a level of testing beyond what is "normal" for the transit bus industry.

### 2.2 Interview Bus Manufacturers and Transit Authorities

Three transit bus manufacturers and five transit authorities were selected for interviews on the basis of several factors including size, recent purchases or sales, apparent willingness to cooperate, and experience with "new" buses.



Transit authorities selected and interviewed were:

- Central Ohio Transit Authority (COTA)
- Chicago Transit Authority (CTA)
- Metropolitan Atlanta Rapid Transit Authority (MARTA)
- New York City Transit Authority (NYCTA)
- Southeastern Michigan Transit Authority (SEMTA).

Manufacturers selected and interviewed were:

- GMC Truck and Coach Division
- Grumman Flxible Corporation
- Neoplan USA Corporation.

Through written and verbal communications, meeting dates were established with those persons having knowledge of bus testing and/or procurement. Two representatives from Battelle and one or more representative from each organization contacted were involved in each interview. Typically, transit operators were represented by the head of the maintenance or engineering organization, and manufacturers were represented by the head of the engineering organization. The purpose of the activity and Battelle's approach were reviewed at the beginning of each meeting. Discussion was structured around the list of questions under "Approach" in Appendix B. The results of each meeting were documented in trip reports and are discussed in more detail later in this report.

### 2.3 Prepare Final Report and Bus Test Plans

Survey results were analyzed and a preliminary draft of the "First Article Nonrevenue and Revenue Bus Test Plan" was prepared. The draft was then distributed to all interviewees for comments and questions. Some responses were very detailed, some addressed parts of the plan, and some addressed single points, but all responses were helpful and were used to revise the draft before review by the BTLB.

The BTLB reviewed the draft in a working session during their Spring Meeting of 1983 and two board members have responded individually. All inputs by the BTLB and the industry team are reflected in the test plans presented in Appendix A.

### 3.0 RESULTS

The results of the interviews with transit bus manufacturers and transit authorities and the comments and suggestions of the BTLB are summarized in this section. Concerns of the transit industry and the selection of bus tests are then reviewed. The section ends with a suggestion of how the test plan can be used by the transit bus industry.

#### 3.1 Comments by Interviewees

The eight interviews with transit authorities and transit bus manufacturers were structured around the "Description of Battelle's Task on First Article Bus Testing Procedures" which is Appendix B. Appendix C is a synopsis of the responses to the specific questions listed under Approach, Item (2), in Appendix B. The comments by the interviewees showed a broad range of opinion and formed an excellent basis for structuring the concerns of the industry and the First Article Bus test plan.

#### 3.2 Comments and Suggestions by BTLB

The draft test plan was reviewed item-by-item by the BTLB. There were no comments on the selection of test subjects but there were requests for confirmation of our conclusions on some aspects of the plan and questions and suggestions on other aspects. Since there had been progress reports made to the BTLB throughout the preparation of the draft, points remaining for their concern were limited. They are summarized by the following questions and suggestions:

- (1) Why limit the tests to new buses?
- (2) Why not include articulated buses?
- (3) Improve the definition of First Article Bus by adding "any major change in configuration".
- (4) One-half hour of CBD cycle is all that is needed for brake test.

- (5) Tests should be performed to confirm the Obstacle Avoidance Test.\*
- (6) The 60 mph stop required by Federal Motor Vehicle Safety Standard (FMVSS) may have been eliminated.
- (7) The audible discrete frequency portion of the Interior Noise and Vibration Test should remain.
- (8) How do we pay for the revenue tests?
- (9) Do the revenue tests prove anything?

### 3.3 Selection of First Article Bus Tests

The selection of nonrevenue and revenue tests was based on the concerns of the transit industry and knowledge of recent problems encountered in the introduction of new bus designs and new components important to maintenance of bus operation in revenue service. There was no desire to introduce new tests or test procedures. New tests are included only when tests now required by Federal regulation or standard practice in the transit industry do not serve the purpose of assuring operability and serviceability of the First Article Bus. The concerns of the industry and the rationale used in selecting tests for inclusion in Appendix A are described under the next two headings.

### 3.4 Concerns of the Industry

Concerns expressed relative to First Article Buses were essentially the same as for production buses. Therefore, one combined list of concerns will be discussed. In this section, the list will be condensed to the major concerns which can be addressed by First Article testing.

The concerns expressed by transit manufacturers and suppliers were:

- Maintainability/serviceability
- Reliability
- Ability to meet procurement specifications
- Ability to meet manufacturer's process specifications

---

\* Tests were subsequently performed at the Transportation Research Center of Ohio to confirm the specified test.

- Safety
- Ability to meet Government standards
- Ability to meet internal (manufacturer's) requirements
- Performance
- Durability
- Fixes for known faults
- Maintenance costs
- Structural integrity/life
- Fuel economy
- Ability to pass property quality control checks
- Parts availability and standardization
- Availability of training
- Sameness with earlier buses
- Life cycle cost
- Compliance with design
- Producibility
- Weight
- Return on investment
- Warranty features
- Design of critical components
- Driver acceptability
- Passenger comfort.

Some of the concerns are outside the scope of the transit operator's concern in First Article testing. These concerns and the rationale for this decision are as follows:

- Ability to meet manufacturer's process specifications--This is a manufacturer's concern which cannot be alleviated by testing. Internal quality control is necessary.
- Ability to meet internal (manufacturer's) requirements--This is a manufacturer's concern which cannot be alleviated by testing. Internal quality control is necessary.
- Ability to pass transit authority quality control checks--This is a manufacturer's concern which cannot be alleviated by testing. Internal quality control is necessary.

- Parts availability and standardization--This is a procurement decision. However, this concern cannot be alleviated by testing.
- Availability of training--This is a procurement decision. However, this concern cannot be alleviated by testing.
- Sameness with earlier buses--This is a concern of both transit manufacturers and operators, but it is best alleviated by quality control checks.
- Life cycle costs--The capital cost aspect is something that cannot be verified by testing. However, operations and maintenance costs are important and can be verified by testing.
- Compliance with design--This is a manufacturer's concern which cannot be alleviated by testing. Internal quality control is necessary.
- Producibility--This is a manufacturer's concern, but is not something that can be alleviated by testing.
- Weight--This is a procurement decision. Once the weight of the bus is set by the manufacturer and accepted by the operator, it will change little, if any.
- Return on investment--This is a manufacturer's business concern.
- Warranty features--This is a procurement decision. The extent of the warranty is important but is not something that can be verified by testing.

It is important to note that proper quality control was mentioned several times. A quality control program appears necessary if the manufacturer and operator are to have confidence that all buses are alike. Certainly it will be necessary to have confidence that buses not subjected to First Article Testing are the same as those tested.

The concern "Ability to meet procurement specifications" is important but it transcends and encompasses other concerns such as reliability, safety, performance, and so forth. This concern can be alleviated by testing relative to these other concerns.

The concern "Ability to meet Government standards" likewise encompasses a large number of concerns; i.e., compliance with Federal Motor Vehicle Safety Standards (FMVSS) and Environmental Protection Agency (EPA) Regulations. Concerns relative to EPA regulations are important but appear best alleviated by certifications from the manufacturer. He is best equipped to perform the necessary tests and more knowledgeable about the subject. Concerns relative to the FMVSS are also important but can be considered as a part of the larger concern "Safety".

Two concerns--"Fixes for known faults" and "Design of critical components"--are a part of larger concerns relative to reliability, safety, performance, etc. Although these two concerns are best alleviated by testing relative to these larger concerns, special attention during testing should be paid to components previously faulty or deemed critical.

"Durability" is basically the same concern as "Structural integrity/life". Both structural strength and structural durability are included in our test plan.

"Maintenance costs" is a part of the larger concern "Operations and maintenance costs". This concern is addressed by several of the items in the following condensed list of interviewee concerns:

- Maintainability/serviceability
- Reliability
- Safety
- Performance
- Structural integrity/life
- Fuel economy
- Driver acceptability
- Passenger comfort.

Two other concerns discussed with the interviewees do not fit within the above discussions. However, they are significant and noted here.

First, the use of the term "normal operating conditions" means local operating conditions to transit manufacturers and operators. It, therefore, follows that procurement specifications should use the term "local operating conditions". Whether or not the transit operator should specify his local operating conditions remains an open subject. On the one hand, doing so supplies the transit manufacturer with detailed information about the local operating conditions. On the other hand, by defining these conditions, the transit authority is sharing the risk that the bus will operate properly with the transit bus manufacturer.

Second, with regard to our question on how Battelle could do a better job on this plan, the responses to this question do not, for the most part, relate directly to First Article Testing. However, they do provide some insight as to recommendations for further work and how that work should provide support to the transit industry.



Significant comments were:

- Improve bus specifications to help both the transit manufacturer and the transit operator by clarifying and simplifying wording on specifications and test requirements.
- Do nothing that will require revolutionary changes in buses or bus design; keep the bus industry evolutionary.

### 3.5 Test Selection

On the basis of industry concerns, it is then possible to propose specific tests which will (1) show that the First Article Bus performs as expected and (2) assist in alleviating the transit operator's concerns. These tests are described in general here. Details are contained in Appendix A.

