

NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

**SUMMARY OF PROGRESS
THROUGH 1985**

5
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NATIONAL RESEARCH COUNCIL

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NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

**SUMMARY OF PROGRESS
THROUGH 1985**

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

1985

NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT

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 and (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 Technical Assistance.

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 PTC for administration through the Transportation Research Board.

The Board operates under the National Research Council, which is administered by 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 PTC, and administration and surveillance of the contract work are the responsibilities of the PTC 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.

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Washington, D.C. 20418

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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 is responsible for operation of the TSG, the membership of which is as follows.

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JOHN DURHAM, *Office of Technical Assistance, Urban Mass Transportation Administration*

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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. Deane N. Aboudara.*)

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 Graeb (TRB Representative), R. Ian Kingham (NCTRP Staff).

NCTRP Research Field—Administration: Finance

Panel A31-2—Fern M. Cole (Chairman), Mary Kay Christopher, Thomas J. Cullinan, Si Dornfeld, Lloyd A. Gimple, Lap Thong Hoang, William F. McFarland, Joseph S. Silien, Ron Jensen Fisher (UMTA Liaison Representative), Kenneth E. Cook (TRB Liaison 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 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 PANELS—Continued

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), W. Campbell Graeb (TRB Liaison Representative), R. Ian Kingham (NCTRP Staff).

Panel B36-1(2)—Michael D. Meyer (Chairman), Don Bryan, Ken Goon, Kevin E. Heanue, Buford Johnson, Walter Kudlick, Lilian Liburdi, R. David Minister, Theodore von Briesen, Ted Williams, Kenneth R. Yunker, James M. Ryan, (UMTA Liaison Representative), W. Campbell Graeb (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 Graeb (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 Graeb (TRB Liaison Representative), Crawford F. Jencks (NCTRP Staff).

NCTRP Research Field—Planning: Impact Analysis

Panel B40-2—James C. Echols (Chairman), Judith A. Byman, Frank Davis, Jr., Herb Levinson, Byron Lee, Carl L. Natvig, Brian E. McCollom (UMTA Liaison Representative), W. Campbell Graeb (TRB Liaison Representative), R. Ian Kingham (NCTRP Staff).

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 E. 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—Materials and Construction: Specifications, Procedures, and Practices

Panel D48-1—Edward K. Farrelly (Chairman), Peter Contos, Jehuda Gross, Michael Sammon, Roger Staehle, Arthur A. Thue, Peter L. Todd, Robert J. Wilson, Fred L. Sing (UMTA Liaison Representative), Elaine King (TRB Liaison Representative), R. Ian Kingham (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—Verdi Adam (Chairman), R. R. Biege, Jr., 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 1985

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 and (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 Technical Assistance.

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 PTC for 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 spon-

sored 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.

PROGRAMS AND FINANCING

Four programs have thus far been referred to the PTC for administration, and a fifth 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 PTC on March 30, 1982. It consists of eight problems ranging in funding from \$30,000 to \$300,000. Two of these were designated

