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INSTITUTE FOR RAPID TRANSIT  
RECOMMENDATIONS FOR A NATIONAL RAPID TRANSIT  
RESEARCH AND DEVELOPMENT PROGRAM

EXHIBIT SCHEDULE

- Exhibit A - General Description of Program
- Exhibit B - Project Area
- Exhibit C - Work Program
- Exhibit D - Data Collection, Analysis  
and Reports

Institute for Rapid Transit  
1612 K Street, N. W.  
Washington, D. C. 20006

June 20, 1969

EXHIBIT A

GENERAL DESCRIPTION OF PROGRAM

	Page
I Project Objectives	1
II Summary of Project Facilities	2
III Implementation of Project	3
IV General Applicability	4
V Applicant Agency and Principal Staff	5

## NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

### I. PROJECT OBJECTIVES

The object of this project is to establish a permanent rapid transit development and research center. The term "rapid transit" is used here in its broadest meaning, i.e., any form of passenger carrying vehicle operating over its own private right of way. It is not to be limited to the traditional concept of "steel wheel on steel rail."

Because of the growing realization that the development of good rapid transit is closely associated with the improving health of our great metropolitan centers and the continued growth of the smaller areas of population concentration, it is imperative that rapid transit be made as attractive, pleasant and efficient as possible.

In order to insure that rapid transit fills the role cast for it in the rapid growth of urban centers throughout the country, continuing research and development in this field is mandatory. This can best be carried out by the establishment of a permanent rapid transit development and research center. The program of such a center would be twofold. There are many areas where significant improvements can be made in the comfort, reliability and speed of existing properties. There are also many areas where modernization of existing facilities need careful overall study and guidance that can best be handled by an industry-wide research and development center. In addition to serving existing operating rapid transit systems, the program of the center would include evaluation and possibly large scale testing of future rapid transit system concepts which presently exist only on the drafting board or in the earliest development stage. Such studies could accelerate the practical application of some of these emerging concepts for the benefit of the industry in general and the metropolitan population in particular.

In addition to research and development of rapid transit systems and hardware, the program would include the broader areas of planning and marketing rapid transit as it affects the community at large. Rapid transit is a powerful tool for aiding urban planning and, in this way, it could be better integrated at the national level into overall urban development plans.

The activities of the research and development program for rapid transit would include the following but not necessarily be limited thereto:

1. Development of test procedures and performance standards.
2. Proving ground testing, including public trials for test of public reaction.
3. Monitoring of work of contractors and grantees under the jurisdiction of the research center.

4. Control of research projects undertaken by other operating properties or manufacturers at locations as approved by the center other than the site of the research center.
5. Modification, improving or repairing of test vehicles, systems, sub-systems, components.
6. Bench testing, monitoring of test operations; acquisition of performance data.
7. Documentation and analysis of test results and progress of projects undertaken by the research center.
8. Information and data processing, acquisition processing, storage, display abstracting, summarizing, translation, illustration, printing, etc.
9. Computation, manipulation and simulation of data.
10. Receipt, storage, distribution of reference works and special publications.
11. Group consultation and conference.
12. Necessary engineering study and design.

## II. SUMMARY OF PROJECT FACILITIES

It is proposed to acquire an adequate site adjacent to an operating rapid transit system. On this site would be erected an appropriate building to include the following research and development activities:

- A. An area to house, inspect, modify and service one rapid transit laboratory-type car.
- B. A shop equipped with small power tools, drill press, lathe, saw, grinder, etc., to support the inspection and servicing center.
- C. A small laboratory to be equipped with specialized laboratory facilities of the type not readily available elsewhere in the area.
- D. A connecting track to the test track and/or operating rapid transit system.
- E. Telemetering computer and photographic facilities to support various test activities.
- F. The required administrative office space.

- G. A research library.
- H. A small auditorium.
- I. A conference room.

### III. IMPLEMENTATION OF THE PROJECT

The location adjacent to an operating rapid transit system is considered essential to the research and development center. It will make possible the ready acquisition of passenger reactions to specific changes. It will make possible the handling of heavy car modifications that could not be handled in the laboratory center. It will provide either trackage or right of way for the operation of the test car or cars. A single test track of not less than five miles in length will be necessary to support the research and development center. By locating the center adjacent to an operating property, it would be possible to use either an unused section of track or an unused portion of the right of way in order to provide five miles of test track. Using an existing right of way would save literally millions of dollars in right of way acquisition, plus the time necessary to acquire a new right of way.

The management of the national rapid transit research and development center would be carried out under the auspices of the Institute for Rapid Transit. The Institute for Rapid Transit would be responsible for acquiring an appropriate technical and administrative staff to handle the actual research and development projects. The Institute for Rapid Transit would be responsible for appointing an advisory committee to assist the research and development center and an executive board to review, approve and authorize all testing projects and operating budgets of the research and development center.

The research and development testing program would include actual test track operation either in the course of updating existing operating properties or assisting in the development of emerging concepts on new properties. Much of this work can be handled at the research and development center laboratory.

The administrative staff of the research and development center will be authorized to assign to laboratories and test centers testing phases for which these existing centers are already well equipped.

The research and development center will be instructed to explore, research and develop marketing techniques tending to increase the utilization of rapid transit throughout the country.

The research and development center will be in a position to cooperate on national or local levels in those urban planning activities where the rapid transit point of view can furnish a significant contribution to the overall activity.

It is estimated that 18 months will elapse after the approval of the application before the research and development center will be available for use. Work, however, on many phases of this project can begin immediately after its approval. The actual site acquisition work can begin. The work of designing and constructing the building on the site can be started. The design and construction of the test track and its connection to the research and development center can proceed at once. In addition to this, certain phases of the actual research and development program can be started -- data acquisition work from operating properties; cataloging of information reports, etc., on past activities can be started; detailed planning work for projects to be handled by the center can proceed; a program for employing the center's administrative and operations staff can be drawn up.