#### 3.5.1 Types of Tests

These tests can be classified into three types--Safety, Performance Evaluation, and Revenue Operations.

3.5.1.1 Safety Tests. Safety tests address the safety concern. Although the transit operator must place much confidence in the transit manufacturer's ability to design a safe vehicle, some safety tests can be performed. Specifically, the three nonrevenue tests envisioned are Braking, Handling and Stability, and Structural Strength and Distortion.

The Braking Test is an adaptation of the FMVSS 121 test. The Handling and Stability Test shows the performance of the bus when operated under adverse conditions. The Structural Strength and Distortion tests are an expansion of tests that would normally be performed on a production bus.

3.5.1.2 Performance Evaluation Tests. Performance evaluation tests address those concerns best alleviated by nonrevenue (test-track) tests--performance, fuel economy, and, to a limited degree, passenger comfort (through noise and vibration tests).

The Performance Test shows the acceleration and top speed capabilities of the bus when operated under a specific loading configuration. In a like manner, the Interior Noise and Vibration Test shows noise and vibration levels generated by the bus and experienced by passengers when the bus is operated under specific loading conditions and at different speeds. An Exterior Noise Test is also included in the nonrevenue tests to measure the noise level experienced by pedestrians and people waiting to board the bus.

The Fuel Economy Test shows the fuel economy of the bus when operated under specific load and operating conditions. Although the data from this test cannot be used to predict in-service fuel economy without adjustment, it provides indication of the fuel economy of the bus under closely controlled conditions. Further, work in this area may allow accurate estimates of in-service fuel economy to be made.

3.5.1.3 Revenue Operation Tests. The third type of tests are revenue operation tests. They address the following concerns: Structural Durability, Service Reliability, and Equipment Reliability, Maintainability and Life.

A clear consensus was obtained from the interviews that the best test for reliability and structural integrity/life is revenue transit operations on the purchaser's property. Shake-table and test-track tests were also mentioned, but concerns were raised that, in both cases, some means must be found to relate test conditions to the actual operating environment (road conditions, passengers, drivers, maintenance personnel). Other concerns were raised because shake-table tests stress some components (e.g., suspension components) at an accelerated pace while other components, e.g., air compressor, are not stressed sufficiently. Little confidence was expressed in either track tests or shake-table results when compared to actual revenue operations. Most interviewees believed that 1 to 2 years of revenue operations should be sufficient to expose significant problems. Obviously, the longer the test the better, but for practical reasons the revenue tests described in Appendix A would be performed during one year of revenue service.

Most interviewees believed that only one bus need be subjected to revenue First Article Testing. However, this approach is statistically unacceptable and as a practical matter, unworkable. The revenue tests in Appendix A are based on monitoring the operation and condition of the first ten production buses for one year. The transit authority should keep accurate and complete records on the ten buses and should have

sufficient records to ensure that the remainder of the new buses are performing at a similar level.

Because of the unique nature of these tests, and in keeping with the interview results, it also appears that any failure of identical items of a First Article Bus be considered a "fleet failure". Typically, the declaration of a fleet failure requires that all buses be treated as if they also experienced this failure. The transit manufacturer is responsible for determining the action that needs to be taken and making those modifications necessary on all buses in the production run.

Destructive tests were also noted as possible tests for structural integrity/life. However, destructive tests are an important part of the development of a transit bus. The appropriate point for such tests is during the prototype stages where the manufacturer can perform them at a reasonable cost and not during the production stage. Therefore, it does not appear appropriate to require that First Article Buses are subjected to destructive tests. Most problems which would be disclosed by destructive tests will also be revealed in revenue operations. It must be stressed that revenue test results should be closely monitored and appropriate action taken should a failure be uncovered if these tests are to be meaningful.

Based on the above discussion, the revenue operations test envisioned would require that ten First Article Buses be subjected to near continuous in-service operations for one year under the most severe conditions available at the purchasing transit authority. Data would be collected and analyzed regarding Structural Durability, Service Reliability, and Equipment Reliability, Maintainability and Life as described in Appendix A.

### 3.6 Roles of Participants

In theory, the best organization to perform First Article Testing is an independent test organization. However, such an approach is probably not realistic. For example, transit manufacturers are reluctant to supply detailed information about their buses and most interviewees believed that the manufacturer should be responsible for all tests.

Transit authorities, in most cases, do not have the expertise nor staff to perform the nonrevenue tests presented in this report. However, it is a logical function

for the transit authority to perform the Revenue Tests. It then remains for the transit bus manufacturer to confirm compliance with safety and performance requirements by performing Nonrevenue Tests.

A clear consensus was obtained regarding the potential roles of APTA and UMTA. The interviewees believed that First Article Testing is a contractual matter between the transit manufacturer and the transit authority and that APTA and UMTA should not have direct part in the First Article Testing. They could, however, be most useful in disseminating test results and in providing financial support for obtaining data.

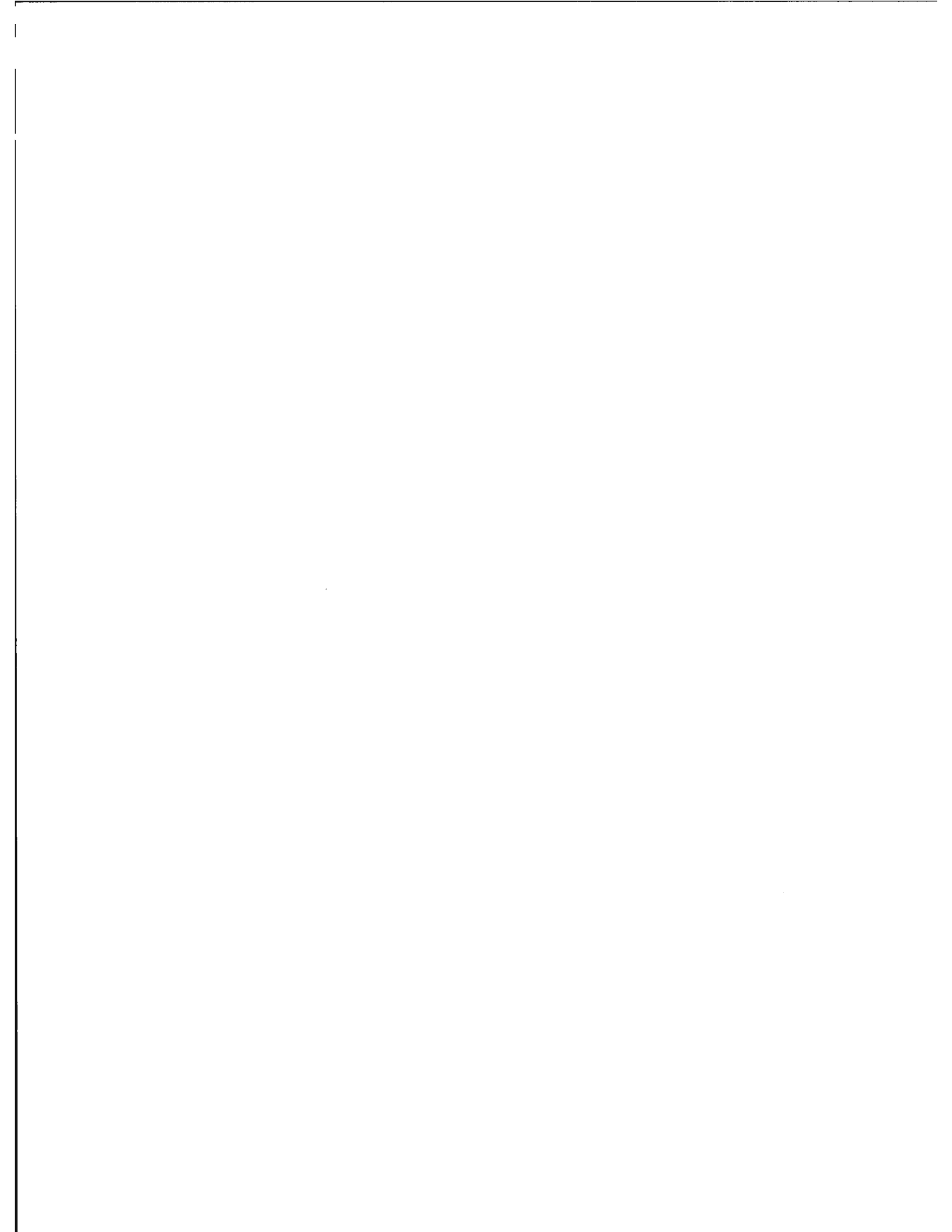
### 3.7 Conclusion

The specific conclusions of this task are presented in Appendix A. Appendix A states the intent of the test plan, defines First Article Bus, and includes both test plans and criteria for evaluation of test results.

Appendix A is structured so that it can be added to the procurement package of a transit authority and can be a basis for agreement between the transit authority and bus manufacturer as to whether the bus being bid is a production bus or a First Article Bus.