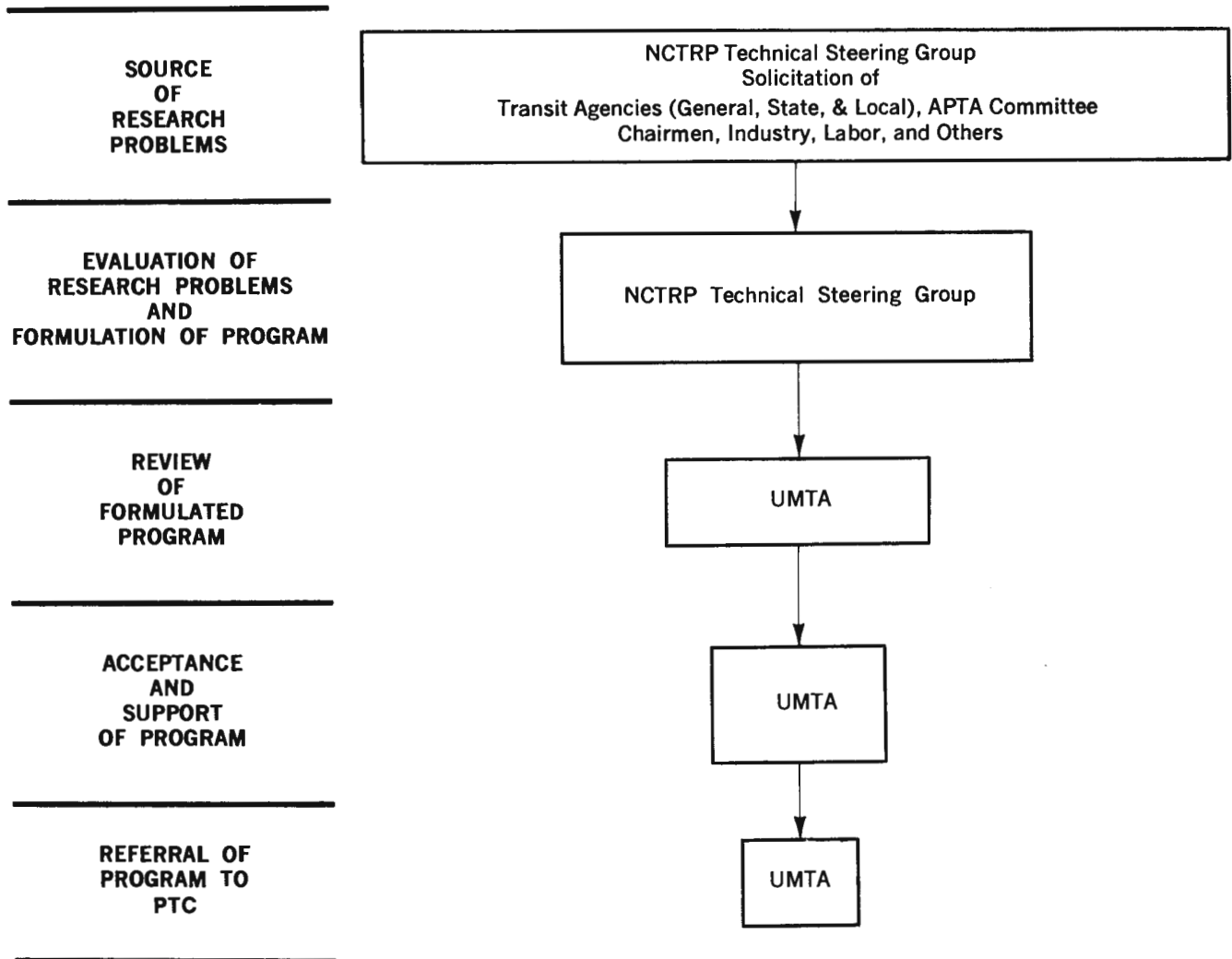


FIGURE 1

Flow diagram for each program from initiation to referral by UMTA for administration by the PTC

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 PTC 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.

The FY 1984 program was developed by the Technical Steering Group on February 1, 1984. Officially referred on May 10, 1984, to the PTC for administration at a project funding level of \$550,000 were six new projects, two of which were designated for subcontracting. The remaining four were slated for TRB syntheses. Incorporated later by agreement with the Associate Administrator, Office of Technical Assistance, was a \$30,000 allocation for follow-up work on Project 30-1. Because a modification to the prime contract was needed to provide the FY '84 funds, the May 10 referral restricted activity to only administrative functions until such time as the modification was effected. This occurred on August 15, 1984, and increased the contract funds by \$975,000, subsequent to which steps were taken toward initiation of technical work.

The FY 1985 program was developed on December 14, 1984, by the Technical Steering Group. It is projected at a funding level of \$800,000 and consists of three new projects, two continuation projects, and two syntheses. UMTA is reviewing the recommended projects for approval, following which action the projects will be referred to the PTC for administration. PTC subcontracting for research will not be possible until funds to support the program year have been made available by UMTA.

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 Subcommittee 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.