Cost

The following is an estimate of the cost of the research and development center facilities:

Site	\$	500,000
Building		700,000
Shop tools		500,000
Laboratory equipment		1,500,000
Test track & shop connection		6,800,000
Total	\$	<u>10,000,000</u>

This application presumes that the rapid transit research and development center is to be a permanent establishment. Events of the future beyond our ability to accurately predict at this time will influence the work of the center to a very large degree. If it becomes the role of the center to assist actively in the final development of any emerging concepts for rapid transit, then the tempo of the center's activities could increase substantially. This application, however, takes a conservative look at specific work areas for the first five years after the center is operative. The estimated cost of this five-year program is \$10 million. The details of the program and an estimated cost for each item therein is set forth in Exhibit "C" of this application.

IV. GENERAL APPLICABILITY

For many years the industry, through the usual process of periodic countrywide meetings, focused attention on its most pressing problems. However, the means of attacking these and many other problems and development areas has never been made available.

The success of the San Francisco Bay Area Rapid Transit demonstration grant and accompanying test track with the several significant research and development programs, brief as it is, has

encouraged the industry to realize that a national research and development center available to all segments of the industry -- operators, suppliers, engineers, designers, etc., -- can greatly improve rapid transit and in this way make it an increasingly effective and attractive adjunct to urban living.

The output of an industry-sponsored center of this sort would provide very specific recommendations in any assigned areas. Vehicles, train control, fare collection, propulsion, route location, aerial or subway structure design, station design and other kindred subjects all could be significantly improved. Reports and studies covering subjects of this sort would be made available to any and all interested in updating existing rapid transit systems or designing the future rapid transit concepts, many of which are in an advanced planning stage at this moment.

#### V. APPLICANT AGENCY AND PRINCIPAL STAFF

The Institute for Rapid Transit was established in 1961 as a not-for-profit corporation under the laws of the State of Illinois. Its charter reads in part, as follows:

"To carry on, encourage, foster, develop, coordinate, promote and publicize research and progress in all aspects of rapid transit, being mass public passenger transportation on private right-of-way (but not to act as a common carrier or otherwise engage in the business of carrying passengers or property)."

The headquarters and permanent staff of the Institute for Rapid Transit are located in Washington, D. C. at 1612 K Street, N.W. 20006. It is governed by a board of directors, selected from among rapid transit operators on the North American Continent, either in operation, construction, and/or planning phases. The Institute is supported entirely by dues levied against the operators, manufacturers, consulting engineers, and other organizations who comprise the membership of the Institute. Every rapid transit city on the North American Continent, as well as many cities in the advanced planning and/or construction phases, are members of IRT. The total income of the Institute for Rapid Transit for the fiscal year ending June 30, 1969 is estimated to be \$123,650.

EXHIBIT B

PROJECT AREA

	<u>Page</u>
I. Area Characteristics	1
II. Administration and Staff	1

## NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

### I. AREA CHARACTERISTICS

For reasons stated previously, it is recommended that the research and development center be located adjacent to an operating rapid transit system which could provide either trackage or rights of way for test track purposes. Such facilities are available in both New York and Chicago.

New York has several miles of double track which are no longer used in revenue service. This trackage could be upgraded and made available for test track operation. The trackage is located close to the Coney Island shops upon which the Research & Development Center could be constructed.

Chicago has several miles of track which would be available for test track operation approximately 20 hours per day. In addition, rights of way are available on both its Skokie Swift and Evanston routes which would permit the construction of a new test track facility. Land is also available for the construction of a Research & Development Center. Chicago is favored for these reasons: (1) It is centrally located, (2) The Research Center of the Association of American Railroads is located there and (3) Many universities, such as Northwestern, Illinois Institute of Technology, University of Illinois, Purdue, etc., interested in urban transportation problems are located in the area.

### II. ADMINISTRATION AND STAFF

A research and development center, capable of carrying on work of the scope and magnitude delineated -n Exhibit "C", needs extensive, competent staffing. In fact, it is quite obvious that the measure of success of such a venture as this, particularly in the research area itself, is largely proportional to the excellence of the staff recruited for the various tasks.

As a first step, the Institute for Rapid Transit would appoint from its membership a Governing Board not to exceed three to five men to govern the rapid transit research and development center. The first task of the Governing Board would be to complete contract negotiations with the United States Department of Transportation regarding the acquisition, construction and management of the center. The Governing Board would be a continuing policy-making body authorized to control the broad activities of the center.

An advisory committee on rapid transit research and development would be appointed early by the Governing Board. This committee would advise the Governing Board during contract negotiating

stages. Later, when the center is operative, the committee would advise the Governing Board on management and operation of the center, including the conduct of research and development projects. The advisory committee should be a reasonably large group composed of operators, manufacturers and engineers.

### Staff

As the construction of the research and development center progresses and approaches the operational stage, the following key positions should be filled:

- A. General Counsel.
- B. Executive Director.
- C. General Manager for Plant and Equipment.
- D. General Auditor.
- E. Librarian.
- F. Director of Technical Activities.
- G. Assistant Director of Technical Activities for Current Technological Research and Development.
- H. Assistant Director of Technical Activities for Future Technological Research and Development.
- I. Director of Data Processing.
- J. Director for Community Aspects.

The responsibilities of these key people will in some instance be constantly changing and, therefore, the supporting staff for each activity needs further study. The General Manager for Plant and Equipment, for example, who will be in charge of the construction phase of the center, will have greatly reduced responsibilities during the maintenance and operation phase. On the other hand, it might be possible to effect some combination of responsibilities among the 11 key personnel listed above. Decisions of this sort must, in the last analysis, be left for the purview of the Governing Board and the Executive Director.

EXHIBIT C

WORK PROGRAM

	<u>Page</u>
Statement of Immediate Needs	1
Research Projects - Traditional Form of Rapid Transit	3
Research Projects - New Concepts	28
Work to be Done Before Center is Completed	34
Cost of Phases	35

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

STATEMENT OF IMMEDIATE NEEDS

From the standpoint of the immediate needs of the rapid transit industry, major research and development effort in many, many specific problem areas is essential. The scope and depth of the research effort required to find answers to the difficulties that plague the industry and make the existing and immediate future service less attractive, efficient and competitive is and has been for many years beyond the capability of the industry.

