NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

SUMMARY OF PROGRESS THROUGH 1983

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

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NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

Administrators, engineers, and many others in the transit industry are faced with a multitude of complex problems that range between local, regional, and national in their prevalence. How they might be solved is open to a variety of approaches; however, it is an established fact that a highly effective approach to problems of widespread commonality is one in which operating agencies join cooperatively to support, both in financial and other participatory respects, systematic research that is well designed, practically oriented, and carried out by highly competent researchers. As problems grow rapidly in number and escalate in complexity, the value of an orderly, high-quality cooperative endeavor likewise escalates.

Recognizing this in light of the many needs of the transit industry at large, the Urban Mass Transportation Administration, U.S. Department of Transportation, in 1980 got under way the National Cooperative Transit Research and Development Program (NCTRP). This is an objective national program that provides a mechanism by which UMTA's principal client groups across the nation can join cooperatively in an attempt to solve near-term public transportation problems through applied research, development, test, and evaluation. The client groups thereby have a channel through which they can directly influence a portion of UMTA's annual activities in transit technology development and deployment. Although present funding of the NCTRP is entirely from UMTA's Section 6 funds, the planning leading to inception of the Program envisioned that UMTA's client groups would join ultimately in providing additional support, thereby enabling the Program to address a larger number of problems each year.

The NCTRP operates by means of agreements between UMTA as the sponsor and (1) the National Academy of Sciences, a private, nonprofit institution, as the Primary Technical Contractor (PTC) responsible for administrative and technical services, (2) the American Public Transit Association responsible for operation of a Technical Steering Group (TSG) comprised of representatives of transit operators, local government officials, State DOT officials, and officials from UMTA's Office of Technology Development and Deployment, and (3) the Urban Consortium for Technology Initiatives/Public Technology, Inc., responsible for providing the local government officials for the Technical Steering Group.

Research programs for the NCTRP are developed annually by the Technical Steering Group, which identifies key problems, ranks them in order of priority, and establishes programs of projects for UMTA approval. Once approved, they are referred to the National Academy of Sciences for acceptance and administration through the Transportation Research Board.

The Board operates within the National Research Council, which serves both the National Academy of Sciences and the National Academy of Engineering, and is uniquely suited for the administrative role because: it maintains an extensive committee structure from which authorities on any transportation subject may be drawn; it possesses the avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; it is recognized for its objectivity and understanding of modern research practices; its relationship to its parent organization is an insurance of objectivity; and it maintains a full-time staff of research specialists in transportation matters to take the findings of research directly to those who are in a position to use them.

Research projects addressing the problems referred from UMTA are defined by panels of experts established by the Board to provide technical guidance and counsel in the problem areas. The projects are advertised widely for proposals, and qualified agencies are selected on the basis of research plans offering the greatest probabilities of success. The research is carried out by these agencies under contract to the Academy, and administration and surveillance of the contract work are the responsibilities of the Academy and Board.

The needs for transit research are many, and the National Cooperative Transit Research and Development Program is a mechanism for deriving timely solutions for transportation problems of mutual concern to many responsible groups. In doing so, the Program operates complementary to, rather than as a substitute for or duplicate of, other transit research programs.

MAILING ADDRESS:

TRANSPORTATION RESEARCH BOARD
2101 Constitution Avenue, NW
Washington, D.C. 20418

OFFICES AT:

2100 Pennsylvania Ave., NW
Washington, D.C.
Phone: 202-334-3224

NCTRP TECHNICAL STEERING GROUP

Annual research programs for the NCTRP are recommended to UMTA by the NCTRP Technical Steering Group (TSG). Under contract to UMTA, the American Public Transit Association, supported by the Urban Consortium for Technology Initiatives/Public Technology, Inc., is responsible for operation of the TSG, the membership of which is as follows.

Chairman

JOHN DYER, *General Manager, Southern California Rapid Transit District*

APTA Transit System Members

PAUL J. BALLARD, *Vice President, Management Services, American Transit Corporation*
THEODORE D. BECK, JR., *General Manager, Niagara Frontier Transportation Authority*
HENRY C. CHURCH, *General Manager, Greater Richmond Transit Company*
JERRY L. EDDY, *Director of Transportation, Regional Transportation District (Denver)*
WARREN H. FRANK, *Executive Director, Central New York Regional Transportation Authority*
HAROLD H. GEISSENHEIMER, *General Manager, San Francisco Municipal Railway*
FRANCIS A. GORMAN, *Vice President and General Manager, Port Authority Trans-Hudson Corporation*
KENNETH M. GREGOR, *Acting General Manager, Metropolitan Atlanta Rapid Transit Authority*
JEFFREY L. GUBITZ, *General Manager, K-Trans (Knoxville)*
GERALD T. HAUGH, *General Manager, San Mateo County Transit District*
L. L. HEIL, *Executive Director, City Transit Service of Fort Worth*
ROBERT B. JOHNSTON, *General Manager, Port Authority Transit Corporation (Camden)*
ERNIE MILLER, *General Manager, Metro Regional Transit Authority (Akron)*
DON S. MONROE, *Executive Director, Pierce County Public Transportation Benefit Area*
NEIL PETERSON, *Executive Director, Municipality of Metropolitan Seattle*
JAMES E. READING, *General Manager, Central Ohio Transit Authority*
JOHN F. SWEENEY, *Vice President and General Manager, Connecticut Transit*
JOHN J. TUCKER, *Assistant Transportation Coordinator, Metropolitan Dade County Transportation Administration*

APTA State DOT Members

DAVID D. KING, *Director, Public Transportation Division, North Carolina Department of Transportation*
KENNETH W. SHIATTE, *Director, Transit Division, New York State Department of Transportation*
CHARLES E. ZELL, *California Department of Transportation*

UCTI/PTI Members

THOMAS DOWNS, *Director of Transportation, District of Columbia Department of Transportation*
FRANK KIOLBASSA, *Director of Public Works, City of San Antonio*
ALAN LUBLINER, *Center City Circulation Project Manager, Department of City Planning (San Francisco)*

Transit Labor Representatives

FRANK O'CONNELL, *International Vice President and Director for Legislation, Transport Workers Union of America*
GEORGE LEITZ, *International Vice President for Bus Operations, Transport Workers Union of America*

Non-Voting Members

PETER BENJAMIN, *Associate Administrator, Office of Technical Assistance, Urban Mass Transportation Administration*
FRANK J. CIHAK, *Director, Technical and Research Services, American Public Transit Association*
JOHN DURHAM, *Office of Technical Assistance, Urban Mass Transportation Administration*
DAVID PERRY, *Acting Transportation Director, Public Technology, Inc.*
EDITH PAGE, *Senior Research Associate, Public Technology, Inc. (Alternate)*

TRB Liaison

KRIEGER W. HENDERSON, JR., *Director, Cooperative Research Programs, Transportation Research Board*

NCTRP PANELS

All work in the NCTRP is assigned to broad research fields under which panels are organized to deal with research in specific problem areas falling within the broad fields. Each project is assigned a panel comprised of outstanding individuals highly knowledgeable in the specifics of the particular project and who are looked to for guidance and counsel throughout the research phase. A listing of all NCTRP panels currently active during this reporting period follows. *(Mr. Frank J. Cihak, Secretary, Technical Steering Group, serves as the TSG liaison representative for all NCTRP Projects. He is assisted in this function by Mr. Patrick Jones.)*

NCTRP *Research Field—Administration: Economics*

Panel A30-1—Robert M. Works (Chairman), William W. Allen, Kamel Boctor, Michael Dewey, John F. Donahue, Jr., Rudolph V. Giangrande, Robert D. Owens, Peggy Schwartz, Patrick M. Sullivan, C. Michael Walton, John Ridgely (UMTA Liaison Representative), W. Campbell Graeub (TRB Representative), R. Ian Kingham (NCTRP Staff).

NCTRP *Research Field—Administration: Finance*

Panel A31-1—Gordon J. Fielding (Chairman), Harvey Berlin, Robert Brownstein, Gary R. Cowan, David E. Fox, Neil D. Lawer, Genevieve L. Leary, Aloysius J. Nehr, Arna V. Shaffer, Kenneth Cook (TRB Representative), R. Ian Kingham (NCTRP Staff).

NCTRP *Research Field—Administration: Personnel Management*

Panel A-33-1—Peter G. Drake (Chairman), Walter Bierwagen, William E. Cross, Jr., Thomas Griess, Chester W. Higgins, Pam Salisbury, Robert M. Works, Frank E. Enty (UMTA Liaison Representative), James K. Williams (TRB Representative), Robert E. Spicher (NCTRP Staff).

NCTRP *Research Field—Administration: Personnel Management*

Panel A33-2—Forest D. Swift (Chairman), Cynthia Burton, Eileen Cioe, Melvin Howard, Byron Lewis, Michael D. Meyer, Hugh A. Mose, Frank Shipman, Betsy Voss, Charles T. Morison, Jr. (UMTA Liaison Representative), Kenneth E. Cook (TRB Liaison Representative), Crawford F. Jencks (NCTRP Staff).

NCTRP PANELS—*Continued*

NCTRP *Research Field—Administration: Personnel Management*

Panel A33-3—Dennis P. Clayton (Chairman), William W. Allen, Malcolm J. Campbell, Michael T. Landers, W. J. Parks, A. B. Hallman (UMTA Liaison Representative), Kenneth C. Cook (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Planning: Alternative Analysis*

Panel B36-1—Manuel Padron (Chairman), John R. Breeding, Don Bryan, Kevin E. Heanue, Buford Johnson, Michael D. Meyer, R. David Minister, Edward V. Taylor, Theodore von Briesen, James M. Ryan (UMTA Liaison Representative), Campbell Graeub (TRB Liaison Representative), R. Ian Kingham (NCTRP Staff).

NCTRP *Research Field—Planning: System Planning*

Panel B38-1—Terry W. Hochbein (Chairman), Stuart A. Bothwell, John F. Davidson, Nathan S. Erlbaum, John R. Gratchner, Robert E. Holibaugh, John M. Reilly, Frank E. Tracy, Conrad A. Wogrin, Thomas Hillegass (UMTA Liaison Representative), W. Campbell Graeub (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Planning: Route Planning*

Panel B39-1—Thomas W. Friedman (Chairman), Bruce T. Bowles, Martin Feuerstein, A. B. Hallman, David A. Hines, Rudolf Kolaja, Charles E. Zell, Brian E. McCollom, George Izumi (UMTA Liaison Representative), W. Campbell Graeub (TRB Liaison Representative), Crawford F. Jencks (NCTRP Staff).

NCTRP *Research Field—Planning: Impact Analysis*

Panel B40-1—John Meyer (Chairman), Gary R. Allen, John E. Arnold, Charles A. Lave, Aloysius J. Nehr, Louis R. Rainone, Robley Winfrey, Edward L. Thomas (UMTA Liaison Representative), Kenneth E. Cook (TRB Liaison Representative), Robert E. Spicher (NCTRP Staff).

NCTRP *Research Field—Design: Track and Ancillary Systems*

Panel C43-1—Edward K. Farrelly (Chairman), George Donato, John C. Mould, Galen Sarno, James Stewart, Ray Wlodyka (UMTA Liaison Representative), Edward J. Ward (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Planning: Impact Analysis*

Panel B40-3—Kathleen E. Stein-Hudson (Chairman), Steven F. Bloomfield, Alinda Burke, Robert T. Dunphy, Bruce Hutchinson, Susan Stropes, Brian E. Sullivan, Vukan Vuchic, Edward L. Thomas (UMTA Liaison Representative), Kenneth Cook (TRB Liaison Representative), R. Ian Kingham (NCTRP Staff).

NCTRP *Research Field—Design: General Design*

Panel C46-1—Joseph P. Greenway (Chairman), Patrick J. Dunne, Victor Hernandez, Alexander L. Irving, Patrick J. McEvaddy, Eugene W. Riley, Ronald O. Swindell, Fred Sing (UMTA Liaison Representative), Edward J. Ward (TRB Liaison Representative), Crawford F. Jencks (NCTRP Staff).

NCTRP *Research Field—Materials and Construction: General Materials*

Panel D47-1—Jack Donahue (Chairman), Jesse Ronald Cole, Harry L. Cuthbert, James T. Hogan, William Laule, Ralph Malec, Duane Perrin, Robert A. White, Denis Symes (UMTA Liaison Representative), Adrian G. Clary (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Operations: Energy Efficiency*

Panel F54-2—Onkar N. Sharma (Chairman), Kamel Boctor, Michael McKenna, Carl Natvig, Orin Zimmerman, Ronald Kangas (UMTA Liaison Representative), Stephen Blake (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Operations: Performance Effectiveness and Efficiency*

Panel F55-1—J. William Vigrass (Chairman), Martin J. Foley, John G. Gaul, Charles Kalkhof, Keith Prouty, Walter Kulyk (UMTA Liaison Representative), James K. Williams (TRB Liaison Representative), Harry A. Smith (NCTRP Staff).

NCTRP *Research Field—Special Projects*

Project Committee—SP60-1—R. R. Biege, Jr. (Chairman), Verdi Adam, Robert N. Bothman, Jack Freidenrich, David S. Gedney, Sanford P. LaHue, Bryant Mather, Thomas H. May, Theodore F. Morf, Edward A. Mueller, David K. Phillips, Robert J. Betsold (FHWA Liaison Representative), K. B. Johns (TRB Liaison Representative), Robert J. Reilly (NCTRP Staff).