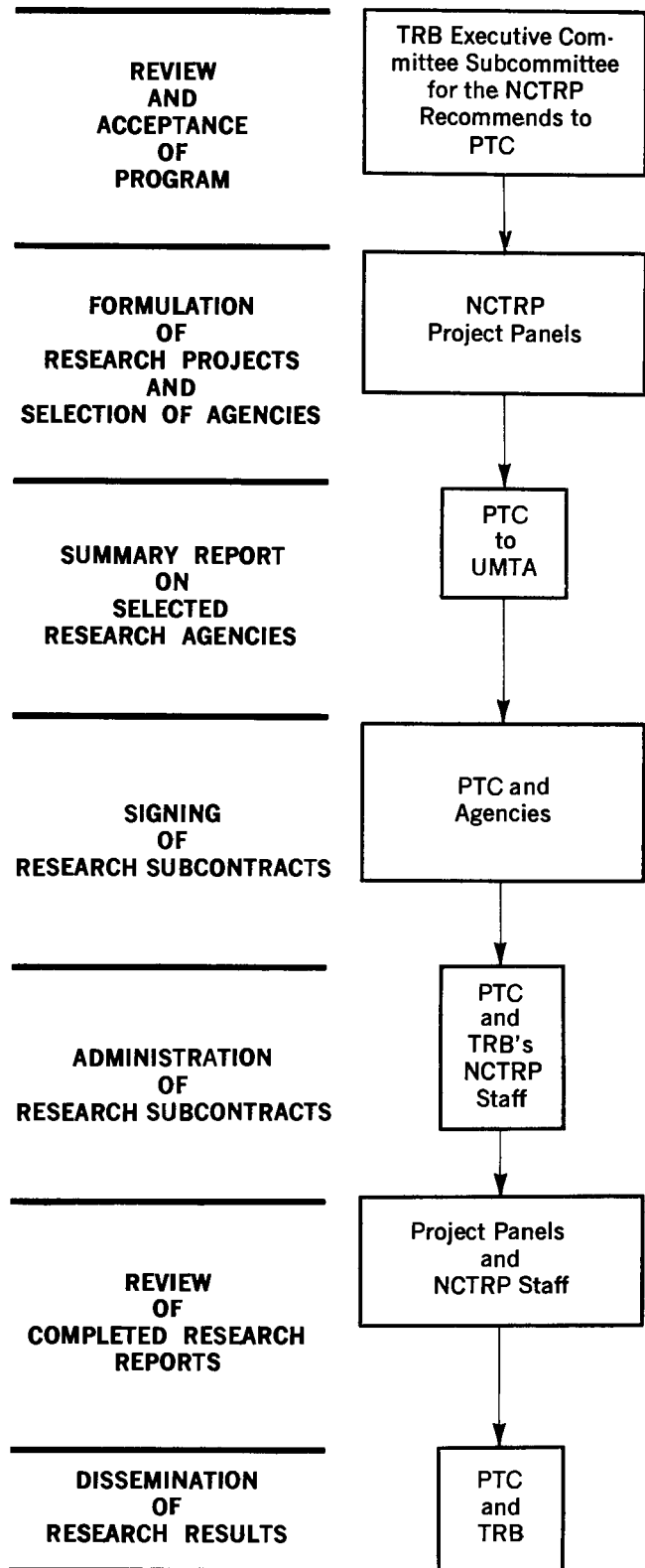


FIGURE 2

Flow diagram for each program after referral to the PTC

NCTRP RESEARCH FIELDS AND AREAS

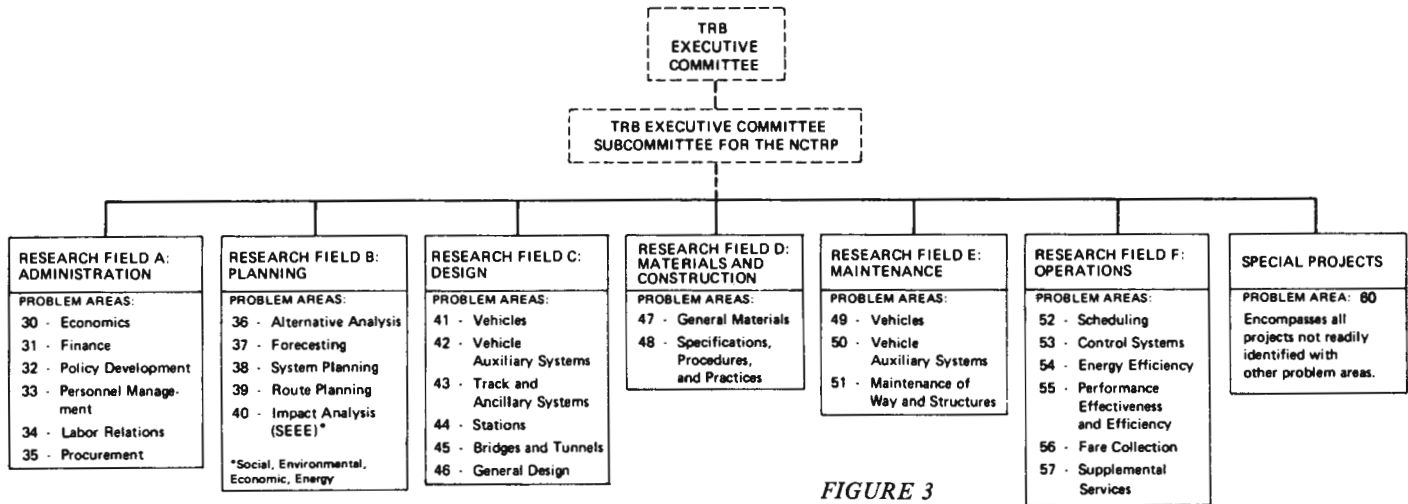


FIGURE 3

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 or advisors to project investigators. Some 148 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 28 States, the District of Columbia, Canada, and Turkey. Employees of transit operating agencies presently constitute 32 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 PTC, 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 NAS/NRC. Unacceptable problems are returned by the PTC 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