APPENDIX A

FIRST ARTICLE NONREVENUE AND REVENUE  
BUS TEST PLAN FOR 35-FOOT AND  
40-FOOT TRANSIT BUSES



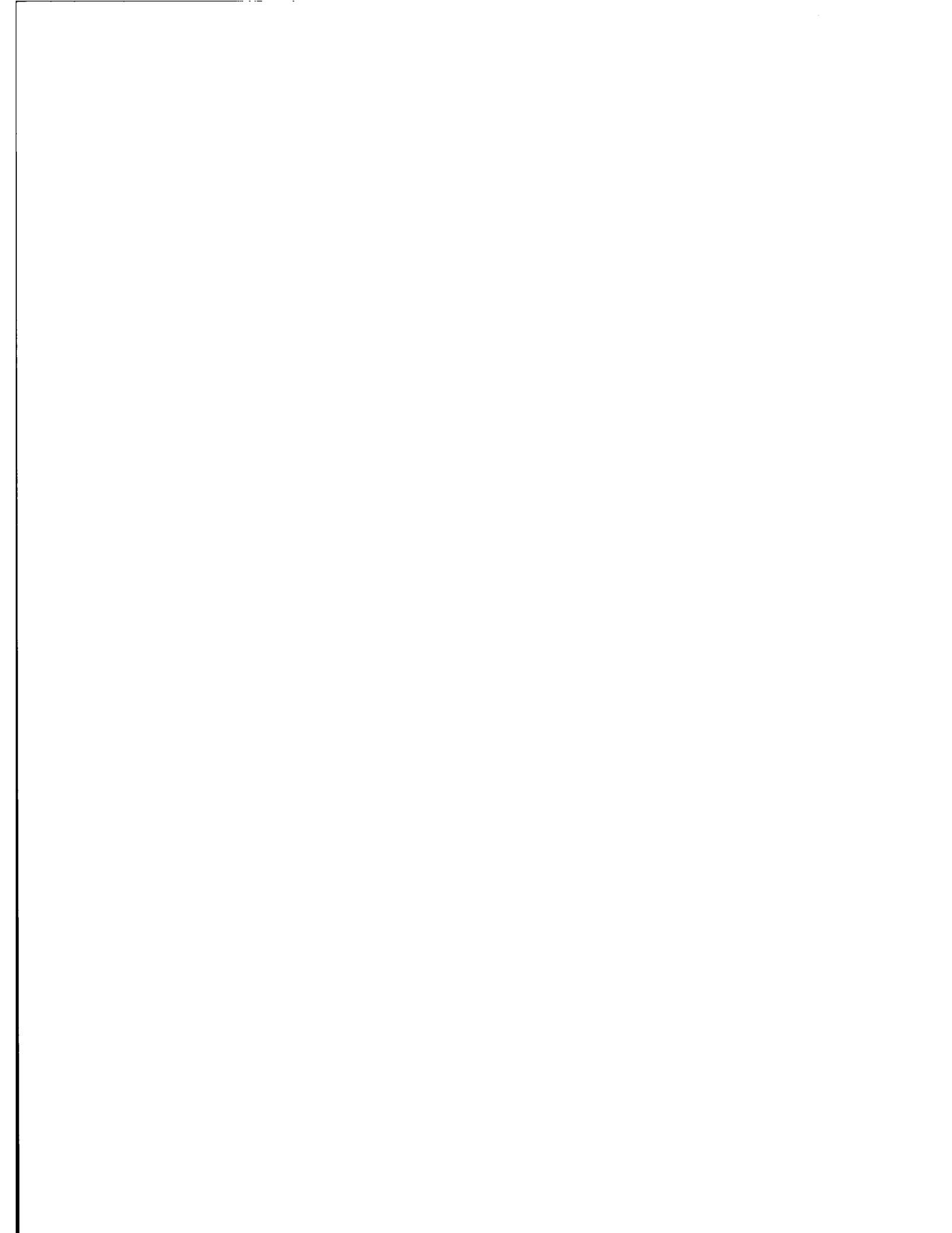


APPENDIX A

FIRST ARTICLE NONREVENUE AND REVENUE  
BUS TEST PLAN FOR 35-FOOT AND  
40-FOOT TRANSIT BUSES

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## APPENDIX A

### FIRST ARTICLE NONREVENUE AND REVENUE BUS TEST PLAN FOR 35-FOOT AND 40-FOOT TRANSIT BUSES

#### INTENT OF TEST PLAN

The tests suggested in this plan are based on the industry's recognition of need for whole bus testing. The plan is presented as a guide to the bus purchaser and bus manufacturer. It is intended that any or all of these test requirements could become a part of the contract between the purchaser and the manufacturer of a "new" bus. The tests are not intended to be new general performance specifications for transit buses and the inclusion of any or all of these First Article Bus tests in a purchase contract would not abrogate or replace any present legal, safety, performance, or other requirements specified in the procurement package.

It is expected that subsequent purchasers of the bus will be interested in the results of these tests and will also desire additional operations and maintenance information and the results of passenger, driver, and maintenance personnel surveys. Since this plan is for use by the purchaser and the manufacturer, development of the additional information of importance to subsequent purchasers of the bus would be done independently of the tests described here.

## DEFINITION OF FIRST ARTICLE BUS

First Article Buses are the first ten buses off the production line that are built for delivery to a U.S. transit authority and:

- (a) Are of a new design that has not been used in revenue service in the United States, or
- (b) Include any major change in configuration or components critical to sustained revenue operation that have not been evaluated and proven acceptable in U.S. transit service.

The final decision on whether or not a bid bus is a First Article Bus and what tests would be performed would be reached by agreement between the transit bus manufacturer and the transit authority purchasing the bus with no third-party involvement.

## TESTS

This plan enumerates ten test subjects for 35-foot and 40-foot transit buses that will help to assure the purchaser that the First Article Bus can be operated successfully in U.S. transit service. The tests are both nonrevenue and revenue and it is suggested that the nonrevenue tests be performed by the bus manufacturer and that the revenue tests be performed and documented by the transit authority. Criteria for evaluation of results are included with each test.

## NONREVENUE TEST PLANS

Nonrevenue tests would be performed by the bus manufacturer on a bus or buses from among the first ten off the production line. One of the buses would be subjected to each of the following tests:

- Structural Strength and Distortion Test
- Acceleration/Gradeability/Top Speed Test
- Braking Test
- Handling and Stability test
- Fuel Economy Test
- Interior Noise and Vibration Test
- Exterior Noise Test.

These tests are described on the following pages.

### Structural Strength and Distortion Test

The objective of this test is to measure and record a number of structural strength and distortion characteristics of a First Article Test Bus under various nonrevenue test conditions. Those test conditions are:

- (1) Shakedown the coach structure by loading and unloading the coach no more than three times with a distributed load equal to 2.5 times gross load.\* Then load the coach with a distributed load to gross vehicle weight.\*\* Measure the increase in floor deflection as the coach weight is increased from curb weight to gross vehicle weight. Then load the coach with a distributed load equal to 2.5 times gross load. Unload the coach and inspect for any permanent deformation of the floor and/or coach structure.
- (2) With the coach loaded to gross vehicle weight, first locate all four wheels on a flat, horizontal surface. Then locate one wheel on top of a 6-inch-high curb and then in a 6-inch-deep pot hole. Repeat for all four wheels. For all nine conditions, verify: (a) normal operation of the steering mechanism and (b) operability of all passenger doors (including sensitive edges, if so equipped), passenger escape mechanisms, side windows, and service doors. With a garden hose and nozzle, leak check windows, passenger doors, and escape hatches.
- (3) Using a load-equalizing towing sling, statically apply a tension load equal to 1.2 times the coach curb weight at an angle of 20 degrees with the longitudinal axis of the coach, first to one side then the other in the horizontal plane and then upward and downward in the vertical plane, to the front towing fixtures. Remove the load. Visually inspect tow eyes and adjoining structure for damage or permanent deformation after each loading condition. Repeat for rear towing fixture(s).

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\* Gross load is 150 lb for every passenger seating position, for the driver, and for each 1.5 sq. ft. of free floor space. For a distributed load equal to 2.5 times gross load, place a 375-lb load on each passenger and driver seat (i.e., seating position) and on each 1-1/2 sq. ft. of free floor space.

\*\* Gross vehicle weight is curb weight plus gross load.

- (4) With the coach at curb weight\*, use the tow bar provided for the coach and a heavy wrecker truck to lift the front wheels clear of the ground. Tow the coach 5 miles at 20 mph. Release the bus from the wrecker. Inspect visually for structural damage or permanent deformation. Operate all doors, windows, and passenger escape mechanisms to assure that the surrounding structures are not deformed.
- (5) With the coach at curb weight on a level hard surface, deflate the tire(s) at one corner. Then jack up the coach to a height sufficient to provide 3 inches clearance between an inflated tire and the hard surface. Re-inflate the tire(s) and release the jack. Inspect visually for structural damage or permanent deformation. Repeat the test at all four wheel locations.
- (6) With the coach at curb weight, hoist the coach with an appropriate two-post hoist system. Use the coach axles or jacking plates to accommodate the lifting pads of the hoist. Note failure of the coach to interface properly with the hoist and any instability of raised coach on hoist. Lower the coach and inspect visually for structural damage or permanent deformation of jacking plates. Repeat the test supporting the coach on jack stands independent of the hoist.