Transit industry and operational problems are manifold and the list of subjects which require study, evaluation and determination is almost overwhelming in sheer magnitude. There has been and is a continuing fragmented approach to these problems by the manufacturers, operators and designers of new extensions and new systems. However, the need for answers is so urgent that most of the research work now in progress is in response to specific emergency situations and it has not been possible to develop and organize a programmed approach towards requisite goals and coordinated industry, operator and designer efforts in this direction.

The conventional steel wheel on steel rail system is for the near future a fundamental ingredient of rapid transit. The vast assets in land, facilities and personnel utilized to operate the rail systems in Boston, New York, Philadelphia, Cleveland, Chicago and soon in San Francisco, and the need for technological improvements to the systems indicates that serious, substantial, determined research and development programs are required. Further new systems, now in the planning stage, must be backed up by sound technological information, data, and tested capability so that investments in the new plant and system is not rendered obsolete before construction is completed.

A programmed approach to the need for research, keeping in mind the timed objectives of meeting the immediate and short range future requirements of existing and proposed rail systems, leads to the conclusion that the work subdivides into three major classifications:

- a) Operations
- b) Rolling Stock Improvements
- c) Environment

The more important individual projects requiring research and development in these broad categories are evaluated on subsequent pages by describing them in the following form:

Project No.  
Title  
Objectives  
Justification of Need

Scope and Approach

Anticipated Results and Benefits

Estimated Costs and Completion Time

Careful and detailed study of the myriad numbers of topics requiring immediate research and development has evolved the nineteen projects listed as the most promising and most necessary.

The project entitled "Environmental and On-Vehicle Noise and Vibration" is perhaps the most important and the broadest in scope in that the technology of the track structure, the rail vehicle (body and truck) and the environment through which the transit line passes are all inextricably intertwined. Breakthrough research and development on this problem could result in rail transit system technology suitable to compete on even passenger comfort and neighborhood social terms with other forms of passenger transport.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

RESEARCH PROJECTS

TRADITIONAL FORM OF RAPID TRANSIT

	<u>Title</u>	<u>Estimated Cost</u>	<u>Years To Complete</u>
<u>OPERATIONS RESEARCH</u>			
67-1	Programmed Control of Operations	\$2,000,000	6
67-2	Fare Collection Systems	350,000	4
67-3	Origin and Destination Data	200,000	4
67-4	Modal Split Formulae	250,000	3
67-5	High Speed Mobile Maintenance Equipment	1,500,000	4
67-6	Automated Track Inspection	500,000	2
<u>ROLLING STOCK IMPROVEMENTS</u>			
67-7	Environmental and On-Vehicle Noise and Vibration	750,000	4
67-8	Harmonic Vibrations	300,000	2
67-9	Alternating Current Power Systems	250,000	2
67-10	Control System, Direct Current Powered Cars	475,000	3
67-11	Braking for Rapid Transit Cars	900,000	4
67-12	Standardization of Rapid Transit Car Components	50,000	10
<u>ENVIRONMENTAL RESEARCH</u>			
67-13	General Aesthetics of Rapid Transit Systems	250,000	2
67-14	Subway Ventilation	300,000	2
67-15	Transit System Standard Practice Manuals	450,000	3
67-16	Transit System Marketing	500,000	4
67-17	Analysis of Transit Agency Composition	25,000	1
67-18	Inventory of Existing Transit Research	50,000	1
67-19	Library	50,000	1
		<hr/> \$9,150,000	

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-1

Project Title: Programmed Control of Operations.

Objectives: Further advance the development and testing of equipment (train, roadway, yard, control center) to fully automate scheduled train operation.

Justification of Need:

Completely programmed operations can provide precise and exact adherence to schedules, reduce car requirements, and reduce operating costs (manpower and electrical power) and thereby provide improved service.

Scope and Approach:

Establish basic operating requirements, develop and test hardware now available and adapt to economically and operationally sound system of control. Operational control by programmed automation involves all phases of scheduled train operation and includes train movements in car storage yards.

Anticipated Results and Benefits:

Improved service at lower cost.

Estimated Cost and Completion Time:

Work will involve field evaluation of existing automated systems. Test track operation of new hardware on test cars.

Cost      \$2,000,000      6 Years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-2

Project Title: Fare Collection Systems.

Objectives: Improve present and develop new fare collection systems and engineer techniques for testing hardware and systems. Improved techniques and hardware should include systems which proportion the fare to the distance traveled and be collected at minimum operating cost.

Justification of Need:

Fare systems providing rates more in proportion to distance traveled are urgently needed in many areas to equitably distribute cost of operation. Techniques for testing and de-bugging new proposals to acceptable standards are needed before new systems can be utilized in changing fare collection on existing rapid transit. In addition, new hardware and remotely controlled fare collection is urgently needed to simplify and reduce operating costs of present fare collection systems.

Scope and Approach:

Inventory present and proposed fare collection systems and hardware on rapid transit. Develop testing techniques for laboratory controlled testing of new systems and hardware improvements for present systems. Investigate, develop and test alternate new systems. Investigate computer applications.

Anticipated Results and Benefits:

Improved service at lower cost.

Estimated Cost and Completion Time:

Work will involve laboratory and field testing of equipment and components.

Cost      \$350,000                      4 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-3

Project Title: Origin-Destination Data.

Objectives: Develop techniques for periodically collecting complete origin-destination data for all points of entry to rapid transit for all hours of day and days of week. Develop program for tabulating data in usable form for planning operations and schedules.

Justification of Need:

Data regarding origin-destination is not available and is essential to adequately planning and evaluating service and changes in services.

Scope and Approach:

Inventory present techniques and develop new extremely low cost means of collecting reliable data.

Anticipated Results and Benefits:

Improved scheduling, planning and operation.

Estimated Costs and Completion Time:

Work will involve analysis, computer programs, field testing and evaluation of new systems for collecting and tabulating data.

Cost \$200,000

4 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-4

Project Title: Development of diversion and modal split formulae as specifically applicable to rapid transit planning.

Objectives: To improve forecasting procedures in calculating rapid transit usage levels.

Justification of Need:

Increased accuracy in evaluating rapid transit patronage is vital in planning for the location and construction of new system facilities. Large capital investments in right of way, physical plant and rolling stock are dependent upon traffic projections made from modal split formulae. Accuracy and confidence in the traffic projections are essential.