TABLE 1
DISTRIBUTION OF PROJECT PANEL
COMMITTEE MEMBERSHIP WITH
RESPECT TO AFFILIATION

AFFILIATION	NO. OF MEMBERS	POSITIONS INVOLVED
Transit Systems	51	56
State DOTs and Other Local Governmental Agencies	30	36
Urban Mass Transportation Administration	14	20
Other Federal Agencies	9	10
Educational Institutions	11	11
Research Institutes	0	0
Industry, Consultants, and Trade Associations	23	23
Professional Societies and Service Organizations	5	5
TRB Liaison Representatives	5	14
All	148	175

TABLE 2
NUMBER OF PROPOSALS SUBMITTED

ITEM	1981	1982	1983	1984	1985*
No. of projects advertised	6	6	5	—	2
Proposals submitted	77	71	52	—	18
Proposals rec'd per project (ave.)	13	12	10	—	9

* Calendar year

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 four program years (FY '80, FY '81, FY '82/'83, and FY '84) ranged from 6 to 25 per project, the average rate of return per project being 13, 12, 10, and 9, 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 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

TABLE 3
NUMBER OF AGENCIES SUBMITTING ONE OR MORE RESEARCH PROPOSALS

NO. OF PROPOSALS SUBMITTED	NUMBER OF AGENCIES SUBMITTING PROPOSALS				
	1981	1982	1983	1984	1985*
1	59	43	41	—	16
2	9	9	4	—	1
3	0	2	1	—	0
4	0	1	0	—	0
All	68	55	46	—	17

* Calendar year

TABLE 4
TYPES OF AGENCIES SUBMITTING PROPOSALS

TYPE OF AGENCY	NO. OF AGENCIES SUBMITTING				
	1981	1982	1983	1984	1985*
Educational institutions	20	11	15	—	4
Research institutes	7	4	3	—	2
Industry, consultants, and trade associations	40	39	28	—	11
Professional societies and service organizations	0	0	0	—	0
State DOTs and other governmental agencies	$\frac{1}{68}$	$\frac{1}{55}$	$\frac{0}{46}$	—	$\frac{0}{17}$
All	68	55	46	—	17

* Calendar year

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 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 by the PTC 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