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NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

SUMMARY OF PROGRESS

THROUGH 1983

INTRODUCTION

At the 1976 UMTA/APTA R&D Priorities Conference there was consensus among spokesmen for the Office of Management and Budget, Congress, and the transit industry that the Urban Mass Transportation Administration, U.S. Department of Transportation, should undertake a cooperative program of R&D to attack near-term problems in transit operations and equipment. This was the genesis of the National Cooperative Transit Research and Development Program (NCTRP) that got under way in November 1980 under the authority of Section 6(a) of the UMTA Act of 1964, as amended (49 U.S.C. 1605(a)). Thereby provided is a mechanism for addressing problems that impede operational effectiveness or productivity, but are not of the character to justify a centrally managed, Federally directed, R&D effort. This mechanism not only enables UMTA's principal client groups to join cooperatively in attempts to resolve near-term public transportation problems through applied research, development, testing, and evaluation, but it also provides them with a channel through which they can directly influence a limited portion of UMTA's annual activities in transit technology development and deployment. Consequently, the NCTRP's overall objectives are:

- To identify problems commonly agreed to be in need of R&D investigation and to establish a priority ordering among them.
- To provide an opportunity for many constituencies, including transit operators and local government officials, to identify problems and participate in developing solutions to them.
- To improve communication and technical information exchange.
- To provide a means of addressing near-term transit problems without requiring detailed, formal involvement of the Federal Government in the execution of R&D projects designed to provide solutions.

The NCTRP operates by means of agreements between UMTA as the sponsor and (1) the National Academy of Sciences NAS, a private, nonprofit institution, as the Primary Technical Contractor (PTC) responsible for administrative and technical services, (2) the American Public Transit Association responsible for operation of a Technical Steering Group (TSG) comprised of representatives of transit operators, local government officials, State DOT officials, and officials from UMTA's Office of Technology Development and Deployment, and (3) the Urban Consortium for Technology Initiatives/Public Technology, Inc., responsible for providing the local government officials for the Technical Steering Group.

Research programs for the NCTRP are developed annually by the Technical Steering Group, which identifies key problems, ranks them in order of priority, and establishes programs of projects for UMTA approval. Once approved, they are referred to the National Academy of Sciences for acceptance and administration through the Transportation Research Board (refer to Figures 1 and 2). There, they are assigned to seven broad research fields under which panels or committees of experts are organized to deal with research in specific problem areas under the broad fields. They analyze the problems, outline particular projects and their objectives, and then prepare research project statements by which a wide solicitation is made for proposals from qualified private and public research agencies. They review the proposals, recommend subcontract awards on the basis of research plans offering the greatest probability of success, and provide counsel to the NCTRP staff responsible for surveillance of work under the research subcontracts. Finally, they review final reports for acceptability, decide if the reports evidence reasonable accomplishment by the agencies of the projects' research plans, and assist staff in determining the warrants for publishing the reports in a regular NCTRP series and distributing them through standing Board processes.

Panel membership is reported both herein and in the TRB Directory and includes persons from state and federal agencies, the UMTA client groups, universities, national associations, institutions with related interests, industry and other agencies. Members are appointed as individuals possessing expertise in specialized areas and not as representatives of the organizations by which they are employed. Because rarely is it possible to acquire members with the required knowledge and judgment who do not have technical biases, concerted attention is given to maintaining a balance of such biases. However, prejudicial biases, along with organizational and personal biases, are scrupulously avoided.

The Board's authority for administration of the Program rests with its Executive Committee from which is drawn the Subcommittee for the NCTRP, the body providing

counsel on all matters relating to policies and procedures for the planning and administration of the Program. The day-to-day activities are carried out by professional staff assigned by the Board. Projects engineers with broad experience in transportation research are responsible for administrative and technical surveillance of the subcontracts. In addition to reviewing quarterly progress reports and monthly progress schedules and maintaining telephone contacts, each engineer regularly visits his assigned projects throughout their subcontract periods. He discusses with each principal investigator the project's status to learn if the research is being pursued in line with the approved research plan. If necessary, frequent meetings involving the staff, panel, and agency personnel are held to review project progress and provide guidance for continuing work. Finally, the projects engineer and the panel evaluate the completed research to determine the degree of technical compliance with the subcontract and the acceptability of the final report to the Board and the Academy.

The research findings are published in either of two regular NCTRP report series, and copies are formally distributed through the Transportation Research Board's selective distribution system.

Although research in the NCTRP is presently sponsored by UMTA, the administrative mechanism is applicable to other agencies' programs as well. However, the following description of how research is administered applies specifically to research sponsored by the UMTA.

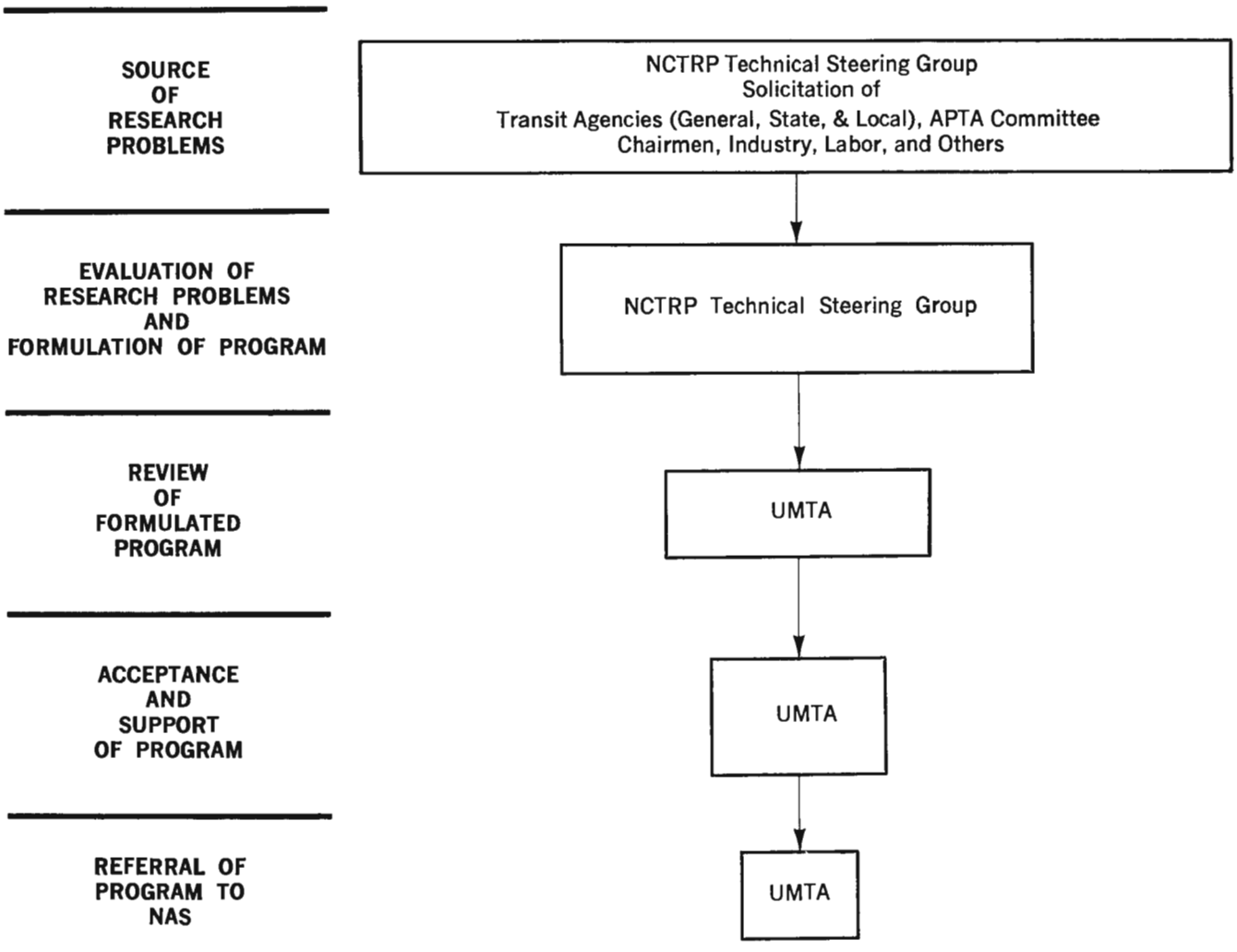

FIGURE 1

Flow diagram for each program from initiation to referral by UMTA to the National Academy of Sciences

PROGRAMS AND FINANCING

Three programs have thus far been referred to the Academy for administration, and a fourth is pending. Referred on November 7, 1980, was the FY 1980 program, the first. Totalling $1,040,000, it consisted of eight problems ranging in funding from $40,000 to $300,000. Two of these were designated for TRB syntheses; the remaining six were scheduled for contract research (see Table 5 for status).

The FY 1981 program, totalling $985,000, was formulated on October 7, 1981, by the Technical Steering Group and referred by UMTA to the Academy on March 30, 1982. It consists of eight problems ranging in funding from $30,000 to $300,000. Two of these were designated for TRB syntheses; the remaining six were scheduled for subcontract research (see Table 5 for status).

The FY 1982/1983 program was developed on October 21, 1982, by the Technical Steering Group and forwarded on November 18 for UMTA approval. Officially referred on January 13, 1983 to the Academy at a total funding level of $1,000,000 were two continuations of earlier projects and ten new projects, four of which are designated for TRB syntheses and to which a fifth was added by project panel action.

At year's end the FY 1984 program was under development by the Technical Steering Group.

Funding to support all research to date is provided from UMTA's Section 6 funds for R&D activity. Although initiation of the NCTRP was accomplished solely with UMTA funds, the planning leading to inception of the Program envisioned that, given the multitude of problems facing them, UMTA's client groups would join ultimately in providing additional support, thereby enabling the Program to address a larger number of problems each year. Presently, the funds available to the NCTRP are sufficient to address but a fraction of the total need represented by problem submittals to the Technical Steering Group.

HOW THE NCTRP IS ORGANIZED TO ADMINISTER RESEARCH PROGRAMS

In line with the Board's responsibility for administering the NCTRP, a TRB Executive Committee Subcommitee for the NCTRP considers all matters relating to policies and procedures required for the planning and administration of the Program. Members of the Executive Committee make up this committee.

In addition, the Board has established seven broad research fields under which project panels are organized to deal with research in specific problem areas under the broad fields (refer to Figure 3). For example, in the broad subject field of Operations, each project falling within the more specific subject area of Energy Efficiency—area 54—is assigned a panel comprised of outstanding individuals who are knowledgeable in the specifics of the particular project and who are looked to for technical guidance while research is in progress. Those projects that do not conveniently fit under one of the first six general fields are assigned to the seventh one, Special Projects.