Scope and Approach:

Parameters influencing rapid transit patronage must be identified and evaluated leading to the development of refined mathematical models for use in prognosticating rapid transit traffic. Existing diversion models must be tested, evaluated, and improved to enable accurate prediction of traffic.

Anticipated Results and Benefits:

Transportation planning procedures will be made more accurate and reliable.

Estimated Cost and Completion Time:

Work will involve mathematical techniques, computer programs, cost collection of field data and evaluation.

Cost        \$250,000                    3 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-6

Project Title: Automated Track Inspection.

Objectives: Develop rail borne equipment suitable for use on electric signalized railways for observing and recording track condition.

Justification of Need:

Automated techniques for measuring and recording alignment, profile, rail wear, condition of rail and joints are essential to refined and improved track maintenance. Equipment suitable to rapid transit clearance diagrams, rapid transit headways, and electrical and signal requirements is not available.

Scope and Approach:

Inventory present techniques (Sperry cars, sound rail flaw detector devices and others). Adapt same to rapid transit requirements and develop additional equipment as required.

Anticipated Results and Benefits:

Improved and safer tracks.

Estimated Cost and Completion Time:

Work will involve design and development and construction of prototype hardware and testing.

Cost           \$500,000                           2 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-7

Project Title: Environmental and On-Vehicle Noise and Vibration.

Objectives: Evaluate and establish theoretical and practical basis for predicting and correcting objectionable noise and vibration from the physical characteristic of rail-vehicle system. Experimentally verify.

Justification of Need:

Transit comfort level (environmental and on-vehicle) must be upgraded and improved to at least the standard the public finds acceptable and desirable in the modern automobile if transit is to improve its competitive position in the choice of mode of travel. Present technology has not solved the problem of rail-vehicle noise and vibration nor are there even empirical guide lines for use as a basis of design.

Scope and Approach:

1. Inventory and evaluate all previous research and studies in field of noise and vibrations of rail borne vehicles.
2. Establish theoretical and practical basis (instrumentation of existing conditions) for predicting noise and vibration levels from physical characteristics of rail-vehicle system.
3. Experimentally test and prove theory.
4. Establish acceptable maximum noise and vibration levels and means by which rail vehicle and track structure within and adjacent to subways, open cut, on bridges and aerial structures may be designed within acceptable standard.
5. Establish noise and vibration level tolerances applicable to maintenance work on track structure and rail vehicle and develop techniques for easily and economically maintaining and monitoring acceptable noise and vibration levels.

6. Research on this problem may investigate or generate major research projects on topics as:
- rail corrugations
  - rail pitting and shelling
  - wheel pitting and shelling
  - resilience of track structure as related to vehicle springing
  - wheel squeal on curves
  - rail and wheel grinding
  - rail car truck riding characteristics, relationships between sprung and un-sprung weight and resonance characteristics
  - rail gauge clearance
  - wheel gauge clearance
  - rail contour
  - wheel profile
  - effects of soil type
  - effects of structure type
  - type of adjacent building:
    - multi-story
    - single dwelling
  - track design:
    - special track
    - rail supports
    - alignment
- Project 67-8 Harmonic Vibrations as related to rail car trucks

Anticipated Results and Benefits:

Objectionable levels of noise and vibrations both environmental and on vehicle will be eliminated.

Estimated Cost and Completion Time:

Work will involve existing cars, trucks, experimental cars, trucks and sophisticated laboratory and on-car instrumentation. Laboratory, test track and operating system track tests and acoustic laboratory and reverberation rooms will be required.

Cost       \$750,000                   4 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-8

Project Title: Harmonic Vibrations as Related to Rail Car Trucks.

Objectives: To develop a better understanding of the dynamic forces acting upon rapid transit trucks so that truck design might be improved by minimizing the possibility of structural or component failures and assuring good riding qualities.

Justification of Need:

Every rapid transit property has experienced varying degrees of truck failures, such as frame and axle cracking, gear tooth destruction, wheel spalling, etc. This condition has resulted in higher maintenance cost, or expensive crash corrective programs with cars out of service and at time concern over safety. In like manner, the industry is unable to predict accurately the riding qualities of any truck design over given track structure. This has resulted, in many instances, of rough riding equipment which makes the rapid transit service less appealing to the public.

Scope and Approach:

- (1) Inventory and evaluate all previous research and studies in this area.
- (2) Conduct extensive instrumented tests on several rapid transit properties measuring lateral and vertical loads on the axle; comparing axles stress and wheel loads; measuring starting and stopping torques; tabulating all truck motion data and correlating these motions with axle stresses and transmission pinion shaft stress.
- (3) Investigate effect of wheel slip, acceleration and deceleration rates and negative return paths.
- (4) Conduct investigations on several rapid transit properties on the causes of wheel shelling with particular emphasis on rail-wheel adhesion and the factors that effect this adhesion.
- (5) Develop criteria for track and truck design to minimize detrimental effects of track and roadbed such as excessive rail wear, rail shelling, rail corrugation, joint wear and the like.

- (6) Investigate the relative inter-face reactions due to varying types of roadbed and truck designs and develop methods and equipment for defining roadbed contribution to dynamic inputs.
- (7) Develop a road-worthiness manual which will permit truck designers to build into final product sufficient durability of equipment and material to assure reasonable operating life with minimum maintenance and to assure good riding qualities.

Anticipated Results and Benefits:

This experiment would develop knowledge not now available which would assure design of trucks that would not fail, be low in maintenance cost and would ride well.

Estimated Costs and Completion Time:

Work will involve extensive field testing and instrumentation of car trucks on several operating rapid transit properties.

Cost      \$300,000                      2 years to complete

Remarks:

This project is complementary to Project 67-7. This (project) is based on a proposal developed by the ATA's Advisory Committee on Car Equipment in cooperation with IRT, which has already been submitted by the ATA to HUD.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-9

Project Title: Alternating Current Power System

Objective: To develop a satisfactory alternating current system for use by rapid transit cars.

Justification of Need:

Alternating current has superseded direct current for nearly all uses because of its ability to be transmitted more easily and economically. This makes it a desirable type of power for rapid transit but, in the past, it has only been used for heavy railway electrification because of the heavy weight and inefficiency of the car equipment. Recent developments in technology make it desirable to re-evaluate the potential of A C power for rapid transit use.