TABLE 5
SUMMARY OF STATUS THROUGH DECEMBER 31, 1985, FOR FY '80 THROUGH FY '84 PROJECTS

PROJECT		RESEARCH AGENCY	SUBCONTRACT AMOUNT OR SUBCONTRACT COST (\$)
NO.	TITLE		
AREA 30: ADMINISTRATION—ECONOMICS			
30-1	Small Transit Buses: A Manual for Improved Purchasing, Use, and Maintenance	Arthur D. Little	\$299,378
AREA 31: ADMINISTRATION—FINANCE			
31-1	The Impacts of Federal Grant Requirements on Transit Agencies	Booz-Allen	49,522 *
31-2	Controlling Rising Operating Deficit Through Capital Investments	Fleet Maintenance	150,000
AREA 33: ADMINISTRATION—PERSONNEL MANAGEMENT			
33-1	Transit Bus Operator Selection and Training for Dealing with Stress	GAMS Inc.	150,000 *
33-2	Assessment of Job Enrichment Programs for the Transit Industry	Public Admin. Service	97,821 *
33-2(2)	Quality-of-Work Life Programs for the Transit Industry—Regional Seminars	Public Admin. Service	52,454
33-3	Public Transit Bus Maintenance Manpower Planning	Fleet Maintenance	100,000
AREA 36: PLANNING—ALTERNATIVE ANALYSIS			
36-1	Improving Decision-Making for Major Urban Transit Investments	System Des. Concepts	200,000 *
36-1(2)	Assessment of Current Planning Practice for Major Transit Investments	System Des. Concepts	30,000
AREA 38: PLANNING—SYSTEM PLANNING			
38-1	National Transit Computer Software Directory	COMSIS Corp.	98,457 *
38-1(2)	National Transit Computer Software Directory—Phase II	COMSIS Corp.	50,000
AREA 39: PLANNING—ROUTE PLANNING			
39-1	A Modular Approach to On-Board, Automatic Data Collection Systems	The MITRE Corp.	148,787
39-1(2)	A Modular Approach to On-Board Automatic Data Collection Systems—Seminar	The MITRE Corp.	26,141
AREA 40: PLANNING—IMPACT ANALYSIS			
40-1	Simplified Guidelines for Evaluating Transit Options in Small Urban Areas	Barton-Aschman	149,960 *
40-2	Estimating Incremental Costs of Bus-Route-Service Changes	System Des. Concepts	150,000
40-3	Strategies to Implement Benefit-Sharing for Fixed Transit Facilities	SG Associates	99,957 *
AREA 43: DESIGN—TRACK AND ANCILLARY SYSTEMS			
43-1	Detection of Low-Level Fault Currents on Rail Transit Systems	Chas. T. Main, Inc.	99,913 *
AREA 46: DESIGN—GENERAL DESIGN			
46-1	Single Cable Communications Technology for Rail-Transit Systems	Poly Inst of NY	150,000
AREA 47: MATERIALS AND CONSTRUCTION—GENERAL MATERIALS			
47-1	Improved Service Life of Urban Transit Coach Brakes	Battelle Mem Inst	300,000
AREA 48: MATERIALS AND CONSTRUCTION—SPECIFICATIONS, PROCEDURES, AND PRACTICES			
48-1	Corrosion Attributed to DC Powered Transit Systems	IIT Research Inst.	200,000
AREA 54: OPERATIONS—ENERGY EFFICIENCY			
54-1	Improve Transit Bus Energy Efficiency and Productivity	Booz-Allen	39,976 *
54-2	Energy Management of Electric Rail Transit Systems	Carnegie-Mellon	150,000
AREA 55: OPERATIONS—PERFORMANCE, EFFECTIVENESS, AND EFFICIENCY			
55-1	Conversion to One-Person Operation of Heavy-Rail Rapid-Transit Trains	Battelle Mem Inst	150,000

* Final Subcontract cost.

† Continuing activity through FY '84. Annual amount varies; total to date shown.

‡ Allocated—Balances are carried forward to support future synthesis studies.

STARTING DATE	EXPECTED COMPLETION DATE	PROJECT STATUS (for details, see latest Summary of Progress)	PROJECT NO.
11/8/82	8/7/84	Completed—Manual published as NCTRP Report 11; research report in review stage	30-1
11/30/81	12/15/82	Completed—Published as NCTRP Report 2	31-1
10/1/85	10/31/86	Research in progress	31-2
10/15/81	4/14/84	Completed—Report summarized in RRD 3; see Prog. by Proj. for rpt. avail.	33-1
11/1/82	2/29/84	Completed—Published as NCTRP Reports 5 and 6	33-2
12/1/84	3/1/86	Research in progress	33-2(2)
11/1/83	10/31/84	Completed—Published as NCTRP Report 10	33-3
11/2/81	11/1/83	Completed—Published as NCTRP Report 4	36-1
2/1/86	10/31/86	Research in progress	36-1(2)
1/3/83	1/31/85	Completed—Report summarized in RRD 4; see Prog. by Proj. for rpt. avail.	38-1
4/1/85	3/31/86	Research in progress	38-1(2)
11/1/82	8/31/84	Completed—Published as NCTRP Report 9	39-1
8/12/85	5/11/86	Research in progress	39-1(2)
10/25/82	10/23/84	Completed—Published as NCTRP Report 8	40-1
11/15/83	1/31/86	Research in progress	40-2
11/1/83	2/1/85	Completed—Published as NCTRP Report 12	40-3
1/3/83	11/30/84	Completed—Published as NCTRP Report 7	43-1
5/1/84	9/30/85	Research in editorial and publication process	46-1
12/1/81	11/30/84	Report in editorial and publication process	47-1
9/1/85	12/1/86	Research in progress	48-1
10/1/81	6/30/82	Completed—Published as NCTRP Report 1	54-1
10/1/81	12/31/83	Completed—Published as NCTRP Report 3	54-2
3/5/84	12/31/85	Report in editorial and publication process	55-1