The following criteria will be applied in evaluating the results of the above tests:

- (1) For Condition (1), maximum floor deflection shall not increase more than 0.60 inch when the coach weight is increased from curb weight to gross vehicle weight and no permanent deformation\*\* of the floor and/or coach structure shall result when the coach is loaded to 2.5 times gross load.
- (2) For all nine test configurations of Condition (2):
  - (a) The steering mechanism shall operate normally.
  - (b) Passenger doors, service doors, windows, and emergency exit latches shall not open due to body distortion.

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\* Curb weight is weight of vehicle, including maximum fuel, oil, and coolant; and all equipment required for operation and required by the specification, but without passengers or driver.

\*\* Within normal measurement tolerances.

- (c) Powered passenger doors shall open and close under power. For the flat, horizontal configuration, opening and closing speeds shall be as specified. For the other eight configurations, opening and closing speeds may be slower than specified.
  - (d) All passenger doors shall be manually operable from inside the coach. For the flat, horizontal configuration, a force of no more than 25 lb shall be required after actuating an unlocking device located at each door. For the other eight configurations a force of no more than 50 lb shall be required.
  - (e) It shall be possible for a single occupant to manually release and punch out side windows and other emergency exits. For the flat, horizontal configuration, required force applications shall not exceed the limiting magnitudes given in FMVSS 217. For the other eight conditions, required face applications shall not exceed twice the limiting magnitudes given in FMVSS 217.
  - (f) With any single wheel located either on top of a 6-inch-high curb or in a 6-inch-deep pot hole, operation of side windows and service doors shall require not more than twice the forces required with all wheels located on a flat, horizontal surface.
  - (g) With any single wheel located either on top of a 6-inch-high curb or in a 6-inch-deep pot hole, relative leakage around windows, passenger doors, and escape hatches shall be no more than twice that observed with all wheels located on a flat, horizontal surface.
- (3) For Condition (3), no visible structural damage or permanent deformation shall result from the static towing tests.
  - (4) For Condition (4), no visible structural damage or permanent deformation shall result from the dynamic towing test and all doors, windows, and passenger escape mechanisms shall operate normally.
  - (5) For Condition (5), no visible structural damage or permanent deformation shall result from the jacking tests.
  - (6) For Condition (6), the coach shall interface properly with the hoist and jack stands and shall be stable in the elevated position. No visible structural damage or permanent deformation shall result from the hoisting tests.



Acceleration/Gradeability/Top Speed Test

The objective of this test is to measure the acceleration, gradeability and top speed capabilities of a First Article Test Bus under nonrevenue test conditions.

For this test, the coach will be operated at seated load weight\* on a smooth, straight, and level roadway. The coach will be accelerated at full throttle from standstill to top speed. Either a continuous speed versus time curve or the time required to accelerate to each 10 mph increment of speed and the top speed will be recorded. Top speed will also be recorded. Gradeability capabilities will be calculated from the test data.

The following criteria will be applied in evaluating the results of the acceleration test.

MAXIMUM TIME FOR ACCELERATION

Speed (mph)	Standard Powerplant (sec)	Low Power Alternative (sec)
10	5.6	6.0
20	10.1	12.0
30	19.0	24.0
40	34.0	45.0
50	60.0	-
60	-	-

Top speed and gradeability shall be as specified by the procuring transit property.

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\* Seated load weight is curb weight plus 150 lb for every passenger seating position and for the driver.

### Braking Test

The objective of this test is to measure: (1) service and emergency brake stopping distance; (2) parking brake grade holding; and (3) maximum service brake temperature, when a First Article Test Bus is operated under various nonrevenue test conditions. Those test conditions are:

- (1) Coach stopping distance for both service and emergency brakes will be measured in accordance with FMVSS121. In general, FMVSS121 calls for stops to be made on a level, straight roadway with the vehicle at gross vehicle weight and at curb weight plus 500 lbs from speeds of 20 mph and 60 mph or top speed, whichever is less.
- (2) Coach parked facing uphill and downhill on a smooth, dry concrete grade with all parking brakes applied at gross vehicle weight and at curb weight plus 500 lbs.
- (3) Coach at seated load weight operated continuously for 2 hours on the Central Business District (CBD) phase of the Advanced Design Bus (ADB) duty cycle. At the beginning of the test, brake drum temperature shall be  $200 \pm 50$  F. At the conclusion of the test, measure and record brake drum temperature\* within one minute of the final stop. Cool the brakes to  $200 \pm 50$  F and repeat the test for 2 hours of operation on the Arterial phase.

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\* Drum temperature shall be recorded for the hottest running drum at a point 0.03 to 0.09 inch outboard of the friction surface and axially inline with the center of the friction lining.

The following criteria will be applied in evaluating the results of the above tests.

- (1) For Condition 1, maximum stopping distances specified in FMVSS are:

Coach Speed, mph	Stopping Distance, ft.		
	Service Brake		Emergency Brake Skid No. 81*
	Skid No. 81*	Skid No. 30*	
20	35	60	83
50	203		435
55	246		520
60	293		613

\* Skid No. refers to the tractive condition of the road surface.

- (2) For Condition 2, the parking brakes shall hold the vehicle stationary on roadway with a 20 percent minimum grade.
- (3) For Condition 3, the maximum brake drum temperature shall not exceed 550 F for either the CBD or Arterial phases.

### Handling and Stability Test

The objective of this test is to measure: (1) steady-state cornering speed on 100- and 400-foot-radius circles and check for oversteer; (2) transient cornering speed; and (3) speed through a double-lane change test course, for a First Article Test Bus under nonrevenue test conditions. Those test conditions are:

- (1) **Steady-State Cornering and Oversteer.** The coach will be driven around a 100-foot radius circle at increasing speed up to 22.5 mph or until the coach can no longer be safely maintained on the circle, whichever speed is lower. Test runs will be made in both clockwise and counterclockwise directions. The test will then be repeated on a 400-foot-radius circle at increasing speed up to 45 mph or until the coach can no longer be safely maintained on the circle, whichever speed is lower. As a minimum, coach speed and steering wheel angle will be recorded.
- (2) **Transient Cornering.** The coach will be accelerated on a straight-away up to 22.5 mph or the maximum speed that could be safely maintained on the 100-foot-radius circle in Condition (1), whichever speed is lower. A steering machine will then be activated to provide a 720 degree/second angular rate of input at the steering wheel. The angular magnitude of the steering input will be equal to that determined under Condition (1) to be required to maintain the coach on the 100-foot-radius circle at 22.5 mph or the maximum safe speed. Coach speed will be held constant throughout the cornering portion of the test and will be maintained for a minimum of 5 seconds after activation of the steering machine. Turns will be made in both clockwise and counterclockwise directions. The test will then be repeated with a coach speed of 45 mph or the maximum speed that could be safely maintained on the 400-foot-radius circle in Condition (1), whichever speed is lower. For this latter test, the angular magnitude of the steering input will be equal to that determined under Condition (1) to be required to maintain the coach on the 400-foot-radius circle at 45 mph or the maximum safe speed.
- (3) **Obstacle Avoidance.** A double-lane change test course will be set up using pylons set with 100-foot-long gates and 12-foot center-to-center

adjacent lanes. That is, a longitudinal distance of 100 feet will be available for the coach to change from one lane to an adjacent lane with a 12-foot center-to-center distance. The coach will run for 100 feet in the adjacent lane and then return to the original lane within a third 100 feet. Coach speed will be held constant throughout a given test run. Individual test runs will be made at increasing speeds up to 45 mph or until the coach can no longer be safely operated over the course, whichever speed is lower. Both left- and right-hand lane changes will be tested.

For all three of the above test conditions, the coach will be ballasted to a load and center-of-gravity location equivalent to that of the full-seated load condition.

The following criteria will be applied in evaluating the results of the above tests:

- (1) For Condition (1), the coach speed shall be equal to or greater than 22.5 mph on the 100-foot-radius circle and 45 mph on the 400-foot-radius circle. In addition, it shall be observed that as speed increases the steering wheel angle does not decrease, i.e., oversteer. Some understeer shall be present.
- (2) For Condition (2), the coach shall demonstrate a well-damped cornering response with little or no tendency to overshoot and shall achieve an essentially stable turn in 1.2 seconds or less.
- (3) For Condition (3), the coach speed shall be equal to or greater than 45 mph.

### Fuel Economy Test

The object of this test is to measure the fuel economy (i.e., miles per gallon) of a First Article Test Bus under controlled nonrevenue test conditions.

In this test, the coach will be operated at seated load weight on a smooth level test track. The coach will be operated over the Advanced Design Bus (ADB) duty cycle, which calls for four phases of operation, i.e., Central Business District, Arterial, Commuter and Idle phases. Operating temperatures of the bus will be stabilized prior to the start of each test. Special attention will be paid to test track characteristics including the use of a level, dry, smooth and hard surface, and to minimizing the impact of uncontrollable variables (e.g., wind and driver performance).