Scope and Approach:

Inventory the various types of A C power systems in use to determine their limitations and areas where improvements can be made. Both single phase and three phase A C power systems should be studied and evaluated. Consideration should be given to A C power distribution with conversion on the car to D C for use by the motors and to an all A C system using A C motors. When some definite ideas are developed for an improved A C system, a car should be equipped for a test.

Anticipated Results and Benefits:

To determine the economic and technical feasibility of A C power for rapid transit use.

Estimated Cost and Completion Time:

Cost        \$250,000                      2 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-10

Project Title: Control Systems for Direct Current Powered R. T. Cars.

Objectives: To develop new forms of car control for direct current powered rapid transit cars that will give improved performance at reduced cost, as well as providing a smoother, more attractive ride for the passengers.

Justification of Need:

The electrical industry has been making rapid advances, especially in the field of static devices which have now been developed to the point where they can handle the power required for rapid transit car operation. The major electrical manufacturers are beginning to offer this form of car control but, even though the future holds great promises, these devices are still experimental and most operating companies are reluctant to buy a whole order of cars with this untried equipment. The research center could render a service to the industry by testing and evaluating one or more car sets of any new control before any operator has to commit himself to a whole order of cars.

Scope and Approach:

1. Inventory and evaluate all previous types of car controls.
2. Study and evaluate any new form of controls offered or proposed, either by the electric companies or the Research Staff, in order to obtain a control system that will combine the maximum reliability and simplicity along with the desired operating characteristics.
3. Install and test one or more car sets of any promising control system on the property of one of the IRT members. Tests shall consist of fully instrumented runs and also operation in revenue service for an extended period in order to determine any unforeseen weaknesses and its acceptance by the public.

4. After testing of several new types of control and the evaluation of test results, every effort should be made to establish a standard type of control for the industry.

Anticipated Results and Benefits:

If a standardized type of car control can be worked out that is satisfactory for use by most of the rapid transit operators (something which has not been obtainable in the past), the industry can expect substantial savings when purchasing equipment. Improved car control is corollary to programmed control of operation.

Estimated Cost and Completion Time:

Work will involve analysis, testing on test track and operational tracks of prototype systems.

Cost   \$475,000                   3 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-11

Project Title: Braking for Rail Rapid Transit Cars.

Objectives: Study and evaluate all existing types of brake systems, such as air, hydraulic, dynamic, track, wheel tread, disc., etc., with a view to developing the safest and most effective method of braking a rail vehicle. Experimentally test all new ideas evolved to determine their usefulness to the Rapid Transit industry.

Justification of Need:

Existing rapid transit brake systems provide the necessary safety requirements by employing dual systems (air and dynamic). Simplification of braking is desired providing safety can be maintained. Smoother braking is desirable to make the ride more comfortable. Existing brake systems depend upon the adhesion between wheel and rail which is an unknown variable. This variable becomes more critical with the trend to Automatic Train Control and Automatic Train Operation.

Scope and Approach:

1. Inventory and evaluate all previous research and studies in the field.
2. Explore fully the use of hydraulic, dynamic, magnetic and other forms of brakes, in addition to the conventional types of air brakes.
3. Investigate the whole field of knowledge about wheel-rail adhesions and study any suggested means of increasing same.
4. Study ways of improving the conventional air brakes to make them respond more quickly and to simplify their operation. The greater use of electrical controls in place of pneumatic operation is suggested as a means of accomplishing this end as well as improving reliability.

5. Study methods of controlling the braking effort based on wheel-rail adhesion, etc.
6. Develop any ideas for a brake system that will be independent of wheel-rail adhesion, if possible.
7. Build any new type of brake that seems to have promise and test on one or more operating properties.

Anticipated Results and Benefits:

Simpler and safer and more reliable brake systems. Improved car braking is corollary to programmed control of operation.

Estimated Cost and Completion Time:

Work will involve engineering design and evaluation construction of prototypes and testing.

Cost    \$900,000                      4 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-12

Project Title: Standardization of Rapid Transit Cars Components.

Objective: To determine whether or not certain standardization of rapid transit components could be developed for and acceptable to the industry for purpose of developing a better vehicle at lower cost.

Justification of Need:

In recent years the price of rapid transit cars have been increasing at a much higher rate than the price for surface transit vehicles (motor bus). Much of this increase in cost is because of added passenger comforts (air-conditioning, improved lighting, more comfortable seating, more attractive appearance, etc.) and improved performance (more sophisticated controls, automatic train operation, etc.) which have been demanded in recent rapid transit orders. However, in the opinion of many equipment specialists, substantial savings are possible if operating properties would standardize whenever possible. This is not a simple task because of the variation in operating requirements and clearance limitations existing on the various operating properties. Nevertheless, there is sufficient justification for an industry investigation of the degree of standardization possible within their limitations.

Scope and Approach:

- (a) Conduct an industry investigation of operating and clearance requirements of all rapid transit properties.
- (b) Evaluate this data to determine in which areas standardization is possible.
- (c) In areas in which standardization is possible, work with operators, car builders, truck builders and suppliers to develop an acceptable standard.
- (d) In areas in which standardization is more difficult work with operators, car builders, truck builders and suppliers to reduce where possible the number of variants.
- (e) Investigate the practicability of a basic car body design, possibly of a modular principle, which could be adopted to different clearance requirements.

- (f) In all cases where standardization appears possible, evaluate whether or not the adoption of such a design would discourage further technological improvement in competition in the specific area of interest.

Anticipated Results and Benefits:

A better understanding of the areas in which standardizations are possible and the savings which might be possible if such standards were adopted.

Estimated Costs and Completion Time:

Cost	\$50,000	10 years to complete
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NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-13

Project Title: General Aesthetics of Rapid Transit System.

Objectives: Develop evaluation of effect of general aesthetics of rapid transit system and expense in relation to transit riding.

Justification of Need:

Determination of amount of investment in general aesthetic treatment of rapid transit system as compared to simple functional design (stations, cars, right of way) both capital and maintenance in relation to effect on transit usage is an essential economic ingredient to planning, building and maintaining a sound rapid transit system. Consideration to be given exterior appearance relation to environment. The competition for limited capital and maintenance funds during design and operation requires a more definite technique than is currently available for establishing proper distribution of investment.