TABLE 5 Continued
SUMMARY OF STATUS THROUGH DECEMBER 31, 1985, FOR FY '80 THROUGH FY '84 PROJECTS

PROJECT		RESEARCH AGENCY	SUBCONTRACT AMOUNT OR SUBCONTRACT COST (\$)
NO.	TITLE		
AREA 60: SPECIAL PROJECTS			
60-1	Synthesis of Information Related to Transit Problems	TRB	660,000 ^a
	TS-1: Cleaning Equipment and Procedures for Transit Buses	ATE Mgmt	75,000 ^b
	TS-2: Priority Treatment for Buses on Urban Streets	PAWA	75,000 ^b
	TS-3: Effects of Fuel Additives and Alternative Fuel Grades for Transit Buses	Southwest Res Inst	30,000 ^b
	TS-4: Guidelines for Allocation of Time for Transit Coach Maintenance Functions	XYZYX Info Corp.	30,000 ^b
	TS-5: Extraboard Management Procedures and Tools	L. C. McDorman	40,000 ^b
	TS-6: Traffic Control and Regulation at Transit Stops	W. W. Rankin	45,000 ^b
	TS-7: Bus Communications Systems	Mitre	45,000 ^b
	TS-8: Passenger Information Systems for Transit Transfer Facilities	J. J. Fruin	45,000 ^b
	TS-9: Transit Fare Collection: Problems and Alternatives to Paper Currency	Mitre	75,000 ^b
	TS-10: Use of Part-Time Operators	L. C. McDorman	50,000
	TS-11: Transit Marketing: Success and Failures	Richard L. Oram	50,000
	TS-12: Use of Incentives to Attain Specified Performance Standards in Collective Bargaining for Mass Transit	Darold T. Barnum	50,000
	TS-13: Bus Inspection Guidelines	C. I. Giuliani	50,000

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 PTC's research subcontract is either:

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

The research agency's proposal is made a part of the subcontract with the PTC. Thus, in addition to the specific research objectives outlined in the subcontract, the re-

search 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 professional 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

TABLE 6
AGENCY DISTRIBUTION OF FY '80 THROUGH
FY '84 PROJECTS

TYPE OF AGENCY	PROJECTS AND CONTINUATIONS	
	NO.	%
Educational institutions	2	9
Research institutes	2	9
Industry, consultants, and trade associations	18	78
Professional societies and service organizations	1	4
State DOTs and other governmental agencies	0	0
All	23	100

STARTING DATE	EXPECTED COMPLETION DATE	PROJECT STATUS (for details, see latest Summary of Progress)	PROJECT NO.
11/7/80	"	Research in progress	60-1
2/16/81	12/31/81	Completed—Published as NCTRP Synthesis 1	(TS-1) 60-1
3/16/81	12/31/81	Completed—Published as NCTRP Synthesis 2	(TS-2) 60-1
10/1/82	9/30/83	Completed—Published as NCTRP Synthesis 3	(TS-3) 60-1
12/9/82	11/30/83	Completed—Published as NCTRP Synthesis 4	(TS-4) 60-1
11/31/83	10/31/84	Completed—Published as NCTRP Synthesis 5	(TS-5) 60-1
12/27/83	3/31/85	Completed—Report in review stage	(TS-6) 60-1
11/21/83	3/31/85	Completed—Report in review stage	(TS-7) 60-1
11/21/83	12/31/84	Completed—Published as NCTRP Synthesis 7	(TS-8) 60-1
12/2/83	12/31/84	Completed—Published as NCTRP Synthesis 6	(TS-9) 60-1
11/15/84	3/31/86	Completed—Report in review stage	(TS-10) 60-1
11/15/84	5/31/86	Completed—Report in review stage	(TS-11) 60-1
12/1/84	6/30/86	Completed—Research in progress	(TS-12) 60-1
11/15/84	3/31/86	Completed—Report in review stage	(TS-13) 60-1

quarterly progress reports and monthly progress schedules and maintaining telephone contacts, each engineer visits his assigned research agencies throughout their sub-contract 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 un-

dertaken. 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 prac-

tioners 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 findings 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