Members of the project panels do not act as consultants

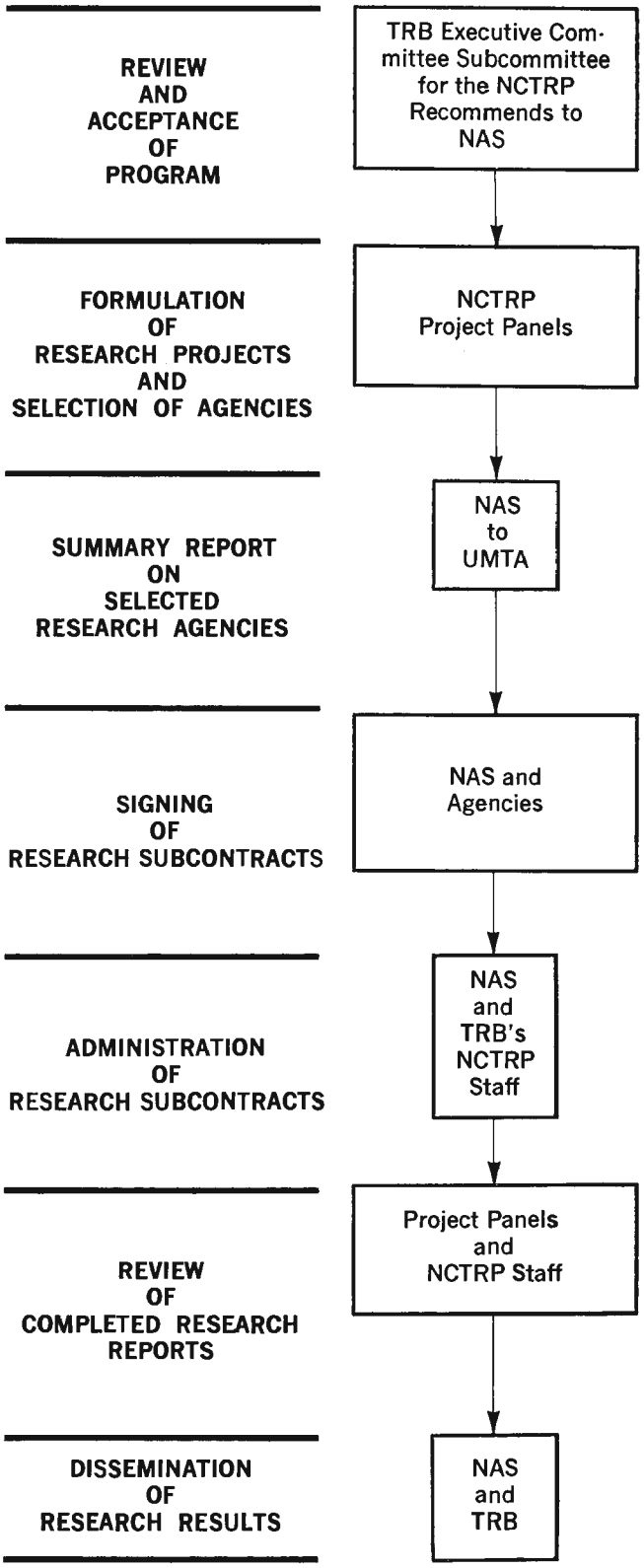

FIGURE 2

Flow Diagram for Each Program After Referral to the National Academy of Sciences

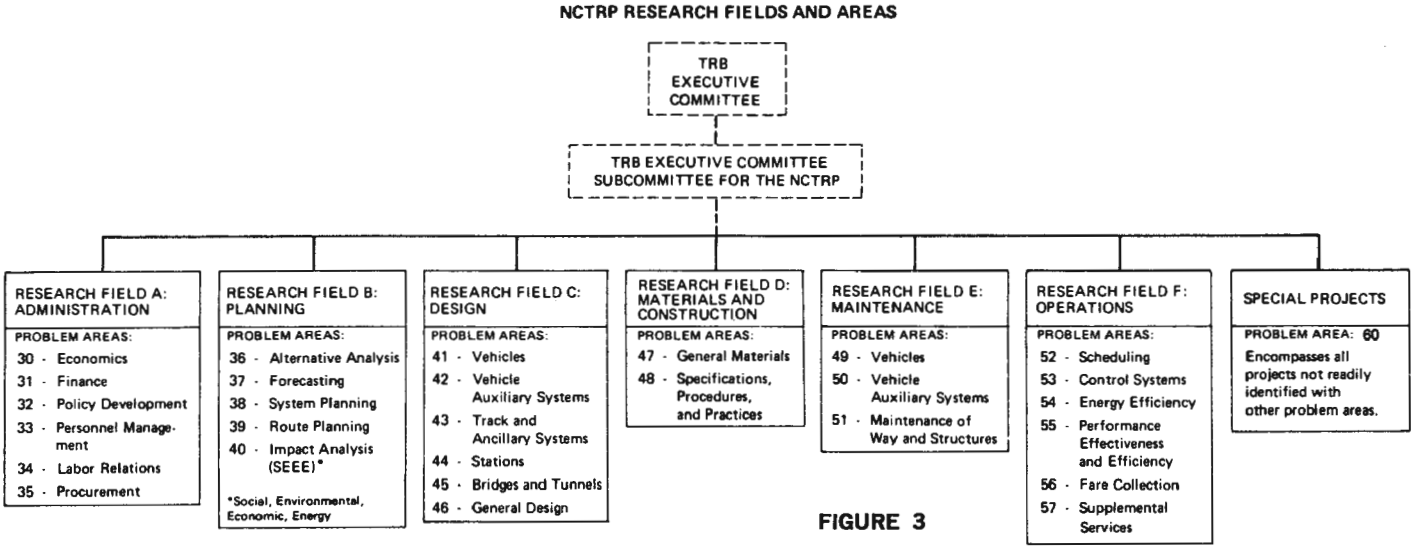

FIGURE 3

or advisors to project investigators. Some 135 individuals serve without compensation on these project panels, and their total yearly contribution to the Program is an impressive and laudatory effort by volunteer professionals. Members are drawn from the agencies given in Table 1, and they come from 26 States, the District of Columbia, and Canada. Employees of transit operating agencies presently constitute 34 percent of panel membership. The duties and responsibilities of the membership include:

- Developing an operation plan geared to reaching the major problem area objective, including estimates of total cost and time to achieve the objectives.
- Drafting definite statements of objectives for projects within the problem area and within the funds allotted.
- Reviewing research proposals and making recommendations regarding selection of research agencies.
- Reviewing research progress.
- Providing guidance regarding technical aspects of the research.
- Reviewing and evaluating project reports as to the accomplishment of objectives and suitability for publication.
- Making recommendations as to whether or not studies of problems included in prior fiscal year programs should be continued.

Following the NCTRP staff review made after program referral to the Academy, the recommended program is referred to the TRB Executive Committee Subcommittee for the NCTRP for comments as to the critical need for the research, the availability of other suitable sponsors, and whether or not the research items are appropriate to be identified with the Academy. Unacceptable problems are returned by the Academy to UMTA with the reason for rejection and, when appropriate, with a recommendation for disposition.

HOW THE PROJECTS ARE PLACED UNDER CONTRACT

It is important to note that the NCTRP is not in the business of awarding grants for basic research. Rather, the Program calls for subcontract research with specific objectives that, if achieved, will result in solutions that are practical and readily usable. As the NCTRP officially gets each year's program under way, the project panels meet to write research project statements based on the research problems referred by UMTA.

These statements are then sent automatically to a mailing list of more than 3,000 interested individuals and research agencies. Because of deadlines the NCTRP must meet, proposals must be submitted according to fixed deadlines, and extensions simply cannot be granted.

In line with this process, submittals for the first three program years (FY '80, FY '81, and FY '82/'83) ranged from 6 to 25 per project, the average rate of return per project being 13, 12, and 10, respectively (refer to Table 2). One agency submitted four proposals in one of the years; however, most agencies submitted only one each (refer to Table 3).

The types of agencies responding with proposals for the two programs are given in Table 4. The TRB, which through its Special Projects Division produces the NCTRP's

TABLE 1

DISTRIBUTION OF PROJECT PANEL COMMITTEE MEMBERSHIP WITH RESPECT TO AFFILIATION

AFFILIATION	NO. OF MEMBERS	POSITIONS INVOLVED
Transit Systems	45	49
State DOTs and Other Local Governmental Agencies	29	32
Urban Mass Transportation Administration	14	18
Other Federal Agencies	10	10
Educational Institutions	12	12
Research Institutes	1	1
Industry, Consultants, and Trade Associations	24	24
Professional Societies and Service Organizations	5	5
TRB Liaison Representatives	7	18
All	147	169

TABLE 2

NUMBER OF PROPOSALS SUBMITTED

ITEM	1981	1982	1983*
No. of projects advertised	6	6	5
Proposals submitted	77	71	52
Proposals rec'd per project (ave.)	13	12	10

* Calendar year

synthesis of transit practice reports, is not included. Projects making up the three programs are given in Table 5, and the types of agencies selected to carry out the projects are given in Table 6.

The opportunity to propose is open to anyone possessing extensive, demonstrated capability and experience in the problem areas in question; never are projects developed with the intent that they go to particular agencies. Because the projects are seeking practical remedies for pressing operational problems, it is expected that only the highest level of agency capability will be applied in meeting the commitments of the proposal—capability cannot be developed at project expense. Consonant with the goal of providing practical, readily usable solutions to pressing problems, there are fairly stringent specifications for proposals and agency attributes that are acceptable to the mission-oriented nature of the NCTRP.

The staff and panel members evaluate all proposals in a uniform manner, with primary consideration given to:

- The understanding of the problem and the merit of the research plan and approach.
- The experiment design and the promise of fulfilling the objectives of the project statement.
- The qualifications of the principal investigator(s).
- The adequacy of the facilities.

The proposed budget is not one of the primary factors because the funds available for research are given in the project statement. The budget does not enter the evaluation process leading to agency selection, except when specific items are reviewed to better determine manpower allocations. When the proposed cost exceeds the funds available, the proposal is rejected on receipt.

A panel meeting is held to select an agency, and a review is made of all known aspects of agency performance

TABLE 3

NUMBER OF AGENCIES SUBMITTING ONE OR MORE RESEARCH PROPOSALS

NO. OF PROPOSALS SUBMITTED	NUMBER OF AGENCIES SUBMITTING PROPOSALS		
	1981	1982	1983*
1	59	43	41
2	9	9	4
3	0	2	1
4	0	1	0
All	68	55	46

* Calendar year

TABLE 4

TYPES OF AGENCIES SUBMITTING PROPOSALS

TYPE OF AGENCY	NO. OF AGENCIES SUBMITTING		
	1981	1982	1983*
Educational institutions	20	11	15
Research institutes	7	4	3
Industry, consultants, and trade associations	40	39	28
Professional societies and service organizations	0	0	0
State DOTs and other governmental agencies	1	1	0
All	68	55	46
No. of projects advertised	6	6	5

* Calendar year

on other research projects under NCTRP or elsewhere. The successful proposals are retained by the panel members for use in monitoring the research. Proposals are considered to be privileged, and the information in them is not released outside of the Academy unless explicit approval is obtained from the agency. Policy also holds that panel notes, deliberations, etc., are privileged.

Following the selection meeting, a summary report on the recommended research agencies is sent to UMTA, and subcontract negotiations follow in due course, as does subcontract execution and commencement of research. Again, it should be emphasized that the NCTRP is a program of subcontract research—it does not operate on a grant basis. Further, proposals can be received only in response to advertised project statements, as the funds available each year to the Program are earmarked in their entirety for research problems specified by the sponsor—UMTA.

The policy of the NCTRP is to provide a debriefing to unsuccessful proposers. The initiative for obtaining a debriefing lies with the proposers and must be requested in writing. The debriefing is intended to indicate to the proposers the technical areas in which their proposals were judged weak and deficient and how the weaknesses or deficiencies were factors in their not having been selected. All debriefings are conducted in a scrupulously fair, objective, and impartial manner, and the information given the unsuccessful proposers is absolutely factual and consistent with the evaluations by the NCTRP panels. The factors constituting the basis for selection of the successful agency are identified, but the debriefing does not include a point-by-point comparison of all the elements considered in the evaluation criteria. Neither is there any revelation of confidential business information, trade secrets, techniques, or processes of the other proposers, nor is there any indication of the relative merits or technical standings of the unsuccessful proposers.

The Academy's research subcontract is either:

- Cost-Reimbursement (CR)

TABLE 5
SUMMARY OF STATUS THROUGH DECEMBER 31, 1983, FOR FY '80 THROUGH FY '82/'83 PROJECTS

PROJECT NO.	TITLE	RESEARCH AGENCY	SUBCONT AMOUNT SUBCONT COST ($)
	AREA 30: ADMINISTRATION—ECONOMICS		
30-1	Small Transit Buses: A Manual for Improved Purchasing, Use, and Maintenance	Arthur D. Little	$299,37
	AREA 31: ADMINISTRATION—FINANCE		
31-1	The Impacts of Federal Grant Requirements on Transit Agencies	Booz-Allen	49,52
	AREA 33: ADMINISTRATION—PERSONNEL MANAGEMENT		
33-1	Transit Bus Operator Selection and Training for Dealing with Stress	GAMS Inc.	150,00
33-2	Assessment of Job Enrichment Programs for the Transit Industry	Public Admin. Service	97,82
33-3	Public Transit Bus Maintenance Manpower Planning	Fleet Maintenance	100,00
	AREA 36: PLANNING—ALTERNATIVE ANALYSIS		
36-1	Improving Decision-Making for Major Urban Transit Investments	System Des. Concepts	200,00
	AREA 38: PLANNING—SYSTEM PLANNING		
38-1	National Transit Computer Software Directory	COMSIS Corp.	100,00
	AREA 39: PLANNING—ROUTE PLANNING		
39-1	A Modular Approach to On-Board, Automatic Data Collection Systems	The MITRE Corp.	148,78
	AREA 40: PLANNING—IMPACT ANALYSIS		
40-1	Simplified Guidelines for Evaluating Transit Options in Small Urban Areas	Barton-Aschman	149,96
40-2	Estimating Incremental Costs of Bus-Route-Service Changes	System Des. Concepts	150,00
40-3	Strategies to Implement Benefit-Sharing for Fixed Transit Facilities	SG Associates	99,95
	AREA 43: DESIGN—TRACK AND ANCILLARY SYSTEMS		
43-1	Detection of Low-Level Fault Currents on Rail Transit Systems	Chas. T. Main, Inc.	99,95
	AREA 46: DESIGN—GENERAL DESIGN		
46-1	Single Cable Communications Technology for Rail-Transit Systems	Poly Inst of NY	150,00
	AREA 47: MATERIALS AND CONSTRUCTION—GENERAL MATERIALS		
47-1	Improved Service Life of Urban Transit Coach Brakes	Battelle Mem Inst	300,00
	AREA 54: OPERATIONS—ENERGY EFFICIENCY		
54-1	Improve Transit Bus Energy Efficiency and Productivity	Booz-Allen	39,97
54-2	Energy Management of Electric Rail Transit Systems	Carnegie-Mellon	150,00
	AREA 55: OPERATIONS—PERFORMANCE, EFFECTIVENESS, AND EFFICIENCY		
55-1	Conversion to One-Person Operation of Heavy-Rail Rapid-Transit Trains	Battelle Mem Inst	150,00
	AREA 56: FARE COLLECTION—PERFORMANCE, EFFECTIVENESS, AND EFFICIENCY		
	AREA 60: SPECIAL PROJECTS		
60-1	Synthesis of Information Related to Transit Problems	TRB	460,00
	TS-1: Cleaning Equipment and Procedures for Transit Buses	ATE Mgmt	75,00
	TS-2: Priority Treatment for Buses on Urban Streets	PAWA	75,00
	TS-3: Effects of Fuel Additives and Alternative Fuel Grades for Transit Buses	Southwest Res Inst	30,00
	TS-4: Guidelines for Allocation of Time for Transit Coach Maintenance Functions	XYZYX Info Corp.	30,00
	TS-5: Extraboard Management Procedures and Tools	L. C. McDorman	40,00
	TS-6: Traffic Signing at Bus Stops	—	45,00
	TS-7: Bus Communications Systems	Mitre	45,00
	TS-8: Passenger Information Systems for Transit Transfer Facilities	J. J. Fruin	45,00
	TS-9: Transit Fare Collection: Problems and Alternatives to Paper Currency	Mitre	75,00

* Final subcontract cost.
[a] Continuing activity through FY '82/'83. Annual amount varies; total to date shown.
[b] Allocated—Balances are carried forward to support future synthesis studies.