Scope and Approach:

Inventory present systems and improvements to them to establish relationship between affect of general aesthetics of rapid transit system on transit usage.

Anticipated Results and Benefits:

Establish basic system for evaluating proportions of elements of rapid transit investment.

Estimated Cost and Completion Time:

Cost     \$200,000                     3 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-14

Project Title: Subway Ventilation

Objectives: Establish rational basis for design of ventilating systems for subways.

Justification of Needs:

There are almost as many techniques for analyzing subway ventilation as there are engineers that have been assigned to subway ventilation problems. The ventilation conditions in the new Montreal subway are an indication that not all subways are adequately ventilated.

Scope and Approach:

Inventory and test all subway ventilating systems and develop a theory, code and standard practice for design of subway ventilating systems. Consideration of following items to be included:

- |                   |                               |
|-------------------|-------------------------------|
| humidity          | fans                          |
| temperature       | train configuration           |
| air velocity      | adverse conditions - i.e.,    |
| air pressure      | relative train positions      |
| shock waves       | criteria - temperature limits |
| soil effects      | - pressure limits             |
| vent shaft design | - velocity limits             |
|                   | - draft limits, etc.          |

Anticipated Results and Benefits:

Adequate subway ventilation and sound basis for design of new systems, modification of existing systems.

Estimated Cost and Benefits:

Work will involve theoretical analysis, field testing.

Cost \$300,000 2 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-15

Project Title: Transit System Standard Practice Manuals.

Objectives: Develop design and construction standard practice manuals applicable to rapid transit requirements as regards structural loadings, fireproofing, clearances, lighting, stairs, signals, electrical distribution, signing, etc.

Justification of Need:

There are no standard practice manuals applicable to rapid transit design. All properties and designers use various variations and adoptions of AREA and AASHO codes. The variations are generally established by individual judgments and past practice and with little foundation based on actual measured stress and strain resulting from rapid transit loadings. Similarly, universal standards as to fireproofing, clearances, lighting, stairs, signals, electrical distribution, signing, etc., are not available.

Scope and Approach:

Inventory and evaluate present practices, conduct strain gage tests on existing operations and develop general structural, fireproofing and clearance standards, etc.

Anticipated Results and Benefits:

Safer more accurately proportioned structures and operating conditions.

Estimated Cost and Benefits:

Work will involve theoretical analysis, field testing.

Cost \$450,000 3 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-16

Project Title: Marketing Operations for the Urban Transit Industry

Objectives: To develop formal recommendations for transit agency marketing operations and strategies.

Justification of Need:

The transit industry should adopt advanced marketing procedures to attract more patrons to its services. Study of the techniques and conduct of marketing operations within a transit agency framework requires objective analysis.

Scope and Approach:

To identify those marketing techniques that are applicable to the urban transit agency and to establish organizational recommendations on how they can be carried out by transit agencies. Existing rapid transit marketing strategies would be surveyed in terms of patronage and profitability. Study the psychology relative to Public Relations particularly after operation commences and during construction.

Anticipated Results and Benefits:

Improve transit patronage by generating public acceptance of transit riding and public knowledge of the availability and extent of transit service.

Estimated Cost and Completion Time:

Work will involve developing a marketing strategy, promotional campaigns and testing same.

Cost \$500,000                      2 years to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-17

Project Title: Analysis of Transit Agency Composition

Objectives: To analyze the composition, organization, functioning and financing characteristics of urban transit agencies.

Justification of Need:

Existing transit agencies vary in their policy making structures, operating concepts, financial support, etc. Better understanding by community planners and decision makers of desirable transit agency characteristics could come through an evaluation of existing agency concepts.

Scope and Approach:

An intensive inventory of existing transit agencies to identify such items as the number and method of appointing boards of directors, the existence of advisory boards, tax and borrowing powers, political jurisdictions served, etc.

Anticipated Results and Benefits:

Formation of increasingly efficient transit agencies better equipped to meet with the challenges of public transport complexities.

Estimated Cost and Completion Time:

Cost \$25,000 1 Year to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-18

Project Title: Inventory of Existing Research and Development Being Conducted by the Rapid Transit Industry.

Objectives: To catalog and summarize research efforts being conducted individually by various transit agencies.

Justification of Need:

A number of experimental projects have been undertaken, and will continue to be undertaken by the rapid transit industry. To prevent wasteful duplication of effort, the nature and findings of these activities need to be promulgated throughout the rapid transit industry.

Scope and Approach:

To summarize and publish the results and findings of those research and development activities recently conducted by the rapid transit industry as well as make known those projects under consideration for future investigation.

Anticipated Results and Benefits:

Improved coordination of transit agency research activities leading to more efficient productivity from the limited resources available.

Estimated Cost and Completion Time:

Cost \$50,000 1 year to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-19

Project Title: Rapid Transit Industry Reference Library

Objectives: To establish a reference library on rapid transit industry and allied technical subjects to include a bibliography and abstract summary of new reports and publications.

Justification of Need:

There us no one central industry source of information on the rapid transit industry on a formal organizational basis nor printed summary of new technical developments and findings. To some extent, this project would be a logical extension of the Institute for Rapid Transit's present efforts to act as a clearinghouse of information on the rapid transit industry.

Scope and Approach:

To inventory existing technical literature applicable to the rapid transit industry and development of a corresponding bibliography. Also, to publish in abstract form, reports on new publications of interest to those working in the metropolitan transportation and planning fields. Include scale models(static and working) slides and movies.

Anticipated Results and Benefits:

Improved communication and retrieval of information concerning developments in the rapid transit field.

Estimated Cost and Completion Time:

Cost \$50,000 1 year to complete

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

RESEARCH PROJECTS

NEW CONCEPTS

There is wide recognition among transportation experts in government, the universities and the transit industry of a need for developing new ideas, new approaches and new concepts for rapid transit. For this reason, it is proposed that a portion of the research program's efforts and activities be devoted to the search for new ideas and concepts. Such efforts would be in addition to work by the research program in coping with the many immediate rapid transit research requirements which mostly involve the traditional steel-wheel-steel-rail form of rapid transit.