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

Report			
No.	Title, Project, Pages, Price		
1	Transit Bus Energy Efficiency and Productivity—Bus Equipment Selection Handbook (Project 54-1),	55p.,	\$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),	142 p.,	\$10.40
4	Improving Decision-Making for Major Urban Transit Investments (Project 36-1),	47 p.,	\$7.20
5	Assessment of Quality of Work-Life Programs for the Transit Industry—Research Report (Project 33-2),	99 p.,	\$8.80
6	Assessment of Quality-of-Work-Life Programs for the Transit Industry—Model Programs (Project 33-2),	37 p.,	\$6.80
7	Detection of Low-Current Short Circuits (Project 43-1),	216 p.,	\$14.00
8	Simplified Guidelines for Evaluating Transit Service in Small Urban Areas (Project 40-1),	119 p.,	\$10.40
9	Modular Approach to On-Board Automatic Data Collection Systems (Project 39-1),	123 p.,	\$10.40
10	Public Transit Bus Maintenance Manpower Planning (Project 33-3),	56 p.,	\$8.00
11	Small Transit Vehicles—How to Buy, Operate, and Maintain Them (Project 30-1),	49 p.,	\$7.60
12	Strategies to Implement Benefit-Sharing for Fixed-Transit Facilities (Project 40-3),	214 p.,	\$14.00
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
3	Diesel Fuel Quality and Effects of Fuel Additives (Proj. 60-1, Topic TS-3),	62 p.,	\$7.60
4	Allocation of Time for Transit Bus Maintenance Function (Proj. 60-1, Topic TS-4),	24 p.,	\$6.40
5	Extraboard Management: Procedures and Tools (Proj. 60-1, Topic TS-5),	38 p.,	\$7.60
6	Transit Bus Fare Collection: Problems with and Alternatives to Paper Currency (Proj. 60-1, Topic TS-9),	20 p.,	\$6.80
7	Passenger Information Systems for Transit Transfer Facilities (Proj. 60-1, Topic TS-8),	39 p.,	\$7.60

NOTE: Out-of-print publications marked with a bullet (•) are available only in microfiche form from the Transportation Research Board. See final page of this document for ordering information.

TABLE 8
NCTRP RESEARCH RESULTS DIGESTS *

DIGEST NO.	PROJ. NO.	TITLE, PAGES, PRICE
1	33-1	Review of Literature Related to Bus Operator Stress, 15 p., \$3.00
2	60-1	Project to Synthesize Information on Transit Problems, 3 p., \$1.00
3	33-1	Predicting and Dealing with Transit Bus Operator Stress, 4 p., \$1.00
4	38-1	National Transit Computer Software Directory, 9 p., \$1.00

* See Table 5 for project titles. See final page of this document for ordering information.

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 PTC. 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.

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

An important decision facing many transit managers in small urban or rural areas is how to choose from among several types of small buses. Several factors can influence the choice: the trade-off between capital cost and operating cost; the ease with which the buses can be operated; and their maintenance requirements, among others. The general objective of this research was to develop a workbook style manual for local transit operators. As a basis for the manual, the research called for the development of a data base as well as an analysis framework for deciding how one should buy and maintain small buses.

This analysis of data showed that maintenance costs can vary from a low of 0.17 labor-hours per 100 bus-miles to a high of 1.69 labor-hours per 100 bus-miles, combined with a materials cost ranging from \$1.20 per 100 bus-miles (in 1983 dollars) to \$9.80 per 100 bus-miles. The wide range in costs results from variations in the following factors: the type of bus (van, body on van chassis, body on truck chassis, or purpose-built); the make of the bus; the severity of the duty cycle that the buses are subjected to; the severity of the climate in which the buses operate; and the accumulated mileage of the bus. Detailed data are presented in this manual on the quantitative effect of these factors. In operations costs, the two significant elements are labor and fuel. Labor costs for operators can be easily estimated by each transit manager based on local labor wages and fringe benefits and are not, therefore, presented in the manual. Fuel consumption data, on the other hand, are not as easily available, and are presented in the manual. Fuel efficiency can vary from a low of 3.6 miles per gallon for purpose-built buses to a high of 8.9 miles per gallon for vans. Significant variations around these numbers can result from differences in duty cycle and engine type (gasoline or diesel).

The data described above are for use in a life cycle cost (LCC) analysis that is developed as a step-by-step, workbook procedure in the manual. The result of this LCC

analysis is one important factor to be taken into account in choosing a bus.

Additional factors that must be taken into account in buying a bus include the type of fuel that is to be used; the nature of auxiliary equipment that is desired (especially wheel-chair lifts); the maneuverability of the buses; the availability of spare parts; and the facilities needed to maintain the bus. Qualitative information and guidelines are presented in the manual on each of these factors.

The manual is published as NCTRP Report 11, "Small Transit Vehicles: How to Buy, Operate, and Maintain Them." A research report will be published in 1986.

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: \$49,522

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 sig-

nificantly 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."