Test procedures will be in accordance with those developed under UMTA's transit bus fuel economy testing program conducted by Battelle's Columbus Laboratories at the Transportation Research Center of Ohio.\*

The weight of fuel used, fuel temperature, and time required for a test bus to run the test phases will be recorded and converted into fuel economy (miles per gallon) and average speed (miles per hour).

Criteria for acceptability of the fuel economy test results will be set by agreement between the manufacturer and purchaser of the buses.

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\* "Fuel Economy Testing of Six 40-Foot Transit Buses", Report No. DTUM60-81-C-71103-11-1, prepared by Battelle's Columbus Laboratories for U.S. Department of Transportation Urban Mass Transportation Administration (March 1983).

### Interior Noise and Vibration Test

The objective of this test is to measure interior noise levels and check for resonant vibrations in a First Article Test Bus under various stationary and operating nonrevenue test conditions. Those test conditions are:

- (1) With a white noise generator and loud speaker system create a white noise level of 80 dBA at the outside skin on the left side of the coach (i.e., the side opposite the doors). Measure the noise level at various points throughout the interior of the coach. All openings, including doors and windows, shall be closed and the engine and all accessories switched off during the test.
- (2) Accelerate the test coach at full throttle from a standing start to 35 mph on level commercial asphalt or concrete pavement in an area free of large reflecting surfaces within 50 ft of the coach path. Measure coach-generated noise level at ear height of a seated 50th percentile male in the rear most passenger seats, at the middle of the passenger compartment or engine-transmission location for coaches with under-floor engines, and at the driver's seat. All openings shall be closed and all accessories shall be operating during the test.
- (3) Operate the coach at various speeds from 0 to 55 mph on various road conditions with and without A/C on. Record any abnormal audible or visible resonant vibrations or rattles within the coach.

The following criteria will be applied in evaluating the results of the above tests.

- (1) For Condition 1, the sound level at any point inside the coach shall not exceed 65 dBA.
- (2) For Condition 2, the coach-generated noise level experienced by a passenger at the designated seat locations in the coach shall not exceed 83 dBA, and the driver shall not experience a noise level of more than

75 dBA. If the noise contains an audible discrete frequency\*, a penalty of 5 dBA will be added to the sound level measured.

- (3) For Condition 3, any audible or visible resonant vibration or rattles within the coach shall be judged to be equivalent to or less than those occurring in current heavy-duty transit buses.

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\* An audible discrete frequency is determined to exist if the sound power level in any 1/3-octave band exceeds the average of the sound power levels of the two adjacent 1/3-octave bands by 4 decibels (dB) or more.



### Exterior Noise Test

The objective of this test is to measure exterior noise levels when a First Article Test Bus is operated under various nonrevenue test conditions. Those test conditions are:

- (1) Coach stationary with the engine at high idle and in neutral gear.
- (2) Coach pulling away from a stop at full throttle.
- (3) Coach accelerating at full throttle at or below 35 mph and just prior to transmission upshift.

Airborne noise generated by the coach will be measured on both sides of the coach at points 50 feet from the perpendicular to centerline of the coach with all accessories operating. Instrumentation, test sites, and other general requirements will be in accordance with SAE Standard J366. The curb idle test will be conducted with the microphone located longitudinally in line with the rear bumper. The pull-away test will begin with the microphone located longitudinally in line with the front bumper.

The following criteria will be applied in evaluating the results of the above tests.

- (1) For Condition 1, the coach generated noise at high idle shall not exceed 65 dBA.
- (2) For Condition 2, the coach generated noise shall not exceed 83 dBA.
- (3) For Condition 3, the coach generated noise shall not exceed 83 dBA.

If the noise contains an audible discrete frequency, a penalty of 5 dBA will be added to the sound level measured.

## REVENUE TEST PLANS

Revenue tests would be performed by the transit authority during operation of the first ten production buses in revenue service for one year. During that period the failure of identical items covered by the warranty will be considered a fleet defect and treated as such by the manufacturer. The normal wear of components in keeping with current operations and practices of the industry should not be considered fleet defects. Each of the following tests will be documented during the one year of revenue service:

- Structural Durability Test
- Service Reliability Test
- Equipment Reliability, Maintainability, and Life Test.

These tests are described on the following pages.

### Structural Durability Test

The objective of this test is to identify and record any structural deterioration (i.e., deformation, cracks, and/or excessive corrosion) for a First Article Test Bus in revenue service.

Once monthly, the coach shall be washed and its entire underside, including all structural members, shall be steam cleaned. All structural members shall be inspected visually for damage, cracks, permanent deformation, and/or excessive corrosion. The entire outside and inside surfaces of the body, doors, windows, and openings shall be inspected for signs of structural deterioration. At each inspection, bus mileage shall be recorded along with any structural defects or deterioration identified.

The following criteria will be applied in evaluating the results of the above tests:

- (1) No visible structural damage, cracks, or permanent deformation shall be observed.
- (2) No measurable reduction\* in part thickness shall result from corrosion.

In addition to the above revenue testing of a First Article Test Bus, the bus Supplier may also provide structural durability-related experience and information obtained during both nonrevenue and revenue testing of the prototype bus(es) and any revenue testing/operation of the First Article Test Bus conducted outside of the U.S.

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\* Within the normal measuring tolerances of micrometers, calipers, and/or depth gages (0.001 inch).

### Service Reliability Test

The objective of this test is to record mean mileage between vehicle-design-related service failures for a First Article Test Bus in revenue service.

Both the type of failures and the accumulated bus mileage at the time of each service failure\* will be recorded. The total accumulated mileage at the time of the last failure of a given type, divided by the number of failures of that type up until that time, gives the mean mileage between failures for that specific type of failure. In addition to overall or total bus reliability, the mean mileage between failures for selected subsystems and types of failures will also be determined.

Service failures will be broken down into three types. Those are:

Type 1 - Road Call. A vehicle-design-related failure resulting in an enroute interruption of revenue service. Service is discontinued until the coach is replaced or repaired at the point of failure.

Type 2 - Coach Change. A vehicle-design-related failure that requires removal of the coach from service during its assignments. The coach is operable to a rendezvous point with a replacement coach.

Type 3 - Bad Order. A vehicle-design-related failure that does not require removal of the coach from service during its assignments but does degrade coach operation.

Within each type, failures will be further classified by the specific subsystem or component that failed, e.g., engine, transmission, air conditioning. Subtotals will be developed for each type of failure and for each subsystem or component regardless of type of failure.

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\* All vehicle-design-related failures resulting in an interruption of revenue service or a degradation of coach operation are to be reported. This includes both component and adjustment failures.

The following criteria will be applied in evaluating the results of the service reliability tests, provided that all specified preventative maintenance procedures are followed.

SERVICE RELIABILITY CRITERIA

Service Failure Type	Criterion, Mean Mileage Between Failures Shall be Greater Than
Type 1 - Road Call	20,000
Type 2 - Coach Change	16,000
Type 3 - Bad Order	10,000

Also, mean mileage between failures for specific subsystems or components shall be equivalent to or greater than for the comparable subsystem or component on current heavy-duty transit buses.

In addition to the above revenue testing of a First Article Test Bus, the bus Supplier may also provide mean mileage between failures data obtained during both nonrevenue and revenue testing of the prototype bus(es) and of any revenue testing/operation of the First Article Test Bus conducted outside of the U.S.

### Equipment Reliability, Maintainability, and Life Test

The objective of this test is to record the frequency, maintenance personnel man-hours, and replacement parts required for both scheduled and unscheduled maintenance and servicing actions\* for a First Article Test Bus in revenue service.

The total accumulated bus mileage at the time of each scheduled or unscheduled maintenance or servicing action along with a description of the action taken, the number of maintenance personnel man-hours required to complete the action and the replacement parts required will be recorded. From this recorded data, the mean frequency, in terms of bus mileage, and the mean number of maintenance personnel man-hours per action will be determined for specific types of maintenance and servicing actions important to the transit authority. Also, mean component life will be determined from part replacement actions. In this latter respect, special emphasis will be placed on "new components".\*\*

Maintenance personnel will be classified into five skill levels and the maintenance man-hours required for each maintenance or servicing action will be reported in terms of the specific skill levels required. The five skill levels are:

- 1M: Cleaner, Fueler, Oiler, Hostler, or Shifter
- 2M: Mechanic Helper or Coach Serviceman
- 3M: Service Mechanic or Class B Serviceman
- 4M: Journeyman or Class A Mechanic
- 5M: Specialist Mechanic or Class A Mechanic Leader.