New concepts is a relative term which for our purpose could be divided into two parts - new concepts which are the adaptation in some new form of concepts, with which the industry is familiar, (the rubber-tired rapid transit system in Montreal is an example) - and new concepts which incorporate ideas and developments with which the industry has had little experience (the gravity-vacuum system, Teletrans and Starrcar are examples).

While there is no exact line dividing these two groupings of new concepts, it would appear that research involving linear motor rail-highway vehicles, self-propelled (electrically driven) cars are examples of projects that would fit the first category. Since projects of this type are adaptations of known concepts, the requirements for research in these areas are more easily recognized and preliminary project descriptions for each project can be developed and are attached to this application.

The development of specific research requirements for such projects as ground-effects vehicles, one or two place rapid transit vehicles (Teletrans and Starrcar), gravity-vacuum rapid transit systems, etc., are more difficult to determine without considerable investigation. These projects are basically the development and adaptations of new system ideas to rapid transit applications. Research requirements for these new systems would involve:

1. Extensive and detailed feasibility studies to determine whether or not these new systems can efficiently transport relatively large numbers of people in frequent stop, moderate, speed service with high acceleration and deceleration rates which is characteristic of rapid transit service.
2. Assuming feasibility studies are encouraging, test track installation would have to be made to determine technical feasibility and to resolve the technical problems always encountered in a new development.

Since studies to determine feasibility of application could be

undertaken at reasonable costs, the research program would undertake such studies for these and other systems that might hold some promise. Test track demonstrations, on the other hand, could involve huge sums and therefore the number of such projects would have to be limited. Consequently we are not recommending expensive demonstrations of any specific system until studies have been completed which would indicate that one or more proposals have sufficient promise to justify the cost of an actual demonstration.

Another area of new concept research which is difficult to be specific without exhaustive study but nevertheless should be included in the research program activities would include application of rapid transit to services other than the usual trunk line haul from the Central Business District to residential areas in the city and nearby suburbs. These could include such services as:

1. High speed service between airports and CBD.
2. Development of new ideas or application of known technology for new downtown distribution system particularly for metropolitan areas that might not otherwise justify rapid transit.
3. A similar development of less expensive forms of rapid transit for application to passenger volumes which would not justify the traditional form of rapid transit.

With the continually increasing speed and capacity of aircraft used in scheduled airline service, the need for specialized rapid transit service from the airport and the Central Business District becomes more and more necessary. The extension of the mainline rapid transit service to the airport such as has been done in Cleveland might be a solution in certain cities. However, in larger metropolitan areas, transportation via an urban rapid transit system to a downtown area with a multiplicity of stops might not be attractive to an airline passenger with his bags and baggage. Similarly, there might be a need for such services in cities which might not otherwise require rapid transit. There is a need to investigate whether the traditional form can be adopted or some new form of rapid transit developed to provide such services.

Improved distribution systems for the downtown areas of our medium size cities might be very important in stabilizing and revitalizing the Central Business Districts of such cities. Similar systems might also be employed as secondary distribution systems in cities with existing rapid transit systems as well as in airports and large shopping centers. These potential applications provide a market for a medium density rapid transit system whose costs would be substantially less than the traditional trunk line rapid transit. It is proposed that the Research and Development Program investigate the possibility of applying the Skybus or mini-rail (as used in Expo 67) principles or modifications thereof as well as other new concepts including moving belts to these demands for medium density rapid transit systems.

Finally, there are, in all large and medium size cities, many surface transit lines with passenger volume which could not justify the capital investment required for a traditional rapid transit system. If such lines could be upgraded into some form of semi-rapid transit service, operations would be improved by higher speeds and greater regularity of service to the benefit of existing passengers and for the purpose of attracting additional transit patronage. The Research and Development Program would investigate the feasibility of bus rapid transit, limited tram operation and some of the newer systems as mentioned above as possible methods of improving service on medium density surface lines.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-20

Project Title: Linear Motors

Objectives: To determine whether the advantages of Linear Motors could be adopted for propulsion of rapid transit equipment.

Justification of Need:

Linear motor propulsion has the following advantages over existing rapid transit propulsion systems:

- (a) Completely independent of adhesion between wheels and rails.
- (b) It eliminates the design problems involved in handling the centrifugal forces on rotary machines.
- (c) Rotor overheating in linear machines is not a problem.
- (d) Since only the primary winding is carried on the vehicle, only these losses have to be dissipated within the vehicle. Earlier experiments with this form of traction were faced with high costs. It would be the purpose of this investigation to determine whether or not in the light of modern technology these costs could now be reduced.

Scope and Approach:

- (a) Inventory and evaluate all previous research and studies in this area, particularly recent railroad investigations in England and Japan as well as linear motor application in other fields.
- (b) From this evaluation determine the desirability of proceeding with a feasibility study.
- (c) Conduct detailed laboratory experiments into the feasibility of this form of propulsion.
- (d) Develop full scale equipment for testing and further development on the test track.
- (e) If developmental and experimental work is successfully accomplished, install linear motor propulsion equipment on a selected short shuttle rapid transit operation on an existing operating property so that the principle could be tested in passenger service.

Anticipated Results and Benefits:

This investigation would determine whether or not the technical and commercial problems involved in linear motor propulsion could be overcome. If these could be overcome, linear motors or some other form of magnetic propulsion might provide a new breakthrough in rapid transit propulsion.

Remarks:

Should the Department of Transportation conduct research in linear motors for high speed mainline railroad operation, our efforts could be limited to application of their results to moderate speed frequent stop service with high acceleration and deceleration rates, the basic characteristics of rapid transit service.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-21

Project Title: Rail-Highway Vehicles.

Objectives: To resolve certain technical problems encountered in the operation of automotive vehicles over railroad right of way.

Justification of Need:

- (a) Recent developments in New York and New Orleans would indicate that surplus railroad track might be used by airport buses to bypass congested highway areas between the Airport and Central Business District.
- (b) Developments in Philadelphia and elsewhere point to the possible need for a dual purpose vehicle in other applications.
- (c) Recent and previous experiments have demonstrated the feasibility of a dual purpose vehicle providing certain problems associated with guidance, tire wear and adhesion could be overcome.