	EXPECTED COMPLE-TION DATE	PROJECT STATUS (for details, see latest Summary of Progress)	PROJECT NO.
/82	8/7/84	Research in progress	30-1
/81	12/15/82	Completed—Published as NCTRP Report 2	31-1
/81	10/14/83	Research in progress	33-1
/82	12/31/83	Research in progress	33-2
/83	10/31/84	Research in progress	33-3
/81	11/1/83	Research in progress	36-1
/83	4/30/84	Research in progress	38-1
/82	4/30/84	Research in progress	39-1
/82	4/23/84	Research in progress	40-1
/83	8/15/85	Research in progress	40-2
/83	2/1/85	Research in progress	40-3
/83	4/2/84	Research in progress	43-1
–	—	Subcontract pending	46-1
1/81	5/31/84	Research in progress	47-1
1/81	6/30/82	Completed—Published as NCTRP Report 1	54-1
1/81	12/31/83	Completed—Published as NCTRP Report 3	54-2
–	—	Subcontract pending	55-1
7/80	[a]	Research in progress	60-1
6/81	12/31/81	Completed—Published as NCTRP Synthesis 1	(TS-1) 60-1
6/81	12/31/81	Completed—Published as NCTRP Synthesis 2	(TS-2) 60-1
1/82	9/30/83	Completed—To be published as NCTRP Synthesis 3	(TS-3) 60-1
9/82	11/30/83	Completed—To be published as NCTRP Synthesis 4	(TS-4) 60-1
1/83	10/31/84	Research in progress	(TS-5) 60-1
–	—	In developmental stage	(TS-6) 60-1
1/83	11/30/84	Research in progress	(TS-7) 60-1
1/83	11/30/84	Research in progress	(TS-8) 60-1
1/83	11/30/84	Research in progress	(TS-9) 60-1

TABLE 6

AGENCY DISTRIBUTION OF FY '80 THROUGH FY '82/'83 PROJECTS

TYPE OF AGENCY	PROJECTS AND CONTINUATIONS NO.	%
Educational institutions	2	11
Research institutes	3	17
Industry, consultants, and trade associations	12	66
Professional societies and service organizations	1	6
State DOTs and other governmental agencies	0	0
All	18	100

- Cost-Plus-Fixed-Fee (CPFF)
- Fixed Price (FP)

The research agency's proposal is made a part of the subcontract with the Academy. Thus, in addition to the specific research objectives outlined in the subcontract, the research agency's cost estimates are also recognized as being part of the agreement. However, the principal investigator does have flexibility in conducting the research, if it is consistent with the general scheme of the proposal.

KEEPING TRACK OF RESEARCH IN PROGRESS

A professionl staff is assigned to NCTRP by the Board. Currently, five projects engineers with wide-ranging expertise are responsible for administrative and technical surveillance of the contracts. In addition to reviewing quarterly progress reports and monthly progress schedules, and maintaining telephone subcontracts, each engineer visits his assigned research agencies throughout their subcontract periods. He discusses with each principal investigator his project's status to learn if the research is being pursued in line with the approved research plan. Finally, the engineer and cognizant project panel evaluate the completed research to determine the degree of technical compliance with the subcontract.

SYSTEMATIC PLANNING FOR GETTING RESEARCH RESULTS FROM NCTRP PROJECTS INTO PRACTICE

Promoting Useful Results

Previous narrative substantiates the fact that many activities take place between initiation of research programs and execution of research contracts. Many additional ones take place before formal publication of the final report is realized. At the milestones of the process network reflecting all activities, NCTRP concentrates on the opportunities to increase the odds for acquiring useful research results and to increase the probability that useful results will find their way into practice more quickly. Beyond the sponsor's first weighting of the odds by setting the goals for a program of applied research dedicated to solving pressing operational problems, the NCTRP tries to further weight the odds favorably by:

- Establishing the agency and personnel qualifications that are mandatory if the goals are to be achieved. Emphasis is placed on the importance of a record of successful past performance in endeavors similar to those to be undertaken. Further, it is also stipulated that proposals are not acceptable if they do not contain specific statements as to how the contemplated results can be used to improve practice.
- Utilizing persons who are not only experts in the particular problems area but who also have a complete understanding of the needs of the practitioners to define the research problem and its objectives in the form of a precise project statement on which fully responsive research proposals can be based. Experts drawn from transit agencies play a major role in this task.
- Exercising extreme care in the process of selecting research agencies to ensure not only that the proposed research plan is the best possible in addressing the specifics of the objectives but that it also culminates in the best promise for providing the practitioner with a product that is both usable and readily implementable.
- Establishing—on the basis of staff and project panel review of and suggested modifications to the research plan —a clear meeting of the minds as to what specifically is expected from the research and the personnel carrying it out in order to meet the needs of practitioners.
- Acquiring an amplified research plan that is intended to detail comprehensively the approved research plan and to include a specific schedule of events for the major tasks. This document is used by the staff in the day-to-day surveillance of the project's progress and by the project panel as required.
- Carrying out project surveillance sufficient to keeping the research in line with the approved research plan, constantly keeping the researchers aware of the needs of practitioners, and insuring that all project developments through final reporting center around these needs.
- Requiring research reports in a format that is designed specifically to ease the burden of the busy practitioners in assimilating what has resulted from the research and how it can be used. Different treatment is given to the material that would be of interest to other researchers.

NCTRP Reporting of Research Results

In an applied research program such as the NCTRP, the sponsor rightfully expects not only results that are accurate but also findings that can be readily put into practice. This means that the final research reports (refer to Tables 7 and 8) must be presented in language understandable to practitioners and in such format as to permit easy assimilation. Too many of today's research reports are frequently so clouded by obscure language and format that the reader must spend precious time and effort in translating them into concise and readily usable working documents.

Research agencies for the NCTRP are required to report their results in a form that succinctly summarizes the find-

ings and likewise informs the reader of the application of the findings. These objectives are accomplished through a "Summary of Findings," and a chapter on "Interpretation, Appraisal, and Application of Results." The detailed research techniques and analyses in which a researcher would be interested are presented in appendices and do not have to be labored through to extract the findings. The Program specifies style and organization of all reports to guide the researcher in his writing to provide a document of maximum use by the sponsors and others.

Prior to publication, extraordinary measures are taken to ensure that useful research results are made immediately available to the appropriate personnel. One means consists of forwarding copies of the research agency drafts of final reports. According to the urgency of the particular circumstances, these drafts may be either uncorrected or corrected on the basis of an acceptance review. Several copies of unedited drafts of the agency reports are retained until formal publication in either of the two regular NCTRP series (Reports or Syntheses of Transit Practice) and are available, on a loan basis, to others having an interest in the research. Once published in their entirety, the drafts are destroyed.

After publication in the NCTRP series, each report or synthesis is distributed immediately through the Transportation Research Board's selective distribution system. Copies go automatically to about 100 libraries, Board transit representatives, educational institutions, liaison representatives, appropriate panels and committees of the Board, and individual members who have selected publications in the particular subject area of the report. Special distribution lists are developed as appropriate to ensure receipt by all segments of the operating agencies of information helpful to their operations. As a further means of disseminating the research reports, announcements of their availability are made to the trade press. Each of these reports contains a staff-prepared foreword that directs the attention of the busy reader to the persons who would be most interested in the results and, also, to how the results fit into present knowledge and practice. Also, during the conduct of the work, periodic progress reports are prepared by the staff and sent to UMTA as a measure of providing a current awareness of on-going work. In addition, the Board's Technical Activities Staff personnel follow the progress of the work throughout its conduct and consequently are able, in their activities, to discuss application of the research results with those best able to use them. Research findings not published in the NCTRP series are stored on microfiche by the Academy. On an interim basis, the findings are sometimes reported in a *Research Results Digest,* described next.

The *NCTRP Research Results Digest* series—flyers published at frequent intervals—is a means for providing practitioners with an early awareness of the research results emanating from NCTRP projects. By making results known as they are developed and prior to publication of the final reports in the regular NCTRP series, it is hoped that their early use in practice will be encouraged. For the most part, each Digest is intended to be very brief in summarizing specific findings—they do not deal with research methodology—and require the reader to expend very little time in determining how the research results may be of use to him. The basic format is couched in terms of the problem and the solution to it, the findings, and applications. Practitioners should find them of direct assistance in serving the intermediary, or interpretive, position between research and operating personnel, for each Digest speaks directly to the vital factors of:

- Whether the research stands alone or whether it has to be combined with results from other research in order to be useful.
- Whether the results are defined explicitly enough to permit direct application to practice.
- Whether the results have to be translated into the working tools with which the practitioner is familiar.
- Whether the research findings have been evaluated sufficiently to make some reasonable determination of the probability of their success when applied to practice.

IMPLEMENTING RESEARCH RESULTS

Emphasis has been given in the foregoing to the devices employed to obtain solutions that are directly applicable to practice. Because the NCTRP process does not include an implementation activity, the initiatives for incorporating the solutions in practice must be taken by the UMTA and transit agencies. To this end, the Program's final concentration is on the reporting of research findings in one or more of the variety of publications described earlier and, as will be done in future annual reports, providing whatever details are available on the experiences of the States and transit agencies in using the products from NCTRP research. With this objective, the Program will be grateful for any information on actual application of results and associated benefits. Because the research addresses critical, national problems, the assumption is that documented use and payoff to any one agency should attract others to give the results a try in whatever degree they see fit. Only if the results get around and are used can it be said that UMTA truly is capitalizing on its investment. Otherwise, projects that were highly successful might just as well have been failures; the end result is the same—the money will have been spent in vain.

SUMMARY

The National Cooperative Transit Research and Development Program is a unique subcontract research effort designed to respond quickly and efficiently to the needs of UMTA and the transit industry through solution of near-term public transportation problems. Although the Transportation Research Board administers the Program, the research content is solely the prerogative of the Urban Mass Transportation Administration. The Program is one of applied (rather than basic) research, and every possible effort is made to help administrators and engineers put the findings to early use. Program policy ensures maximum exposure of the research while in progress in the hope that research results will, in fact, more quickly find their way into practice in the form of policies, procedures, specifications, and standards of the operating agencies.

TABLE 7
PUBLISHED REPORTS OF THE NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

Rep. No.	*Title, Project, Pages, Price*
1	Transit Bus Energy Efficiency and Productivity—Bus Equipment Selection Handbook (Project 54-1), 55 p., $7.20.
2	Impacts of Federal Grant Requirements on Transit Agencies (Project 31-1), 73 p., $7.60
3	Reduction of Peak-Power Demand for Electric Rail Transit Systems (Project 54-2), (In press)
4	Improving Decision-Making for Major Urban Transit Investments (Project 36-1), (In press)
5	Assessment of Quality of Work-Life Programs for the Transit Industry (Project 33-2), (In press)

Synthesis of Transit Practice

No.	*Title, Pages, Price*
1	Cleaning Transit Buses: Equipment and Procedures (Proj. 60-1, Topic TS-1), 39 p., $6.80
2	Enforcement of Priority Treatment for Buses on Urban Streets (Proj. 60-1, Topic TS-2), 30 p., $6.40

TABLE 8
NCTRP RESEARCH RESULTS DIGESTS [a]

DIGEST NO.	PROJ. NO.	TITLE, PAGES, PRICE
1	33-1	Review of Literature Related to Bus Operator Stress, 15p, $3.00

[a] See Table 5 for project titles. Orders must be prepaid if for less than $10.00. Make request to Publications Office, Transportation Research Board, 2101 C tion Avenue NW, Washington, DC 20418.

PROGRESS BY PROJECT

Only those areas are listed in which there are projects. For a complete list of project areas, refer to Figure 3.

AREA 30: ECONOMICS

Project 30-1 FY '81

Small Transit Buses: A Manual for Improved Purchasing, Use, and Maintenance

Research Agency: Arthur D. Little, Inc.
Principal Invest.: R. Nayak
Effective Date: November 8, 1982
Completion Date: August 7, 1984
Funds: $299,378

One of the important decisions facing both rural and urban transit decision-makers is whether to invest scarce funds in more expensive or less expensive small transit buses. Available small buses (i.e., ranging from van conversions to 31-ft heavy-duty small buses) are highly diverse in both capital costs and technology. Their uses are also highly diverse, spanning the range from large transit fleets in major urban areas to small rural operators, and including fixed-route, demand-responsive, shuttle and other services. The complexity of both needs and possible solutions has led to many poor choices of buses for specific duties. In addition, uncertainties with respect to the small bus market have led to a lack of continuity in design and development; perceived problems in bus operation, maintenance, and reliability; a lack of clear definition of bus demand; and little standardization within realistic price ranges. Consequently, no guidelines exist with which transit providers, seeking to purchase or replace small buses, can make objective decisions concerning the best bus type to be procured.

The general objective of this research is to develop a workbook-style manual for local transit operators and to identify key recommendations that might feasibly be taken by transit operators, local governments, states, and UMTA to substantially improve the procurement, appropriate use, and maintenance processes for small transit buses. The manual is intended for use by individuals experienced and inexperienced in the procurement and operation of small transit buses. Furthermore, the manual is intended to assist individuals in the cost-effective procurement, maintenance, and operation of buses in a wide range of local, institutional, service, and operating environments. (Included in the definition of service and operating environments are maximum and average loads; type of service; range requirements (i.e., distance between refueling); wheelchair-lift or ramp needs, and actual usage; types, conditions, and grades of roads/streets; dwell-time constraints; weather extremes; frequency and degree of acceleration/braking; communication equipment requirements; and fare collection equipment requirements.) The manual will be based on research requiring the collection, tabulation, and analyses of primary information and data. While performing the research, investigators must be particularly cognizant of bus maintainability and fuel efficiency. (Included in the definition of maintainability are life expectancy of the bus's power train, body, and major components; minimum mean time before failure (MTBF) rates of components; availability and cost of parts; maintenance and servicing facilities required; skill levels and representative times and costs required for servicing and repair; complexity of subsystems (i.e., lifts and air conditioning).) Fuel efficiency studies should consider duty cycle, propulsion technology, maintenance, bus size and weight, gearing, etc. Transit operators will be the principal users of the research results, although they should also be of interest to manufacturers and funding agencies. To accomplish this objective the following tasks are considered essential but not limiting:

Task 1. Determine the present capital and operating costs, and performance of small transit buses in U.S. operations as affected by (1) service and operating environments, (2) institutional environments, and (3) maintenance availability and sophistication.