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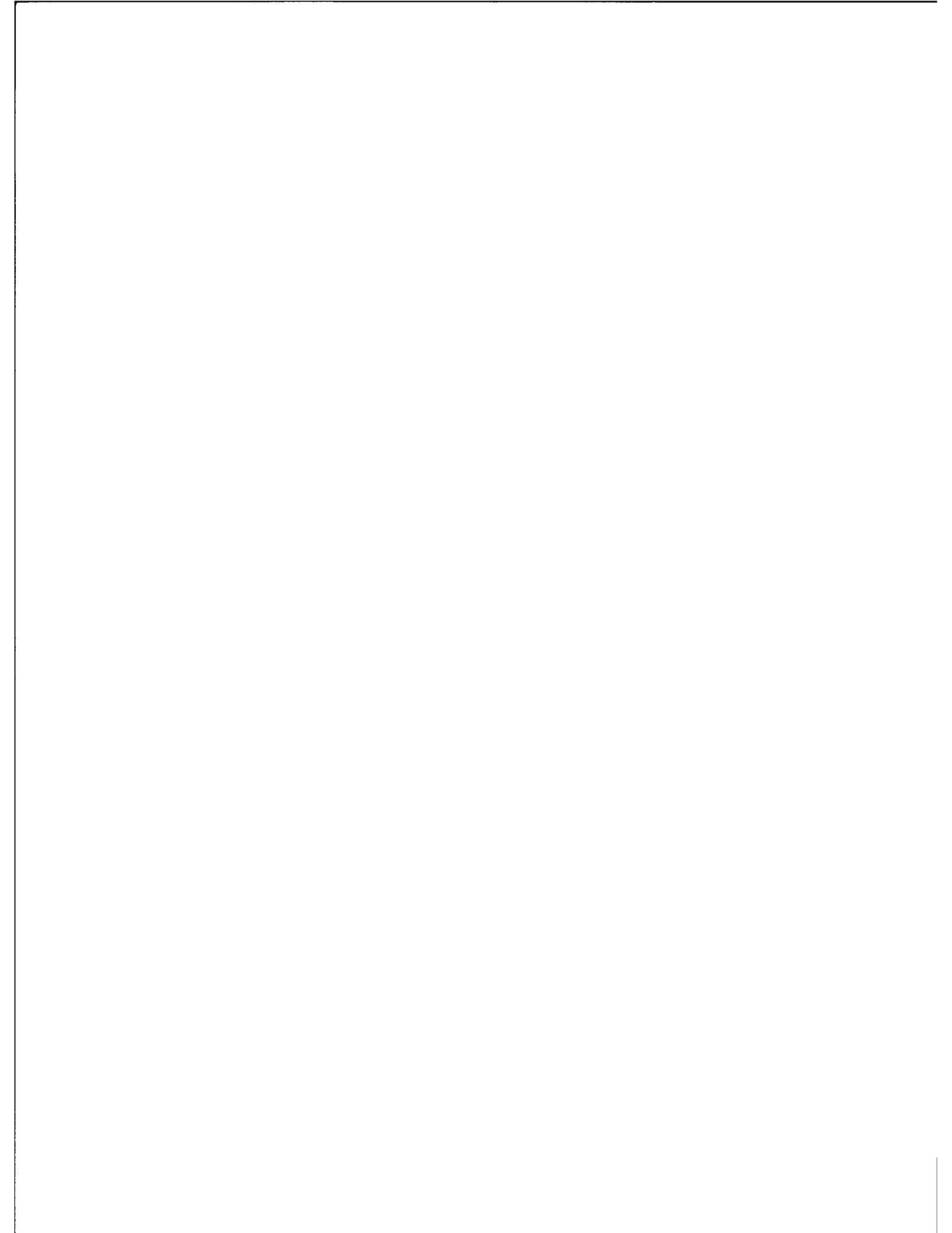
\* All maintenance and servicing actions are included, including fueling, lubricating and other servicing actions.

\*\* "New components" are major components that previously have not been in general use on heavy-duty transit buses in the U.S.

The following criteria will be applied in evaluating the results of the above tests:

- (1) The total composite frequency of bus maintenance and servicing actions and the total maintenance personnel man-hours required to maintain service on a bus over the test period shall be equivalent to or less than for current heavy-duty transit buses on the purchaser's property.
- (2) The mean mileage between replacement for specific "new components" shall be equivalent to or greater than for the comparable component on current heavy-duty transit buses.

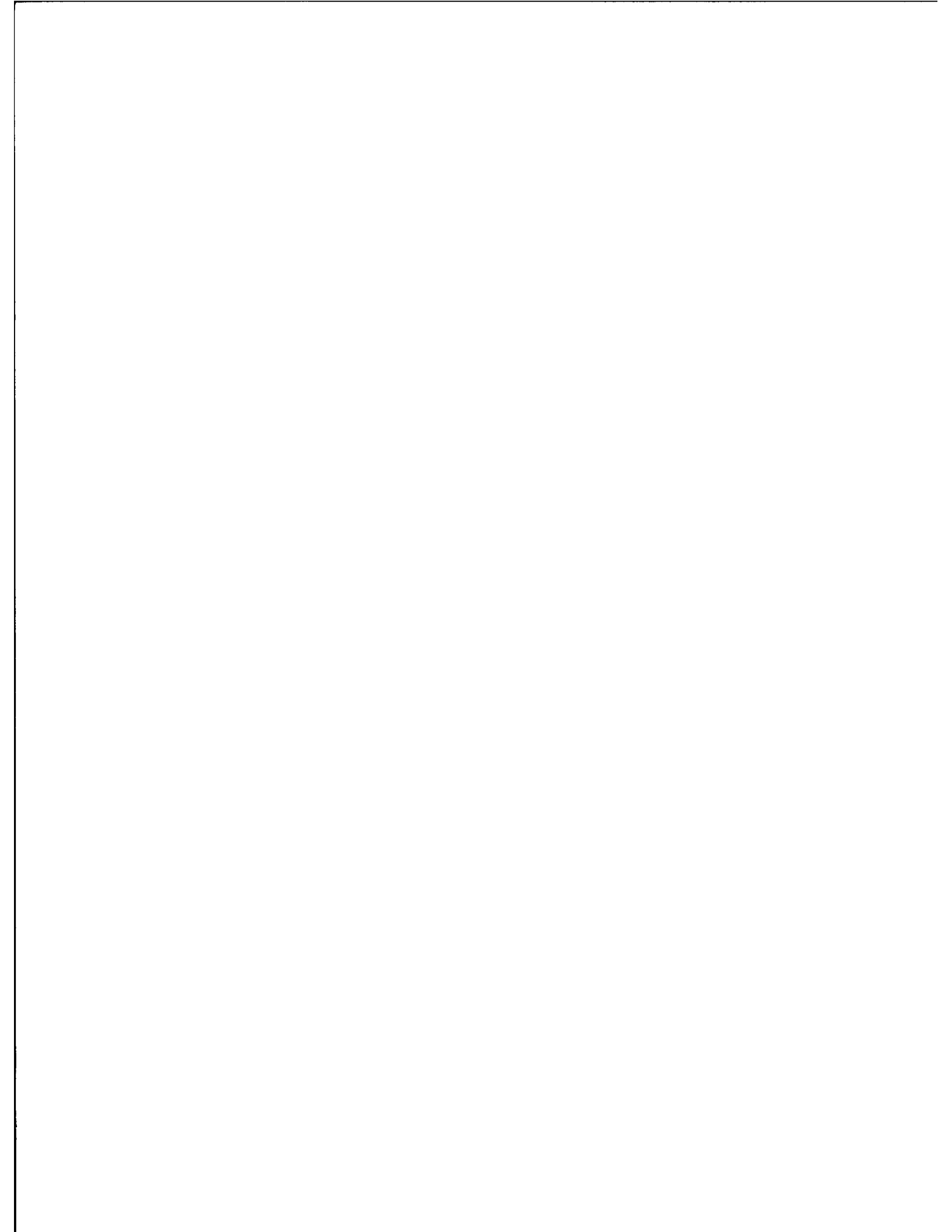
In addition to the above revenue testing of a First Article Test Bus, the bus Supplier may also provide equipment reliability, maintainability, and life data obtained during both nonrevenue and revenue testing of the prototype bus(es) and any revenue testing/operation of the First Article Test Bus conducted outside of the U.S.





APPENDIX B

DESCRIPTION OF BATTELLE'S TASK ON FIRST  
ARTICLE BUS TESTING PROCEDURES



## APPENDIX B

### DESCRIPTION OF BATTELLE'S TASK ON FIRST ARTICLE BUS TESTING PROCEDURES\*

#### PURPOSE

To establish test requirements for inclusion in procurement packages for First Article Buses and to prepare and disseminate First Article test plans to be used by manufacturers and operators in nonrevenue and revenue tests.

#### EXPECTED RESULTS

Two results are expected. The first result will be a definition of a First Article Bus. Presently, we are using the following definitions:

Preproduction. A first full-scale and functional form of a new type or design of bus or bus component manufactured for testing purposes.

Production Bus. A bus manufactured in quantity and sold for profit-making purposes.

First Article Bus. One of a limited number of the first production of:

- (a) A New Bus; i.e., one which has not been used in transit service in the United States. For example, the ADBs when first produced were New Buses.

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\* This appendix was distributed to the eight interviewees for review before our meetings and was the basis for structured discussion.