Scope and Approach:

- (a) Inventory and evaluate all previous research and operation of dual purpose vehicles in the United States and abroad.
- (b) Work with interested suppliers to determine if the problems (guidance, tire wear and adhesion) might be overcome in the approach presently being used in the development of a dual purpose vehicle.
- (c) Begin necessary research to develop new approaches to a dual purpose vehicle which would overcome existing problems and/or provide a more satisfactory vehicle.
- (d) Conduct experiments on the test track or on a suitable existing railroad right of way to demonstrate modifications or new approaches to the problem.
- (e) When a satisfactory method is developed, construct a prototype vehicle for demonstration and operation in revenue service.

Anticipated Results and Benefits:

The development of modification or new approaches to overcome the present problems associated with dual purpose vehicles.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

PROJECT 67-22

Project Title: Self-Propelled (Electrically Driven) Rapid Transit Car.

Objectives: To develop a self-propelled (electrically driven) rapid transit car that would have the operating characteristics, including high acceleration and deceleration rates, required in rapid transit service.

Justification of Need:

Rapid transit service for medium density operations might be provided over surplus railroad rights of way at minimum expense if a self-propelled car having rapid transit operating characteristics was available. Such cars might be employed to provide rapid transit service in cities where potential riding densities could not justify the capital costs of a full rapid transit system. Such cars might also be employed to provide connecting service from the suburbs to existing rapid transit systems. Self-propelled cars now available powered by internal combustion engines are expensive to maintain and do not have the desired operating characteristics.

Scope and Approach:

- (a) Investigate recent developments in fuel cells solar energy, storage battery, etc., to determine whether or not one or more would be incorporated in a self-propelled rapid transit car design.
- (b) Cooperate with others interested in developing these sources of energy.
- (c) Conduct research which might be required to apply these developments to rapid transit service.
- (d) If the results of the studies and research are encouraging, apply one or more new sources of electrical energy to a rapid transit car for experimental operation.

Anticipated Results and Benefits:

A determination whether or not recent technological developments could be used to power a self-propelled electrically driven rapid transit car. If there efforts were successful, applications of the results to transit buses might have even greater application in the interest of lower maintenance cost and a reduction of air pollution.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

WORK TO BE DONE BEFORE CENTER IS COMPLETED

In order to establish a National Rapid Transit Research and Development Program, a small staff should be selected and housed in temporary quarters. Their initial duty would be to review the objectives of the program and the projects which have been suggested as well as other projects which might be suggested in the future to determine exactly what will be required in office, laboratory and test track facilities. This determination would permit detailed design of the necessary facilities, the construction of which would have to be supervised by this staff. Upon completion of the facilities, the staff would be enlarged to full strength.

In the meantime, the staff could devote its efforts to familiarizing itself with the problems of the industry. This should be accomplished by personal contact with operators and suppliers in order to have an understanding of the problems that face the industry. This period could also be used to begin the cataloguing of the industry's research activities to date, analyzing the results of this research and determining what must be done to solve the various problems. Finally, a beginning could be made in the establishment of a rapid transit reference library.

During the design and construction of facilities, the staff could initiate projects which would not require laboratory or test track facilities. For example, many of the planning projects and many of the feasibility studies of new rapid transit systems and concepts could be undertaken by the staff prior to completion of the program's permanent facilities. In like manner, many projects might best be conducted by operating agencies using their facilities, by universities or by consulting engineers, and perhaps by suppliers. Many projects of this sort could be undertaken prior to the completion of the permanent facilities.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

COST OF PHASES

Capital Cost

(1)	Administrative Offices, Library and Shops	\$ 700,000	Building
		500,000	Land
	Shop Tools and Equipment	500,000	
	Laboratory Equipment	1,500,000	
	Connections to Test Track	500,000	
	Total	\$ 3,700,000	
(2)	Test Track (Including Real Estate)	6,300,000	
(3)	Total Capital Cost	\$10,000,000	

Project Cost

It has been estimated that the 19 projects suggested as typical of the type of research projects required for the traditional steel wheel-steel rail form of rapid transit would cost approximately \$9,150,000. The completion time for each of the projects would range from one to five years. Added to this cost would be administrative and maintenance expenses of approximately \$300,000 per year. If an annual budget as suggested of \$1,500,000 were adopted a priority system for scheduling projects would have to be established to keep within the budget.

The estimating of costs for research in new concepts is much more difficult. Feasibility studies of various new systems could be conducted for relatively modest sums, possibly \$100,000 to \$200,000 each. However, the testing of many of these concepts would require specialized facilities and test tracks which would involve costs of many millions of dollars. Obviously only one or two of the most promising new concepts could be undertaken in the first years of operation of the Research and Development Program.

It would appear that the research and development needs for both the traditional form and for new concepts would have to be conducted over a period of years. It is suggested that in the initial years the greater part of the available funds be devoted to the most pressing problems which are involved with the traditional form of rapid transit. As these problems are resolved, then a greater amount can be channelled each year into new concept research and development.

NATIONAL RAPID TRANSIT RESEARCH AND DEVELOPMENT PROGRAM

EXHIBIT D

DATA COLLECTION, ANALYSIS AND REPORTS

- (1) Progress reports will be submitted quarterly describing current project activities and progress to date.
- (2) Technical reports will be prepared and submitted at the completion of each project. These reports will include complete documentation of all pertinent data, evaluations and accomplishments, conclusions and recommendations.
- (3) The Research & Development Center will maintain a continuing record of all rapid transit research projects. This record will include projects completed or in progress by the Research & Development Center, by operating agencies, suppliers, consultants or universities. The record will be brought up to date periodically and will be available to all interested in rapid transit research.
- (4) Financial Reports, in the form of a quarterly balance sheet, will be submitted. The Institute for Rapid Transit will be responsible for project accounting and the maintenance of financial records. An independent professional audit of the project accounts shall be conducted by the auditors for the Institute for Rapid Transit.
- (5) The staff of the Research & Development Center will be responsible for the preparation of all reports other than the financial statements and will also be responsible for collecting data and maintaining continuing contact with transit agencies, suppliers, consultants and others interested in rapid transit research.
- (6) Preparation and publication of all reports will be the financial responsibility of the project.