A. Develop a classification system for small buses by type (life expectancy, maintainability, operating cost) and size.

B. Develop a classification system for operational environments and maintenance programs.

C. Develop a detailed data collection plan for use in determining capital and operating costs for various classes of buses, maintenance programs, and operating environments.

D. Collect data and summarize results for various bus and component classes to provide transit operators with relevant design characteristics and operating experience. Analyze MTBF data (as developed in this study or available elsewhere), design characteristics, and general operating experience for key components, subsystems, chassis types, etc. that are critical to the development of minimum specifications for various service and operating environments, appropriate maintenance actions, and realistic replacement intervals. Develop from these data an engineering analysis of each bus class describing its suitability for various types of service and likely operating results. Assess the practicality of using life-cycle costs to assist in the description of operating results.

E. Identify problems for transit operators and manufacturers in using or producing small transit buses that are supported by the data.

Task 2. Develop practical recommendations for resolution of key problems, identified in the research, for improving the purchase, maintainability, and cost-effective use of small transit buses. These recommendations should be oriented towards actions that can be taken by transit operating agencies to improve delivery of service.

Task 3. Based on the results of Task 1, develop a workbook (flow-chart type) manual that can be used by transit operators to make appropriate small bus choices. The manual should be designed to take as input such planning

factors as service type, anticipated passenger loads, typical speeds, maintenance and institutional factors. Its output should include the classes of small transit buses that are best suited to the projected operating environment, special specification items or options that should be required, the range of maintenance and fuel costs likely to be experienced, and special maintenance provisions that should be undertaken.

Substantial progress has been made through December 31, 1983. Tasks 1A through 1C have been completed and are the basis for data collected from 27 transit agencies representing a total of 316 buses. Nineteen (19) of the 27 agencies have provided data sufficiently complete to warrant entering them into a large computer-based data base. The 19 agencies represent a total of 223 buses, almost eight thousand maintenance events, 2.6 million bus-miles, and 1,200 bus-months of operation. Distributions of variables have been documented and a preliminary analysis of predominant maintenance activities has been completed. Future analyses of variance and regression analyses will allow the analyst to enter the descriptions of bus type, duty cycle, into simple equations and calculate the estimated costs.

AREA 31: FINANCE

Project 31-1 FY '80

The Impacts of Federal Grant Requirements on Transit Agencies

Research Agency:	Booz, Allen & Hamilton, Inc.
Principal Invest.:	Subhash R. Mundle
Effective Date:	November 30, 1981
Completion Date:	December 15, 1982
Funds:	$50,000

As the federal transit program grew, the growth was accompanied by a proliferation of federally imposed requirements. The costs and effects of grant requirements caused increasing concern to transit agencies.

The general objective of this study was to determine the costs and effects of federal legislation, regulations, UMTA circulars, administrative letters and formal administrative guidelines for the Section 3 capital grant application process and to make recommendations for its improvement. The study results are useful to (1) transit agencies in their decision to apply for federal grants, (2) legislators drafting legislation, and (3) the Urban Mass Transportation Administration in amending requirements.

Because of the limitation on available funds, the research specifically excluded consideration of Section 13(c) and 504 requirements. Additionally, the research did not consider Section 5 capital and operating grants; applicability to fixed guideway systems; project management requirements for approved grants; and applicability to specialized transit services.

The study results showed that an application for a Section 3 grant requires from 20 to 30 exhibits of supportive documentation and assurances. The origin of these requirements was traced to the Urban Mass Transportation Act and UMTA promulgated regulations and administrative policies. Requirements varied primarily by project type, rather than by amount of funding request or urban area size. Impacts of compliance included: direct levels of effort; delays in project implementation, inflationary cost escalation and loss of management flexibility. The magnitude and extent of these impacts varied significantly among transit agencies. Reasons for the differences were attributable to factors both within and beyond the control of the applicant agency.

By 1981 the transit industry viewed application procedures as routine. The assignment of a permanent grants function within local agencies has reduced preparation costs. In addition UMTA relaxed several of its reporting requirements. Yet areas for improvement remained. The most significant of these included the need for consolidated guidelines; the need for a streamlined application document; and the need for coordinated local, state, and federal capital programming efforts.

The study results were published as:

NCTRP Report 2, "The Impacts of Federal Grant Requirements on Transit Agencies."

AREA 33: PERSONNEL MANAGEMENT

Project 33-1 FY '80

Transit Bus Operator Selection and Training for Dealing With Stress

Research Agency:	Group Associated Management Services, Inc.
Principal Invest.:	Dr. Brownlee Elliott
Effective Date:	October 15, 1981
Completion Date:	October 14, 1983
Funds:	$150,000

Some bus operators possessing the basic skills to operate the vehicle may still experience difficulties in performing their job satisfactorily because of inability to cope effectively with the public. Use of all possible training and disciplinary action does not help when the individual hired does not have the psychological strengths necessary to deal effectively with continuous public contact, and the resultant stress may lead to more workers' compensation claims for nonvisible physical injury (i.e., heart and psychological problems) as well as to more accidents, absenteeism, and personnel turnover.

Various selection and training methods are currently being used by individual transit agencies. Some of these methods have been developed specifically for application in the transit industry, some have evolved from practice within individual agencies, and others represent modifications to methods originally developed for agencies outside of the transit industry. At present, however, no single method of selecting or training bus operators from the viewpoint of their ability to deal with stress is considered to be generally acceptable for wide application by transit agencies. To ensure that methods have general applicability, the range

of needs and capabilities of different size transit agencies, regional differences, and the makeup of the bus operator population (i.e., male/female and minorities) must be fully considered.

The objective of this research is to provide an evaluative device or questionnaire for use as part of the bus-driver-selection process that will validly indicate the applicant's susceptibility to stress which is likely to affect job performance. The research will also provide two training modules: one designed to help newly hired operators anticipate and deal with typical stressful situations, and one designed to help supervisors recognize stress symptoms displayed by operators and provide guidance on appropriate courses of action.

Reference literature and existing training programs have been reviewed to identify the various environmental, psychological, and physiological factors commonly used in stress analysis. NCTRP Research Results Digest 1 provides a summary of the literature review. A preliminary set of factors and characteristics relevant to the bus operators' job has been prepared by the researchers and reviewed by managers, operators, and labor representatives from selected transit agencies for suggested additions and deletions. Agencies participating in this review included the Detroit Department of Transportation, Kansas City Area Transportation Authority, Regional Transit Service (Rochester, NY), Mercer County Metro (Trenton, NJ), Oklahoma City Mass Transit and Colorado Transit Management (Colorado Springs, CO).

Existing operator-selection-test mechanisms have been evaluated for general applicability in measuring an individual's tolerance for stress. An existing device was modified for use in this research, and the modified version was field tested in the six sites previously mentioned. This device should have wide applicability in the transit industry and is primarily aimed at screening new applicants. The device treats stress factors individually and in groups such as passenger contact, environment, management/union/employee relations, personal problems, and equipment.

Two sample training modules also are being prepared: one for newly hired operator training (and perhaps for voluntary retraining) and one for supervisor training. The primary focus of the new operator training is to alert the driver to typical stress-causing situations and to provide specific guidance on how to cope with each situation. Typical situations include (1) passenger contacts, e.g., fights on the bus; (2) environmental factors, e.g., bad weather; (3) management/union/employee relations; (4) personal problems, and (5) equipment. The supervisor's training module focuses on the recognition of stress symptoms and tendencies (resulting from personal or job-related causes) and on the identification of appropriate courses of action. Both modules will be adaptable by an individual transit agency so that through property-specific modifications they can be made part of existing training programs.

A listing will be provided of pertinent data and resources (films, videotapes, surveys, models, books, papers, etc.) identifying concomitant costs, sources, and transit agencies that are using such methods for selection and stress management training of bus operators and supervisors.

Research should be completed in early 1984.

Project 33-2 FY '81

Assessment of Job Enrichment Programs for the Transit Industry

Research Agency:	Public Administration Service
Principal Invest.:	Dr. Susan G. Clark
Effective Date:	November 1, 1982
Completion Date:	December 31, 1983
Funds:	$97,821

The political and fiscal environment of transit agencies is in a period of significant change. Scarcity of funds will mean a renewed emphasis on productivity and redoubled efforts to retain and motivate quality employees in the absence of financial incentives. New federal policies stressing local initiative will encourage management to be more sensitive to innovative ideas, and a changing work force will make different demands.

Although the transit industry is highly labor-intensive, a great deal of emphasis has been placed in the past on capital development, financial controls, and transportation planning. Potentially, one of the most important areas for improving transit agency effectiveness is the development and management of human resources through job enrichment programs. There is a need for a systematic investigation of the feasibility of job enrichment programs, such as job restructuring, quality circles, and other techniques that utilize the full talents and abilities of transit employees. It is anticipated that the greatest benefits of job enrichment efforts could be derived from first-line supervisors and those they supervise.

For purposes of this study, job enrichment was defined as making the elements of the job both physically and psychologically more stimulating, resulting in more productive behavior. The organization could thus provide an environment that allows and influences self-esteem and promotes a positive attitude about one's employment through an individual's own initiatives. Job enrichment offers several possible benefits to the transit industry. For the organization, it provides the prospect of improving the operating environment by enhancing the effective management of human resources. For the individual employee, the concept fosters greater job satisfaction, improved self-esteem, and higher productivity. The general objective of this research was to assess the feasibility of job enrichment programs for the transit industry for first-line supervisors and those they supervise.

Research is complete; the agency final report has been submitted and reviewed, and will be published as NCTRP Report 5. The agency report is comprised of two main parts, the main text of the final report and an appended document on model programs developed under Task 4. The main text describes the basic philosophies and techniques of "quality of work-life" programs (the term "job enrichment" was expanded to "quality of work life" to better represent the intended purpose of the project), the general characteristics of transit affecting the use of quality of work-life programs, and the current status and potential for imple-

menting such programs. The appended document provides guidelines for implementing five quality of work-life-type programs: work redesign, incentives, task forces, quality circles, and labor-management committees. Pending formal publication in the NCTRP series, the agency final report with the appended document on model programs is available on a loan basis (see final page of this section for ordering information).

Project 33-3 FY '82/'83

Public Transit Bus Maintenance Manpower Planning

Research Agency:	Fleet Maintenance Consultants, Inc.
Principal Invests.:	Richard W. Drake Subhash R. Mundle
Effective Date:	November 1, 1983
Completion Date:	October 31, 1984
Funds:	$100,000

Proper manpower planning for bus maintenance is crucial to the efficient and economical operation of transit agencies. However, this crucial element is often determined in a very inexact manner based heavily on past experience and guesswork that may not be appropriate, particularly for transit agencies experiencing major changes in services, equipment, or facilities.

Transit agencies have recognized that operator manpower planning is necessary to ensure service reliability and maximum labor efficiency. However, equal attention has not been given to manpower planning for bus maintenance functions. This is, in part, because maintenance department job assignments often preclude the interchangeability of personnel among functions, skills are often specialized, and the need for maintenance personnel is dependent on many variables relating to equipment and facilities. In addition, multiplicity of work rules and other factors frustrate efforts to apply planning techniques to maintenance manpower. The result is that many transit agencies merely use such simple ratios as buses per mechanics or maintenance man-hours per miles of operation as the primary tools for performing this extremely critical function.

This project will focus on manpower planning techniques for bus maintenance only. Results of the project will provide transit management (1) better planning tools for maintenance staffing adjustments, (2) data for comparison with representative transit agency data, and (3) assistance in projecting maintenance manpower for optional equipment or subsystems. Successful completion of this project would set the stage for possible future research addressing similar areas in rail maintenance as well as bus and rail operator manpower planning.

The objectives of this project are to (1) develop a methodology for establishing labor estimates required for maintaining specific bus vehicle subsystems and (2) utilizing this methodology, gather data from several transit agencies and prepare standard labor estimates. These estimates must account for variance among agencies in such areas as bus reliability, operating environment, labor efficiency, and equipment characteristics, and must be presented in a format that facilitates their use by bus transit agencies for manpower planning and analysis purposes. Attainment of the project objectives will necessitate, at least, the following tasks:

Task 1. Identify major bus vehicle subsystems such as power plant, lifts, electrical, brakes, etc., for which maintenance manpower data would be gathered.

Task 2. Develop a standard glossary of terms; e.g., qualified mechanic man-hour, maintenance procedures and standards for each system to ensure uniformity of data.

Task 3. Identify site specific criteria; e.g., operating environment, vehicle subfleet, vehicle age that would impact on maintenance manpower requirements.

Task 4. Develop procedures for gathering data; e.g., site visits, questionnaires, etc.

Task 5. Develop procedures for analyzing data, establishing comparisons among properties, and evaluating workforce utilization. These must account for site specific factors from Task 3.

Task 6. Develop methodology for identifying representative agencies for collection of data.

Task 7. Select agencies for collection of data.

Task 8. Obtain approval of panel for project methodology and agency selection.

Task 9. Collect data from bus agencies and perform analysis according to procedures developed in Task 5.