- (b) A Modified Bus; i.e., one which has been used in transit service in the United States, but is now being produced with a distinctly different component or components. For example, the incorporation of a new transmission is a distinctly different component. As a guideline, distinctly different components are those which have a significant impact on bus performance, reliability, maintainability, structural integrity, or life of the vehicle.

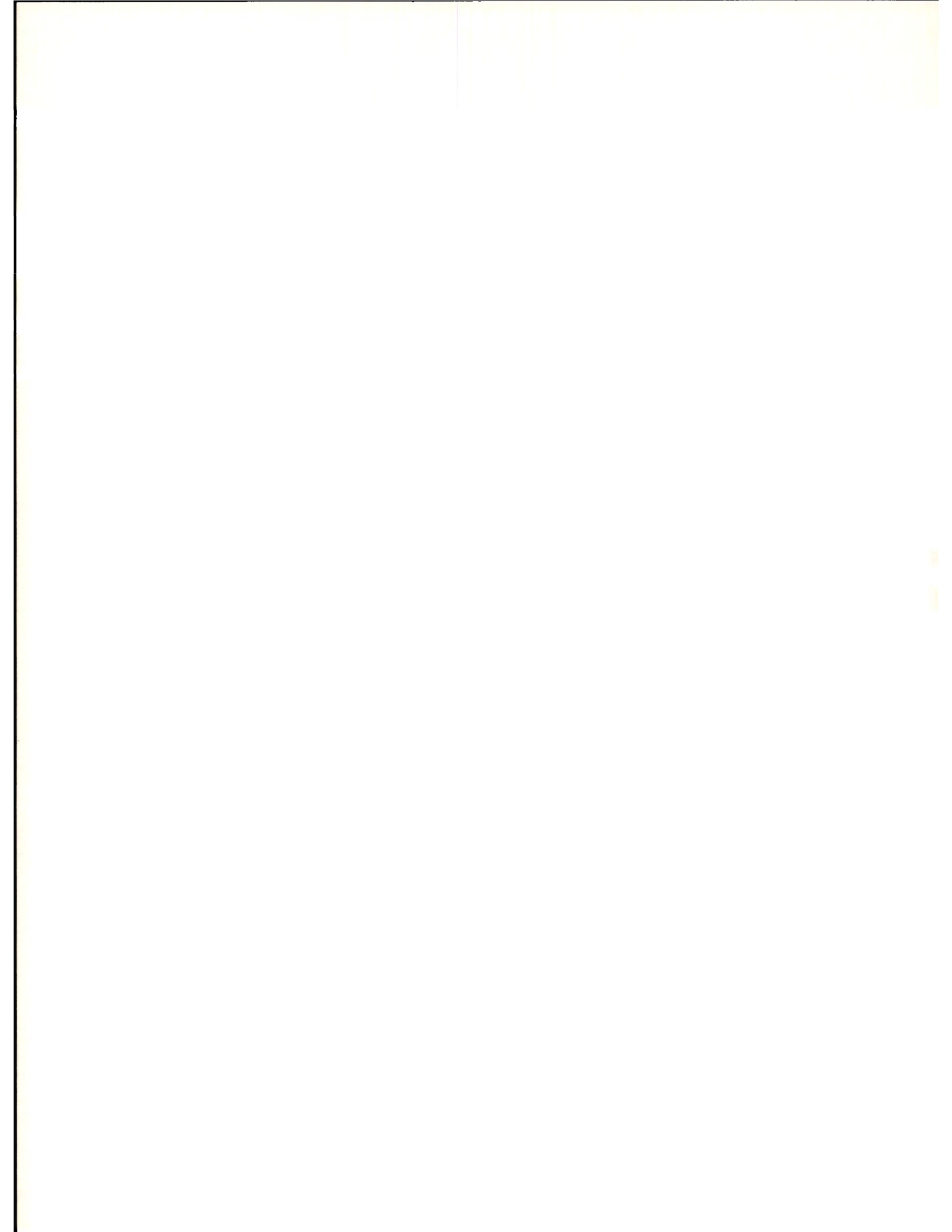
The second result will be draft plans for nonrevenue and revenue First Article Bus testing. These plans will be published and disseminated to the transit community as APTA documents.

#### APPROACH

- (1) Review new product testing practices of automobile and truck manufacturers.
- (2) Interview three bus manufacturers and three transit properties to discuss present tests being performed on preproduction, production, and First Article Buses. The questions we are trying to answer include:
  - (a) What is the appropriate definition of a First Article Bus?
  - (b) What are the major concerns when one produces or procures a production bus?
  - (c) What are the major concerns when one produces or procures a First Article Bus?
  - (d) What are the five most important tests that should be performed on a First Article Bus?
  - (e) Who should perform these tests--the supplier, the procuring property, or an outside, independent test organization?
  - (f) What confidence levels are desired in these tests; i.e., how many buses should be tested?
  - (g) Considering that, on the one hand, lengthy tests increase the confidence in the results, while on the other hand, lengthy tests cost more and keep the bus from productive revenue service, how long should these tests be conducted?
  - (h) Should destructive tests be performed on First Article Buses?
  - (i) What should be done if a First Article Bus fails a test?

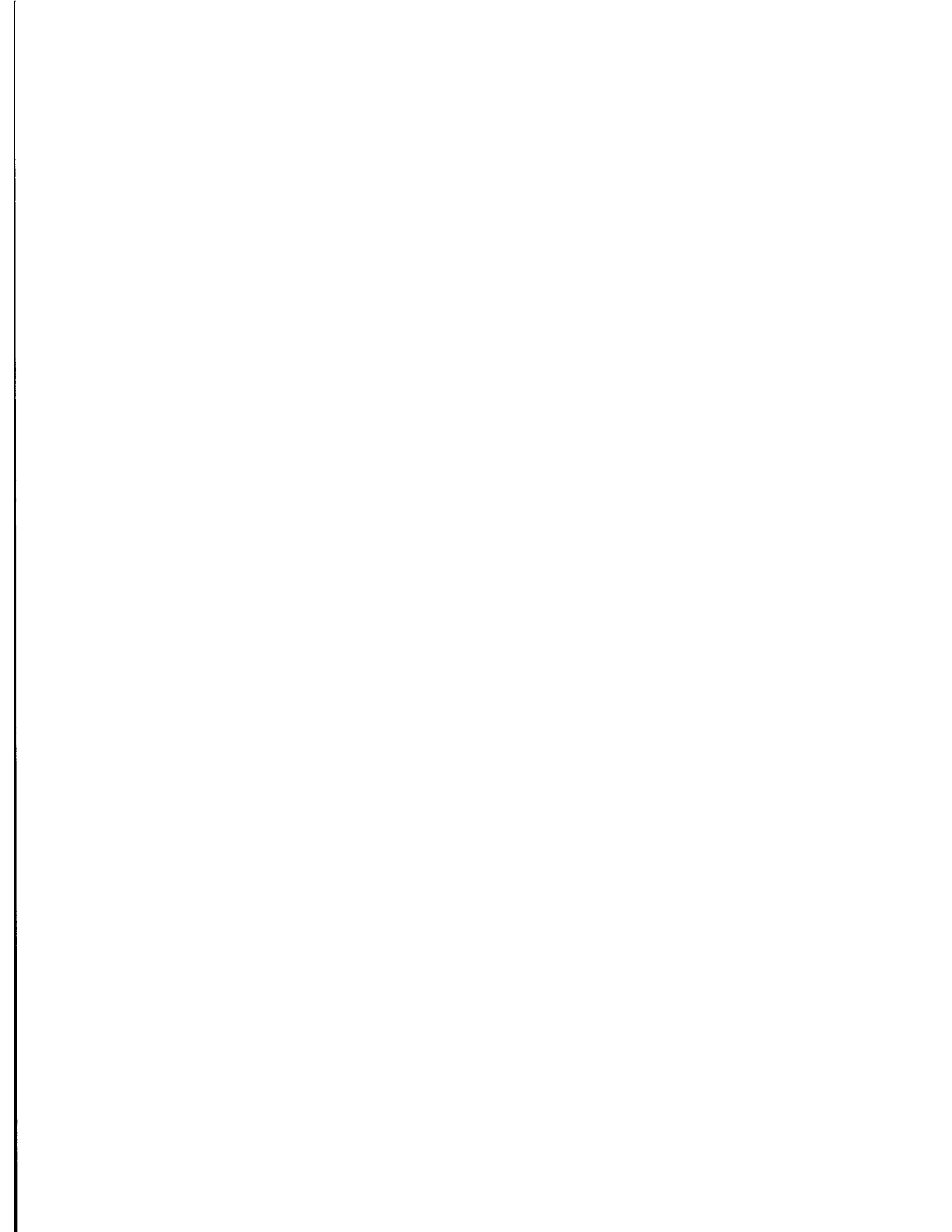
- (j) What roles should UMTA, the supplier and procuring property take in First Article Bus Testing?
  - (k) Some bus specifications state the required life "under normal operating conditions". What is meant by "normal operating conditions"?
  - (l) What test or tests best predict the reliability, durability, structural integrity or life of a First Article Bus?
  - (m) How might we do a better job?
- (3) Prepare initial draft of plans
- Survey results will be used to develop the initial draft of the prerevenue and revenue test plans. This draft plan will contain for each test selected:
- Test objective
  - Description of test
  - Description of test equipment and facility required
  - Test data to be collected
  - Any special prerequisites/conditions.
- (4) Obtain comments on draft test plans from the six manufacturers and transit properties originally interviewed.
- (5) Revise draft test plan and review in a workshop with APTA/Transit Industry.
- (6) Prepare final draft and submit it to UMTA.