Task 10. Develop methodology to permit bus agencies to use the information for maintenance manpower planning, estimating, and analysis purposes.

Task 11. Prepare a draft report for review by the NCTRP.

Task 12. Review the draft report and submit the final version in fulfillment of the technical obligations under the contract for the project.

Research is in progress.

AREA 36: ALTERNATIVE ANALYSIS

Project 36-1 FY '80

Improving Decision-Making for Major Urban Transit Investments

Research Agency:	System Design Concepts, Inc.
Principal Invest.:	Joseph R. Stowers
Effective Date:	November 2, 1981
Completion Date:	November 1, 1983
Funds:	$200,000

The environment for transportation planning and investment decisions is in a period of dramatic change. Fiscal constraints, a posible reorientation of federal transportation policies, and an increasing reliance on local commitment and decision-making are all likely to influence significantly the future of transportation in urban areas. Even with these pressures, however, urban areas will still be facing decisions on major investments in transit systems. Thus, there will be a need in future years for a planning

and analysis process which examines major transportation options and which informs decision-makers so that most cost-effective investment decisions can be effected.

Since 1975, the Urban Mass Transportation Administration has required, as a condition for federal funding support, a structured process termed alternatives analysis for proposed major investments in urban mass transit facilities. This process is used to identify priority corridors for possible major investments and to assess the cost-effectiveness of these investments in comparison to less costly transit improvements. Information generated in the process is used both by federal officials in administering a discretionary capital grant program and by state and local officials in determining priorities and identifying needed improvements in mass transportation services. Three important decision points occur within the UMTA major transit investment planning process. First, appropriate local officials identify the corridor(s) where major investments appear to be most needed. Second, local and federal officials agree on a small set of investment alternatives that encompass a reasonably broad range of options. Finally, local, state, and federal officials agree on one (or more) of these alternatives for advancement into preliminary engineering.

Since the advent of the alternatives analysis requirement, a significant number of urban areas have been involved in some aspect of the process. Concerns have been expressed with the process. For example, there is uncertainty regarding both the effect on the timing of transit investment decisions and the use of information in the federal review process and in local decision-making. Although adjustments to the process have been made to enhance its usefulness in local, state, and federal decision-making, no comprehensive assessment has been made of the degree to which the analytical requirements have provided appropriate information at key decision points.

There is a need to evaluate past experience with alternatives analysis and to recommend improvements in the process that will result in more effective local, state, and federal decision-making. Such an assessment would be useful, for example, in identifying points where decision-makers have not had complete information, where the process has constrained appropriate decisions, or where significant efforts are invested in the development of information that is not used in decision-making. Although it is unclear what direction federal policy will take in regard to alternatives analysis, the need for some form of alternatives analysis for such investments will continue.

The general objective of this research was to assess the federal, state, and local decision-making process for major urban mass transportation investments by evaluating recent alternatives analysis experiences. The purpose of the assessment was to identify potential improvements in policy, procedures, and use of technical information; and to formulate planning procedures recommendations for use by federal, state, and local agencies. Such improvements were in terms of time, cost, scale, presentation of information, role of participants, and the like. (The assessment is not intended to prescribe specific analytical techniques or to judge the appropriateness of previous major urban transit decisions.)

Research has been completed and the report published as:

NCTRP Report 4, "Improving Decision-Making for Major Urban Transit Investments.

AREA 38: SYSTEM PLANNING

Project 38-1 FY '81

National Transit Computer Software Directory

Research Agency:	COMSIS Corporation
Principal Invest.:	David M. Levinsohn
Effective Date:	January 3, 1983
Completion Date:	April 30, 1984
Funds:	$100,000

Over the past decade, computer (software) systems have gained widespread acceptance as important management and operating tools in public transit agencies. Representative software applications include planning (UTPS), scheduling (RUCUS), operations control, maintenance (SIMS), finance, and personnel. It is estimated that the public transit industry spends several million dollars each year on the design of software. Because there are great similarities in the structure and operation of transit agencies, software developed by one agency can often be adapted for use by other agencies with much less cost and effort than custom-designing completely new software. The lack of knowledge of existing software and its applications results in the spending of significant amounts of money by many transit agencies to develop new software that may not be as effective as it could be or may be "reinventing the wheel." Therefore, there is a need for the design and implementation of a detailed and complete national transit computer software directory that can be continuously updated to function as a central clearinghouse, making information available to individual public transit agencies that are planning software development. The anticipated benefit from the design and implementation of the directory is lower costs for software users. Use of the directory should lead directly to commonality of systems, faster software implementation, and public domain software that can be obtained at minimal cost. The benefit of identifying and using transportable software can only be realized if there are provisions for maintenance of the directory on a continuing basis.

The objective of this research is to develop and pilot test a methodology for the establishment and continuous updating of an automated directory of computer software useful to the public transit industry. The directory will have the capability of including (1) software suitable for use by transit agencies of all sizes, and (2) existing and future software for use on computers of all types and sizes.

To accomplish the objective, the following tasks are being conducted:

Task 1—Directory Content. Review and cite the applicable literature describing the availability of computer

software programs for use by public transit agencies. Examples of such references include, but are not limited to, the American Public Transit Association (APTA) "Catalog of Management Information System Applications within the Transit Industry," the American Association of State Highway and Transportation Officials (AASHTO) "Computer System Index," and work of the Institution of Transportation Engineers (ITE). Using these references, and in consultation with the transit industry as appropriate, the researchers will propose content, structure, and format for a directory of computer software. The content of the directory will focus on the principal categories of transit operation, such as finance, operations, maintenance, administration, planning, as well as others deemed appropriate.

Task 2—Methodology. The researchers will investigate existing information systems, such as the Transportation Research Information System (TRIS), the International Road Research Documentation, and others, to evaluate their capabilities regarding the recommended directory as part of those existing systems. The researchers will review and evaluate other methods of designing and maintaining the automated transit directory. This evaluation should include:

- Description of methods reviewed.
- Review criteria used.
- Pros/cons of each method.
- Recommended method.

Task 3—Management Procedures. The ultimate success of this project requires the existence of an organization (not yet identified) that will be responsible for the provision and maintenance of an up-to-date directory. The researchers will define the management function required of this organization. This function will be based on a thorough examination of existing software directories and their deficiencies. The management function should assure that the system will serve the need of both large and small transit agencies.

Task 4—Case Study. As a means of demonstrating the capabilities of the proposed methodology, the researchers will provide an updated "1980 APTA Catalog of Management Information Systems Applications within the Transit Industry." This catalog is to be provided in both hardcopy and machine-readable format. It should contain all of the data elements as defined in Task 1.

Task 5—Directory Maintenance. Evaluate and recommend potential organizations that can provide the management functions as described in Task 3.

Consideration must be given to the following issues:

- How and by whom should the directory be maintained?
- How should directory information be disseminated?
- What will be the estimated cost of this function?
- What permanent funding sources are recommended?

Because the ultimate selection of the organization to maintain the directory will depend on these issues, a complete discussion should be provided, particularly with respect to recommending funding sources; including consideration of applicable laws, regulations, policies, and institutional inter-relationships.

Research is nearing completion. The content, structure, and format for the directory have been developed and the microcomputer d BASE II system by Ashten-Tate has been selected for use. Management procedures for maintenance and updating of the directory have been identified. The case study task of the project is currently being conducted. The preliminary draft final report is expected to be submitted in January 1984.

AREA 39: ROUTE PLANNING

Project 39-1 FY '81

A Modular Approach to On-Board, Automatic Data Collection Systems

Research Agency: The MITRE Corporation
Principal Invest.: Lawrence E. Deibel
Effective Date: November 1, 1982
Completion Date: April 30, 1984
Funds: $148,787

Current economic conditions require that a transit system improve productivity while making the best use of limited resources. Increasing emphasis is being placed on improving route productivity through such means as better schedules, on-time performance, and service allocation. These requirements place an increasing importance on good ridership and schedule adherence data so that responsible decisions on routing and scheduling can be made. In addition, fare-box revenue is becoming increasingly important to the stability of transit systems. Accurate fare payment information by fare category is needed to calculate effects of alternative fare adjustment proposals, including an analysis of the equity of fare structures. The need for ridership, schedule adherence, and fare information is expected to continue for the foreseeable future.

Currently the most predominant form of gathering ridership data in the transit industry is collecting data manually by ride checks or load (point) checks. Information gathered in this manner is expensive to collect and process, limited in scope, and usually infrequent because of the number of "checkers" required. For example, some systems have reported that a point check may provide accurate load data at one location, but may understate true route ridership by as much as 50 percent. Fare/revenue data are generally available only on a systemwide basis. Special efforts that usually rely on driver participation or cumbersome fare-box handling are required to collect route-level fare-payment information.

In recent years, a few transit systems have turned to automated methods to collect ridership, schedule adherence, and fare data. The levels of sophistication of these systems have varied from real-time data collection and analysis systems to more basic systems that provide information in summary form on an historical basis. Although, in general, transit properties that have used these

automated systems have been satisfied, widespread use has not occurred.

There are several reasons why the majority of transit systems have not implemented automated technology: (1) a general lack of understanding of the options available in terms of hardware to provide the information; (2) an uncertainty as to how much of what type of hardware and software is needed; (3) the lack of commitment by transit management to implement the technology; (4) the difficulty in quantifying benefits, together with costs, and in determining the net benefit to the transit system; (5) the general unavailability of funding for much of this equipment at the federal level; and (6) the lack of standardization of functional requirements of the technologies, which, in turn, dampens the availability of hardware and discourages manufacturer participation.

The general objective of this research is to develop requirements and implementation guidelines for the use of automated on-board passenger/fare information collection systems. The system hardware should be constructed on a modular basis. Depending on the complexity of information desired, the modules should include, but not be limited to: (1) basic passenger counters (e.g., treadle, infrared), (2) location detection devices (e.g., odometer, signposts), (3) fare category counter (e.g., electronic fare-box), and (4) data storage/retrieval equipment (e.g., radio, cassette, solid state). Functional specifications for each of these systems are to be developed so that one module or component is compatible with another regardless of manufacturer. Requirements for modules or components will depend on the decisions a transit property must make, which, in turn, determines the level of detail the data collection system must provide. The levels of detail range from systemwide information to detailed stop-by-stop information. The system should be designed so that a transit property can choose, in modular fashion, the level and type of hardware needed for the data desired. Research to satisfy the general objective will require the following tasks:

Task 1. Review existing literature and acquire other information as needed to determine the state of the art of automated data collection systems and information needs requiring passenger counts, schedule adherence, and fare data.

Task 2. Determine modular hardware requirements to provide the information desired for various levels of decision-making. Standardize the functional requirements and develop uniform specifications for the hardware by module type. Upon completion of this task, a technical paper containing the specifications will be submitted to NCTRP for review.

Task 3. Develop methods to permit transit properties to select the modules and supporting hardware in sufficient quantity, on the basis of a sampling plan, to meet their data needs.

Task 4. Develop a format for quantifying all benefits and all costs so that a transit property can determine the overall net benefit compared with alternative means of collecting the data.

Task 5. Investigate other considerations that affect implementation, such as labor restrictions, organizational commitment, and maintenance support capability.

Task 6. Define data processing requirements (hardware/software) and develop flow charts that describe how various outputs can be produced using the data collected together with such external information as schedule data or mileage data.

Task 7. Prepare a manual that describes the methods a transit property would follow to design, select, and implement an automated ridership and fare data collection system. Recommend two (2) transit properties of different sizes to test the application of the manual.

Task 8. Demonstrate the validity of the procedures in the manual by applying the techniques to the two (2) transit properties and revise the manual accordingly.

Task 9. Prepare a technical specification for procurement that describes the electronic/mechanical requirements of the module interfaces.

Task 10. Prepare a final report that includes the revised manual as a stand-alone appendix.

Tasks 1 through 7 are complete. Draft functional specifications for the modular hardware requirements were submitted as required under Task 2. The specifications were reviewed by the NCTRP project panel and several others representing transit agencies and industry. The specifications will be finalized and included with the final report. The design manual for Task 7 was also submitted and reviewed by the project panel. Test applications of the manual (Task 8) will begin soon in Seattle, Washington, and Norfolk, Virginia. Based on the field tests and review comments, the design manual will be revised and also included with the final report as a stand-alone section. Both agency draft reports on the functional specifications for hardware and the design manual are available on a loan basis (see final page of this section for ordering information).

AREA 40: IMPACT ANALYSIS

Project 40-1 FY '81

Simplified Guidelines for Evaluating Transit Options in Small Urban Areas

Research Agency:	Barton-Aschman Associates, Inc.
Principal Invest.:	Dr. David R. Miller
Effective Date:	October 25, 1982
Completion Date:	April 23, 1984
Funds:	$149,960

Small transit systems, as well as larger systems, are caught in a continuing struggle of determining the impacts of transit system investment decisions on users as well as on the community at large. The actual impacts of a transit system are difficult to determine. In addition to the obvious potential impacts, such as changes in vehicle-miles of travel, fuel consumption, pollution, etc., there is also a group of not-so-obvious impacts that relate to the costs

and benefits of a transit investment (e.g., vehicle accidents, peak-hour congestion, traffic volume changes, commercial parking space requirements, and changes in future capital costs for street construction). Nonquantifiable impacts must also be considered, such as changes in mobility for the economically disadvantaged and for those who cannot drive (i.e., handicapped, elderly, and young people).

To ensure that city managers and councils have information on which to make intelligent and consistent appraisals pertaining to such investments, many types of factors must be fully considered. Typical factors are (1) socioeconomic (e.g., percentage of elderly population, minority population, cronic unemployment problems, diversity of existing industries, existence of large institutions), (2) political (e.g., attitude of the "affected parties," social-economic advocate groups), (3) current local concerns (e.g., ecology, air quality, traffic congestion), (4) business decisions, and (5) geographic (e.g., climate, topography, proximity to major urban areas).

Transit planning methods for cost-benefit analysis and for alternatives analysis have been well documented in studies sponsored by AASHTO, FHWA, UMTA, and the Office of the Secretary, U.S. DOT. Typically, however, these studies have been too complex and, in many cases, too data intensive for understandable public presentation and use in small cities. Therefore, research is needed to prepare a technically based, yet *simple,* analytical tool for use in the public decision process relating to the potential impacts of transit alternatives.

The objective of this research is to develop procedural guidelines for use by transit and municipal agencies in guiding their analysis of proposed transit and paratransit alternatives and in presenting their proposals to the decision-making bodies. Use of these guidelines will result in the public's better understanding of proposed investments for a new transit system or improving an existing system. Also, increased use of sound cost-benefit techniques to safeguard against inadequate analyses should result from the availability and use of these guidelines.

Draft guidelines have been developed using the best available techniques to describe how to handle both priceable and nonpriceable factors. Equity and distribution questions of who pays and who benefits are considered. The guidelines have been designed for application by nontechnical persons and are directed to the types of decisions faced in urban areas up to 200,000 population. Such considerations as total costs, avoided costs, transportation alternatives, ridership, urban development factors, conservation of energy and other resources, and typical transit evaluation criteria are included.

Priceable and nonpriceable factors are included in the guidelines to address the specific concerns of small urban areas (i.e., the factors that are important to the community, city council, etc.). These factors cover the anticipated impacts on the transit system itself, on transportation in general, and on the community at large (nonuser impacts). Relevant resource materials have been assembled that have applicability to the evaluation of alternatives for public transit. Information requirements, availability, and sources used in existing analysis techniques have been assessed in relation to the actual needs of small areas.

In addition, an educational and portable package is being developed for use in demonstrating the analysis procedures and the factors considered in evaluating transit improvements and alternatives. The package will be suitable for presentations to city councils and transportation planning boards and will be adaptable to local situations.

Project 40-2 FY '82/'83

Estimating Incremental Costs of Bus-Route-Service Changes

Research Agency: System Design Concepts, Inc.
Principal Invest.: Harry S. Cohen
Effective Date: November 15, 1983
Completion Date: August 15, 1985
Funds: $150,000

In the face of continuing financial pressures on and within the transit industry it is increasingly important to allocate resources in the most effective manner. Accordingly, a better understanding of the cost changes accompanying both service expansions and reductions is required.

To this end, various costing techniques have been developed and used by transit agencies to estimate the incremental or extra transit costs that stem from either service reductions or increases. Thus far there is some doubt about the reliability, accuracy, and applicability of these techniques, especially with respect to bus *route* (as opposed to system) changes. As a consequence, there is a need to assess and validate available or improved techniques to provide simple, but more reliable and accurate, methods for estimating the incremental (or additional variable) costs stemming from service changes on bus routes.

The objective of this research is to develop simple, reliable procedures that permit transit agencies to estimate the incremental cost implications of various bus-route-service changes in a variety of operating environments (e.g., those of differing density, system size, and the like). In a broad context, it should provide a means for helping to address the question: If a specific service should be changed, what is the incremental change in cost? More specifically, it should provide procedures that identify the incremental short-run costs to transit agencies of changes in bus-route-service frequencies (seasonal, day of week, time of day), expanding, curtailing or eliminating routes, or changing periods of operation. The research should also build upon and extend previous cost-analysis studies.

The research approach will involve, but not necessarily be limited to, the following:

A. Identify and evaluate existing cost models (including those listed in the following citation: Booz-Allen Inc., "Bus Route Costing Procedures: A Review," UMTA Report No. IT-09-9014-81-1, May 1981. Available from the National Technical Information Service, Springfield, Va. 22161, NTIS No. PB-82-105198, cost $13.00).

B. Review/update current industry practice (this should consist of polling properties to determine the models (or rules of thumb) that they currently use).

C. Develop simplified incremental cost estimation procedures. Criteria suggested are:

1. Simplicity (emphasis should be on a reasonable level of accuracy with a limited number of variables, and be easy to compute and apply).
2. Minimization of data collection requirements.
3. Wide range application in terms of system size, type, route, and type of changes.
4. Easy update of the cost variables to reflect expected changes in component costs.
5. Design that facilitates the orientation of key staff (scheduling, maintenance, and others) to incremental costing methods.
6. Design that lends itself to intuitive interpretation of results so that it is easy to explain to decision-makers and is viewed as reflecting reality by transit staff.
7. Design that is disaggregate in nature so that it can be used to evaluate individual routes or frequency changes.
8. Consideration of the effects of fixed and variable costs, different management operating policies, different contract work rules, different service contracting procedures, and cost changes that occur both before and after rescheduling.

D. Prepare an interim report that summarizes the findings for review by the NCTRP.

E. Develop and implement a testing method for validating the proposed procedure(s) and comparing the results with those for existing procedures. Consideration should be given to existing procedures, such as the two-variable cost model (bus-hours and miles), the Adelaide model, the Booz-Allen model developed from the UMTA bus-route-costing study, and the procedure currently being used by the participating study agency. It is anticipated that the procedure will be tested at three transit agencies—a large agency (over 200 buses), a medium-sized agency (100 to 200 buses), and a small rural Section 18 agency (less than 100 buses). As a minimum the testing will address the following types of bus-service changes:

1. Effect of service changes at various times of day, days of week, and season.
2. Effect of route extensions or contractions.
3. Effect of route consolidations, additions, and deletions.
4. Effect of service frequency changes.
5. Effect of hours of service changes.

It is desirable that the incremental cost be measured both before and after run and driver assignments. Testing refinement should be done iteratively as appropriate.

F. Identify planning—policy implications and develop typical applications.

1. Show how procedures can help (a) assess service alternatives, including deficit/revenue implications; and (b) make strategic service change decisions.
2. Give sample prototypical applications of procedures.

G. Prepare a draft report for review by the NCTRP.

H. Revise the draft report and submit the final version in fulfillment of the technical obligations under the contract for the project.

Research has begun on Tasks A through C. Substantial progress has been made assembling relevant literature to update current industry practice documentation.

Project 40-3 FY '82/'83

Strategies to Implement Benefit-Sharing for Fixed Transit Facilities

Research Agency: SG Associates
Principal Invest.: Jane A. Howard
Effective Date: November 1, 1983
Completion Date: February 1, 1985
Funds: $99,957

Fixed transit facilities, such as transit terminals, rapid transit stations, and LRT lines and stops, generate substantial passenger traffic and improved accessibility. Consequently, space in the vicinity of such facilities may become more valuable because of its potential for higher intensity use. Opportunities for sharing benefits occur in the development of new transit facilities, the direct connection of developments to transit facilities, the use of air rights over transit rights-of-way, and the development of other real estate holdings. Furthermore, as a consequence of building fixed transit facilities, various other public facilities and utilities are rehabilitated. These opportunities for benefit-sharing by transit agencies are frequently lost, however, because they are not an important consideration in the planning and design phases (i.e., in the location and design of routes and stations).

There is little quantitative information available to transit agencies to assist them in formulating benefit-sharing approaches and arriving at reasonable charges or other contributions for these transit benefits. Therefore, in order to assist operators in planning and financing transit facilities, there is a need to provide (1) information about existing practices, (2) insights into the development process, (3) guidance in relating to private and public sector beneficiaries, and (4) strategies for negotiating benefit-sharing.

The general objective of this research is to assist transit agencies in implementing benefit-sharing. To accomplish this objective, a synthesis of existing information on development-related benefits followed by case studies is required. The report will be written primarily for use by transit planners, operators, and designers, and will reflect the concerns of policy-makers (government officials) and business organizations.

A three-part research approach is suggested, as follows. Part I, addressing items 1 through 6 and comprising not more than one-third of the research effort, consists of a broad-based investigation of the development impacts of fixed transit facilities. It is to be based on a review of the literature and current practice, and will conclude with an interim report. Part II, pertaining to items 7 and 8 and comprising one-third to one-half of the research effort, covers an in-depth study of experiences in implementing

benefit-sharing. Part III, consisting of items 9, 10, and 11 and comprising the balance of the research effort entails (1) the development of generalizations from the interim report and case studies, and (2) preparation of the draft and final reports.

Part I

1. List fixed transit facilities likely to produce benefits to organizations in the public and private sectors. Include rail and bus stations as well as LRT lines/stops.

2. Identify and describe the benefits. These benefits may accrue to property owners and businesses as increases in land value and economic activity. They may also be realized by the public in the form of improved streets and traffic circulation, reconstructed utilities, provision of transit rights-of-way, and new recreation facilities.

3. Describe methods to measure benefits.

4. Identify and describe such benefit-sharing techniques as those provided in the following four categories:

a. *Planning and Acquisition*
   (1) Contributing of land for rights-of-way, stations, and parking facilities by developers or townships.
   (2) Purchasing of extra land for land-banking (e.g., for later conversion of parking into more intensive land use).
   (3) Selling air rights.
   (4) Sharing facilities (e.g., parking in shopping centers, intercity transit terminal).

b. *Design and Construction*
   (1) Providing concession facilities.
   (2) Constructing station accesses by developers.
   (3) Constructing special features by developers (e.g., lighting, plazas, escalators, LRT platforms).
   (4) Locating and designing facilities to preserve development options.

c. *Public infrastructure*
   (1) Rehabilitating utilities.
   (2) Improving street reconstructing and beautification, plazas, malls, etc.
   (3) Improving traffic through intersection channelization, pedestrian underpasses, skywalk systems, etc.
   (4) Establishing parks and recreational areas.

d. *Special Financial Arrangements*
   (1) Creating special assessment districts.
   (2) Establishing tax increment financing.

5. Identify transit agencies that have attempted or are attempting to share transit costs with private and public beneficiaries. Transit agencies should be described by at least (1) organizational context (ownership and operation), (2) benefit-sharing techniques, (3) transit system characteristics, (4) benefit assessment techniques, and (5) character of local economy. Propose case studies, four of which should be concerned with each of the four benefit-sharing categories noted in item 4.

6. Prepare the Interim Report (addressed earlier) on items 1 through 5.

Part II

7. Select transit agencies for an in-depth study of successes and failures in benefit-sharing. Prepare the interview design and conduct the case studies.

8. Evaluate experience with benefit-sharing to identify elements contributing to or impeding implementation.

Part III

9. Develop recommendations for transit agencies to follow in implementing benefit-sharing practices.

10. Prepare a draft report for review by the NCTRP.

11. Revise the draft report and submit the final version in fulfillment of the technical obligations under the contract for the project.

Research has begun on items 1 through 5. Relevant literature has been obtained to serve as the basis for describing benefits and benefit-sharing techniques and to identify potential transit agencies for the case studies.

AREA 43: TRACK AND ANCILLARY SYSTEMS

Project 43-1 FY '81

Detection of Low-Level Fault Currents on Rail Transit Systems

Research Agency:	Chas. T. Main, Inc.
Principal Invest.:	Navan S. Sagar
Effective Date:	January 3, 1983
Completion Date:	April 2, 1984
Funds:	$99,953

Devices presently in use by the rail transit industry can adequately detect and respond to overload fault currents. Detection of less than overload fault currents is particularly difficult because the fault current characteristics tend to resemble characteristics normally associated with train or power switching operations. Rapid and reliable detection of low-current electrical faults on direct-current rail transit systems would provide a significant improvement to safety and operation of these systems.

The objective of this research is to identify and evaluate detection methods and equipment to enhance transit system safety through reliable detection of electrical faults that are not detected by circuit breaker overload protection. Cooperation by transit systems and associated industries is essential to the success of the project, inasmuch as this research seeks a solution that can easily be adapted to various transit systems.

To accomplish this objective, the following tasks will be conducted:

Task 1. Perform an in-depth survey of rail transit systems worldwide, under the auspices of an international institution, such as the International Union of Public Transport, to determine how the problem being researched

is handled on each system. Concurrently, survey the electrical industry organizations and suppliers worldwide for methods and equipment that are potential solutions to the detection problem. Review the work of other industries that may also be relevant to the problem and its solution.

Task 2. Using information obtained in Task 1, identify the electrical system characteristics that will define the parameters of the required detection systems for various types of vehicle propulsion systems and network configurations.

Task 3. Using the parameters developed in Task 2, determine the extent to which available methods and equipment meet the research objectives.

Task 4. Prepare a final report describing the research and its results, including a detailed evaluation of the performance and economics of available methods and equipment.

Research is in progress. Survey forms for collecting information from transit agencies have been prepared, reviewed, and pilot tested with several agencies. After revisions, the survey forms were distributed to all transit agencies and other organizations in the United States. The forms have been translated into French and German and distributed to transit agencies outside the United States by the International Union of Public Transport. Because of several unavoidable delays in the conduct of Task 1, the in-depth survey of rail transit systems worldwide, the project is about 3 months behind schedule. Inasmuch as the survey information provides the basis for the conduct of the other tasks, it is not likely that the delay can be recovered.

Project 46-1 FY '82/'83

Single Cable Communications Technology for Rail-Transit Systems

Research Agency:	Polytechnic Institute of New York
Principal Invest.:	Dr. Frank A. Cassara
Effective Date:	To Be Determined
Completion Date:	
Funds:	$150,000

Rail-transit systems vary from those that have been in existence since the early 1900's to systems presently under design. These systems have typically used, or are planning the use of, multiple cables for the transmission of voice, data, and video information. The various cables provide for long-haul trunk facilities and access to local distribution networks. Additionally, the necessity for VHF or UHF-FM radio transmissions in underground portions of the system may require a separate radiating (or leaky) coaxial cable.