BATTELLE  
Columbus Laboratories  
May 12, 1982



APPENDIX C

COMMENTS BY INTERVIEWEES





## APPENDIX C

### COMMENTS BY INTERVIEWEES

The listed questions are from Approach, Item (2), of Appendix B.

(a) What is the appropriate definition of a First Article Bus?

As a starting point, the following draft definitions were presented:

Preproduction. A first full-scale and functional form of a new type or design of bus or bus component manufactured for testing purposes.

Production Bus. A bus manufactured in quantity and sold for profit-making purposes.

First Article Bus. One of a limited number of the first production of:

- (1) A New Bus; i.e., one which has not been used in transit service in the United States. For example, the Advanced Design Buses (ADB) when first produced were New Buses.
- (2) A Modified Bus; i.e., one which has been used in transit service in the United States, but is now being produced with a distinctly different component or components. For example, the incorporation of a new transmission is a distinctly different component. As a guideline, distinctly different components are those which have a significant impact on bus performance, reliability, maintainability, structural integrity, or life of the vehicle.

For the most part, all transit manufacturers and operators concurred with the draft definitions. However, concern was expressed over the term "significant impact" in the definition of First Article Bus. For example, some persons interviewed believed that a new air conditioning unit did not constitute a significant impact; others did. Overall, however, it appeared that such a change was considered significant.

Some interviewees suggested that any change in weight distribution or an item critical to continued operations constituted significant impact.

One transit operator believed that significant components, not component, should be stressed in the definition.

(b) What are the major concerns when one produces or procures a production bus?

Many concerns were expressed and they are listed below.

- Maintainability/serviceability
- Reliability
- Ability to meet procurement specifications
- Ability to meet manufacturer process requirements
- Safety
- Ability to meet Government standards
- Ability to meet internal (manufacturer) requirements
- Performance
- Durability
- Fixes for known faults
- Maintenance costs
- Structural integrity/life
- Fuel economy
- Ability to pass property quality control checks
- Parts availability and standardization
- Availability of training
- Sameness with earlier buses
- Life cycle cost
- Compliance with design.

Of the above concerns, maintainability/serviceability was noted most often.

Reliability was noted second most often.

Many of the above concerns were shared by both transit operators and manufacturers. Maintainability/serviceability appeared to be an equal concern for both parties. Reliability was a concern predominately of transit operators. Fuel economy was a concern of transit operators, but less important to manufacturers.

(c) What are the major concerns when one produces or procures a First Article Bus?

Most interviewees stated they had the same concerns for both a First Article Bus and a production bus. (See the answers to Question (b) for a complete list of concerns.)

However, some interviewees stated different or additional concerns as follows:

- Producibility
- Weight
- Return on investment
- Warranty features
- Design of critical components
- Driver acceptability
- Passenger comfort.

Again, the major concern, shared by both transit manufacturers and operators, was maintainability/serviceability.

(d) What are the five most important tests that should be performed on a First Article Bus?

Many different subjects were identified as important. They were:

- Engine cooling
- Handling
- Performance
- Noise
- Air conditioning and heating
- Reliability
- Operations and maintenance costs
- Passenger comfort
- Driver acceptance
- Safety
- Durability
- Maintainability/serviceability
- Fuel economy
- Brake life

- Tire life
- Structure
- Ground clearance
- Water test
- Environmental test.

Of the above subjects, performance was noted most often. Structure was next.

- (e) Who should perform these tests--the supplier, the procuring property, or an outside, independent test organization?

All but one interviewee believed that the supplier should perform the tests; one transit property believed an independent test organization mutually selected by the procuring agency and the manufacturer should perform the test.

Several reasons were given for having the supplier perform the test. One interviewee stated that the supplier is the only firm with the necessary background material, test facility and capability to perform the work. Another interviewee stated that properties would "nit-pick the test to death". Concern was also expressed that an independent organization might not be able to maintain the necessary confidentiality.

Some interviewees stated that, although the test could be monitored by the transit authority, the transit authority should accept no responsibility for the test conduct or results.

One interviewee suggested that a supplier should perform the test under a certification process. This process would be basically the same as the FAA certification process for airplanes. The test data would be kept confidential to the supplier. Either minimum standards would be used to judge acceptability or the certification procedures would be used to substantiate the manufacturer's claim, but not the result of the testing.

- (f) What confidence levels are desired in these tests; i.e., how many buses should be tested?

Most interviewees said that only one bus need be tested. Some interviewees suggested that the minor tests (e.g., water spray) should be performed on all buses.

One interviewee believed that the quantity should be selected by the supplier since he is the individual responsible for all testing. Another interviewee suggested that the quantity to be tested is a function of the test planned. A third interviewee suggested that one bus could be tested for maintainability and the configuration of the remainder checked for "sameness".

(g) Considering that, on the one hand, lengthy tests increase the confidence in the results, while on the other hand, lengthy tests cost more and keep the bus from productive revenue service, how long should these tests be conducted?

The answers here range from one extreme to another as follows:

- 500 miles
- 2 to 3 months/10,000 to 15,000 miles
- 4 to 5 months
- 1 year/40,000 miles
- 100,000 miles.

Concern was expressed by some interviewees that extensive testing places an unnecessary burden on the supplier and would significantly impact his profitability. In addition, some interviewees believe that accelerated tests could not duplicate actual in-service operating conditions.

(h) Should destructive tests be performed on First Article Buses?

Most interviewees believe that destructive tests of a complete First Article Bus were not necessary; any required destructive tests should have been performed on preproduction prototypes. One interviewee believed that the manufacturer should be responsible for selecting First Article Bus tests. Whether or not destructive tests should be performed would be a decision for the manufacturer. This same interviewee believed that the best test of a First Article Bus would be two years of in-service use.

(i) What should be done if a First Article Bus fails a test?

All but one interviewee believed that the appropriate modification should be made and the necessary retesting performed. The one exception believed that retesting was not necessary.

In the case of performance tests (e.g., acceleration) a complete retest would be appropriate according to one interviewee. In the case of structural tests, the test should not be restarted. Further, if the modification has safety impact, the manufacturer should pay for the modification. However, if there is no safety impact, payment for the modification should be negotiated between the transit manufacturer and operator.

Another interviewee believed that the required action depends on the type of failure and the transit authority's need for the bus. Minor repairs should be made by the transit authority, but if the bus is unsafe or fails to run under revenue conditions, the manufacturer must perform the necessary repairs.

(j) What roles should UMTA, the supplier and procuring property take in First Article Bus Testing?

Most interviewees believed that the supplier should be responsible for testing. Transit operators should monitor the test only.

UMTA should provide funding for the test and act as a clearinghouse for test results. No specific role was defined for APTA.

(k) Some bus specifications state the required life "under normal operating conditions". What is meant by "normal operating conditions"?

There was a consensus among interviewees that the term "normal operating conditions" means "local operating conditions". However, transit manufacturers do not apparently design a unique bus for each transit property. Rather, they have designed a bus which will operate at transit properties throughout the United States.

Some additional transit operators are planning to define their local operating conditions in their procurement specifications. These conditions include curb height, environmental parameters, crush loads, and so forth.



(1) What test or tests best predict the reliability, durability, structural integrity of life of a First Article Bus?

Several different answers were received to this question. They were as follows:

- Shake-table tests
- Revenue operations for 1 year
- A series of tests—analytical, laboratory, proving ground
- Test track
- Revenue operation for 1 year at 4 transit properties
- Revenue operation for 2 years.

The most popular idea was revenue service. However, no consensus was obtained on the length of the test.

One interviewee stated that test track durability schedules or shake tests provide good results but that shake tests do not give any information about rotating component performance. This interviewee also believed that analysis is best used in conjunction with prototype tests while First Article testing is for verification purposes only.

Another interviewee preferred the shake table approach over proving ground tests because the test conditions can be more closely controlled and the test can be conducted in less time.

One interviewee believed that having a bus for 2 weeks or a month before continuation of production was not useful. They stated that this was an insufficient amount of time to learn anything meaningful about the bus.

(m) How might we do a better job?

Several different answers were received to this question on how Battelle could produce the best possible test plan. No consensus was apparent.

One interviewee suggested that we visit more transit properties. Another interviewee suggested that we identify the major problems from the transit operator's viewpoint.

It was also suggested that steps be taken to make the bus a simple system and to clarify the requirements in procurement specifications. One interviewee suggested anything we could do to keep the bus manufacturing business evolutionary, not revolutionary.