The large numbers of multipair and special-use cables used are expensive to install and maintain. A reduction in the number of cables needed for the communication requirements of transit systems can result in reduced acquisition, installation, and maintenance costs. The ultimate goal of this research is to replace all special-use cables with a single, multipurpose cable.

The objective of this research is to identify and develop recommended system parameters that will permit use of a single, multipurpose, wideband cable to support all rapid-transit communications requirements including, but not limited to: voice, data, video as well as VHF or UHF-FM two-way radio signals. For reliability, the single-cable concept should allow for a backup cable and cable span switching equipment. This research proposes a nonsite-specific solution that considers retrofits and extensions to existing rail-transit systems as well as the requirements of new systems. Proposed solutions to the reduction in the number of cables should include consideration of coaxial cables, fiber optics, and other viable technologies. Any proposed solution must also take into account compatibility with existing communications equipment and systems, improved reliability and maintainability, reduced life-cycle costs, and system expansion (extension and spare capacity).

To accomplish the objective of this research, the following tasks are required:

Task 1. Survey the current communication systems and installation practices of rail-transit agencies to define the scope of the problem. (Some information on North American systems may be available at APTA.) Concurrently, survey the electronic industry for developments that offer potential solutions. Review the work of railroad, mining, and other industries that may be relevant to the problem and its solution.

Task 2. Establish the operational parameters that will be required for a single-cable communication system(s). Generate a range of technical characteristics that will define the nature of the proposed cable system(s) and its (their) configurations.

Task 3. Using the operational parameters and cable characteristics developed in Task 2, prepare design criteria to establish the technical and economic feasibility of the single-cable concept. Submit a fully documented feasibility study showing all alternatives studied and the recommended solution(s) for review and approval by the NCTRP.

Task 4. Using design criteria established in Task 3, prepare a system description in sufficient detail so that user agencies can prepare procurement specifications for specific applications. In addition, prepare a sample system design for a hypothetical 10-mile rail-transit system (5 miles underground and 5 miles on the surface) that includes basic equipment elements, local distribution networks, and its attendant costs.

Task 5. Prepare a draft report for review by the NCTRP.

Task 6. Revise the draft report and submit the final version in fulfillment of the technical obligations under the contract for the project.

AREA 47: GENERAL MATERIALS

Project 47-1 FY '80

Improved Service Life of Urban Transit Coach Brakes

Research Agency: Battelle Memorial Institute
Principal Invest.: Dr. Allen T. Hopper
Effective Date: December 1, 1981
Completion Date: May 31, 1984
Funds: $300,000

The operation and maintenance history of advanced design urban transit coaches shows a dramatic decline in brake life compared with early "new look" coaches. Major factors associated with this decline in brake life appear to be, but are not limited to: increased gross vehicle weight, increased operating speed, body configuration, and changed regulations.

The resultant increased brake temperatures are believed to be the cause of reduced brake life that has increased operational costs to unacceptable levels. Therefore, the need exists to identify and develop methods to increase brake life to previous levels.

The overall project objective is to develop methodologies for improving existing and future urban transit coach brake life. This will include quantification of in-service brake operating temperatures plus identification of methods of reducing brake operating temperatures and/or alternate friction materials.

The project objective will be accomplished in two phases. Phase I will include the following tasks:

Task 1. Confirmation of the premise that temperature is the cause of reduced brake life by the collection and evaluation of brake operating temperatures. This is to be accomplished in cooperation with a major metropolitan transit operator that has experienced the problem. As a minimum, temperature levels will be established for advanced design and early "new look" transit coaches.

Task 2. Development of practical methods for reduction of operating temperatures and/or identification of friction materials for compatibility with the service temperatures determined in Task 1. The following factors must be considered: (a) adaptability to coaches in service, (b) initial and operating costs, (c) regulations, (d) serviceability, (e) reliability, (f) public acceptability, and (g) feasibility.

Task 3. Cost-benefit prioritization of methods for increasing brake life based on Tasks 1 and 2.

Task 4. Preparation of an interim report with recommendations for implementation of Phase II demonstration.

The Phase II effort will include:

Task 5. Demonstration of one or more suggested corrective methods based on selection by the panel from those recommended in Phase I. This will be accomplished in cooperation with a major metropolitan transit operator.

Task 6. Preparation and submittal of the final report.

Research is essentially completed on Phase I of the study. Accomplishment of Task 1 involved (1) detailed design and construction of brake drum and shoe instrumentation; (2) installation and trial testing of instrumentation on a bus in Columbus, Ohio; (3) obtaining and instrumenting brake drums and shoes for Los Angeles buses; (4) installation of instrumented brake drums and shoes on 3 buses in Los Angeles; and (5) collection of in-service brake temperature data from instrumented buses in Los Angeles. Brake temperatures of up to 600 F were recorded during the data collection activities. Accomplishment of Task 2 involved evaluation of temperature-wear properties of brake materials, development of a model for evaluating temperature reducing methods, and selection of retrofitting schemes for increasing service life of brakes. An interim report covering Phase I has been submitted and approved. Research is in progress on Phase II. Because of delays in obtaining equipment for the retrofitting, the completion date has been extended to May 31, 1984.

AREA 54: ENERGY EFFICIENCY

Project 54-1 FY '80

Improve Transit Bus Energy Efficiency and Productivity

Research Agency: Booz, Allen & Hamilton, Inc.
Principal Invest.: Archie M. Riviera
Effective Date: October 1, 1981
Completion Date: June 30, 1982
Funds: $39,976

Because of rapidly rising fuel prices and uncertain fuel availability, there is a critical need in the transit industry to improve energy efficiency. However, as a result of governmental regulation and other factors, the recent trend in bus technology has actually been toward poorer efficiency. For example, the Advanced Design Buses introduced in recent years require more energy than the buses replaced and, compounding the problem, also have fewer seats. Energy efficiency losses are due to many causes including requirements to satisfy environmental considerations, safety, styling, accessibility, and the like.

The objective of this research was to develop guidelines for transit property managers to follow in specifying a new bus. The researchers cataloged the basic types of equipment and options available in 35-ft, 40-ft, and articulated transit buses. Equipment and options include power train features; special equipment; standard component options; basic design and safety features; and environmental controls. Estimates of the relative energy consumption levels of the various items of equipment and options were developed. For each bus type and size, a baseline equipment configuration was specified and the energy-consumption characteristics of each option were related to the baseline. An approach was developed for estimating energy-efficiency characteristics of buses over the full range of operating environments (e.g., terrain, altitude, climate, maximum operating speed, number of stops per mile).

Research has been completed, and the final report has been published as:

NCTRP Report 1, "Transit Bus Energy Efficiency and Productivity—Bus Equipment Selection Handbook." This report includes a concise set of guidelines for use by managers of individual transit properties in selecting and specifying buses for purchase. The guidelines focus on the energy efficiency and productivity of different bus types, equipment, and options and are applicable to properties of all sizes and geographic locations. Sample data for vehicle characteristics are provided for illustrative purposes, but current vehicle data should be obtained from the manufacturers when using the guidelines.

Project 54-2 FY '80

Energy Management of Electric Rail Transit Systems

Research Agency: Carnegie-Mellon University
Principal Invest.: Dr. Richard A. Uher
Effective Date: October 1, 1981
Completion Date: December 31, 1983
Funds: $150,000

Rapidly increasing electric energy costs have resulted in a dramatic increase in operating expenses of transit authorities operating electric rail systems. This problem is further augmented by additional increases in rates being sought by electric utilities. The peak demand component of these rates is directly associated with the electric energy generation, transmission, and distribution facilities cost. As major electric energy consumers, transit authorities are subject to allocated costs associated with these facilities. If transit authorities can improve the management of peak demand on their systems, energy costs can be significantly reduced. Several transit authorities have developed strategies for: reducing peak energy consumption (such as load management), improving vehicle energy efficiency, and more energy efficient operating practices.

The objective of this research was to provide guidelines for transit authorities to lower peak electric demand and, thereby, lower costs.

The preliminary draft final report has been submitted and reviewed, and comments have been forwarded to the principal investigator. Data were collected from four transit agencies and analyzed to determine probable peak power demand cause factors. Monitoring strategies were identified for controlling peak demand and the costs of the various strategies were determined. Load management techniques were evaluated using simulation models. The contract was amended to provide for the preparation of a slide presentation on the project findings and to make the presentation to officials of individual rail transit agencies. Comments received during the presentations were considered in revising the final report.

Research has been completed and the report has been published as:

NCTRP Report 3, "Reduction of Peak-Power Demand for Electric Rail Transit Systems."

AREA 55: PERFORMANCE EFFECTIVENESS AND EFFICIENCY

Project 55-1 FY '82/'83

Conversion to One-Person Operation of Heavy-Rail Rapid-Transit Trains

Research Agency: Battelle Memorial Institute
Principal Invest.: Joseph A. Hoess
Effective Date: To Be Determined
Completion Date:
Funds: $150,000

There is increasing pressure to provide more cost-effective operation of heavy-rail rapid-transit trains. A major candidate for improving productivity is reduction of crew size to one person. This has been accomplished in the following systems:

- Lindenwold/Philadelphia—Port Authority Transit Corporation
- San Francisco—Bay Area Rapid Transit District
- Washington, DC—Washington Metropolitan Area Transit Authority
- Atlanta—Metropolitan Atlanta Rapid Transit Authority

The reduction will soon be implemented in Miami and Baltimore.

The older rapid transit systems, however, continue to require a second crew member aboard each train. These systems include the following:

- Boston—Massachusetts Bay Transportation Authority
- New York—New York City Transit Authority
- New York/New Jersey—Port Authority Trans-Hudson Corporation
- Philadelphia—Southeastern Pennsylvania Transportation Authority
- Cleveland—Greater Cleveland Regional Transit Authority
- Chicago—Chicago Transit Authority

To provide one-person operation on the older rapid transit systems, it will be necessary to address problems at least in the areas of:

1. Operational safety.
2. Operational practices.
3. Manpower/labor relations.
4. Regulatory matters.
5. Plant and equipment.

The objectives of this research are (1) to evaluate the issues that must be addressed in contemplating conversion of two-person systems to one-person operation including the identification of those issues unique to the particular system and (2) to develop a framework for an economic assessment of the effects of implementation of one-person operation. The research should include, but not be limited to, the following tasks:

Task 1. Perform a survey of each two-person heavy-rail rapid-transit system in the United States to determine the specific issues or problems that need to be addressed if such system were to be converted to one-person train operation. This survey shall be based on consultation with organizations including system management, employee representatives, regulatory agencies or advisory boards, and other appropriate organizations.

Task 2. Perform a survey of one-person conversions implemented by heavy-rail rapid-transit systems in Europe and identify the issues and problems addressed; the methods of solving them; and the effectiveness of such solutions as measured by such indicators as operational efficiency and reliability, safety statistics, and changes in the workforce. These systems shall include, but not be limited to, London, Paris, Hamburg, and Berlin.

Task 3. Evaluate the issues and problems identified in Tasks 1 and 2 as they would affect the conversion to one-person operation from the technological, operational, institutional, and human resource perspectives. The evaluation shall include the need for, and degree of, recommended application of closed-circuit TV, automatic train operation, radio communications, and other elements.

Task 4. Prepare a framework for an economic assessment of the effects of implementation of one-person operation. This framework shall include identification of cost elements that must be considered in a site-specific analysis and plan such as:

a. Changes to car equipment.
b. Changes to wayside and station equipment.
c. Changes in workforce, such as reduction in train crews and additions to wayside equipment maintenance staff.
d. Operating practice revisions.
e. Changes in wage rates resulting from implementation of one-person operation.

AREA 60: SPECIAL PROJECTS

Project 60-1 FY '80

Synthesis of Information Related to Transit Problems

Research Agency:	Transportation Research Board
Principal Invest.:	Thomas L. Copas
Effective Date:	November 7, 1980
Completion Date:	Continuing
Funds:	$460,000

Transit administrators, engineers, and researchers are continually faced with problems on which much information exists either in documented form or in terms of undocumented experience and practice. Unfortunately this information is often fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem is frequently not brought to bear on its solution. Costly research findings may be unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

In this project, particular transit problems, or sets of closely related problems, will be selected by the NCTRP Technical Steering Group as topics for information synthesis.

For each topic the objectives are:

1. To locate and assemble documented information.
2. To learn what engineering practice has been used for solving or alleviating the problem.
3. To identify all ongoing research.
4. To learn what problems remain largely unsolved.
5. To organize, evaluate, synthesize, and document the useful information that is acquired.

Through December 1983, research has been completed on the first four assigned topics. Two reports have been published as:

NCTRP Synthesis of Transit Practice 1, "Cleaning Transit Buses: Equipment and Procedures" and
NCTRP Synthesis of Transit Practice 2, "Enforcement of Priority Treatment for Buses on Urban Streets."

Two additional reports are in the NCTRP editorial and publication process:

NCTRP Synthesis of Transit Practice 3, "Effects of Fuel Additives and Alternative Fuel Grades for Transit Buses," and

NCTRP Synthesis of Transit Practice 4, "Guidelines for Allocation of Time for Transit Coach Maintenance Functions."

Research is in progress on the following five topics selected for study under the FY '82/'83 program: TS-5, "Extraboard Management Procedures and Tools"; TS-6, "Traffic Signing at Bus Stops"; TS-7, "Bus Communication Systems"; TS-8, "Passenger Information Systems for Transit Transfer Facilities"; and TS-9, "Transit Fare Collection: Problems and Alternatives to Paper Currency."

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