Project 31-2 FY '84

Controlling Rising Operating Deficit Through Capital Investments

Research Agency: Fleet Maintenance Consultants, Inc.
Principal Invest.: Richard Drake
Effective Date: October 1, 1985
Completion Date: October 31, 1986
Funds: \$150,000

The prudent expenditure of already limited capital and operating funds is especially important as plans to reduce federal contributions take shape. Budget proposals, if enacted, will eliminate federal operating funds while reducing transit capital funds to the proceeds of the \$0.01 gasoline tax. Beyond the federal cutbacks, raising money at state and local levels becomes increasingly difficult as transit programs are forced to compete with other community needs.

In the past, tradeoff decisions between capital and operating budgets were not necessary because funds were segregated by program category. More recently, it has been possible to use capital funds for operating purposes under certain conditions. Transit authorities are being asked to review the bases on which both capital and operating expenditures are made. Past policies and practices have tended to favor capital expenditures based on federal and state contributions as well as on regulations and requirements of different levels of government.

Since there are reasonable expectations that the availability of some level of capital funding will continue, even as operating assistance declines, it is prudent to explore the hypothesis that selected capital investments can reduce the need for operating funds in individual transit agencies.

There are numerous areas where capital expenditure can have a favorable impact on operating costs. For example, building a new maintenance facility, installing a two-way radio system, providing automatic vehicle mon-

itoring, developing a computerized maintenance capability, replacing aging vehicles—these and many other projects can be evaluated in terms of their impact on operating dollars. In particular, development of an appropriate strategy for replacement of the bus fleet is an area where additional research could result in significant operating cost savings. Past UMTA policy prescribed a minimum 12-year lifespan before a 40-ft conventional bus was eligible for replacement. UMTA is considering 500,000 miles, or similar yardsticks, as alternative bases for replacement. Because no replacement strategy has been validated technically, capital funds may be spent in advance of real need. Scarce operating dollars, in contrast, may continue to be expended in an inefficient manner to prolong the service life of a bus at inordinately high operating cost. A well timed expenditure of capital funds to buy new buses actually could reduce the total of annual operating and capital costs, and improve reliability of passenger service.

The overall objective of this research is to adapt or develop methods for evaluating various capital investment opportunities that would provide transit operating agencies and transit funding agencies the means to measure improvements in operating efficiency and service which reduce or help control operating costs.

This study is expected to lead to the identification of various types of transit capital projects that can improve system performance including ridership, vehicle productivity, reliability, fleet availability, trip time savings, and cost savings. The first phase of research will focus specifically on bus replacement strategies and will include development of one or more methods for transit and funding agencies to evaluate alternative strategies. Annual operating and capital cost impacts should be outputs of the method(s) developed. If funds are available, it is possible that future research will concentrate on other types of capital expenditures.

The following tasks are suggested to further the overall general objective and to accomplish the specific objective of Phase I.

Task 1. Identify capital investment opportunities, other than bus replacement considered in Tasks 3 through 6, which would reduce transit operating deficits. From successes and failures described in the literature, recommend investment opportunities for research in future studies.

Task 2. For two or three of the recommended investment opportunities from Task 1, suggest tasks and data requirements necessary to accomplish possible future research, which is presently unfunded, to (a) develop appropriate methods to evaluate their impact on operating costs and operating deficits, and (b) develop appropriate methods for transit agencies to prioritize and select capital investment opportunities to produce cost-effective improvements in operating efficiency and service levels that reduce or help control operating costs. Include time and

cost estimates for the research on each investment opportunity.

Task 3. Summarize past and current research on bus replacement schedules, life-cycle costing analyses, and bus purchasing guidelines. Describe the rationale for the 12-year replacement cycle.

Task 4. Identify current bus replacement practices of selected U.S. transit agencies of various sizes and geographic locations.

Task 5. Develop or adapt methods for transit and funding agencies' consideration to determine optimal fleet replacement schedules for different environments and funding sources. Such methods should consider vehicle-miles, vehicle-hours, duty cycle (terrain, number of stops), climate, fleet size and mix, level of preventive maintenance, spare ratio, bus rehabilitation policy, and data availability for use in the methods.

Task 6. Provide a total of three geographically diverse examples of methods application for hypothetical cases reflecting the real world for small, medium, and large agencies.

Progress to December 31, 1985 includes completion of Tasks 1, 2, and 3 and starts have been made on Tasks 4 and 5. Data collection plans have been coordinated with 10 transit operators and data collection has begun. The agency proposes to augment the rich data base collected for NCTRP Project 33-3 for the purposes of this project.

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: April 14, 1984
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 was to develop an evaluative device or questionnaire for use as part of the bus-driver-selection process that when validated will indicate the applicant's susceptibility to stress which is likely to affect job performance. The research also provided two training modules.

Reference literature and existing training programs were 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.

Existing selection mechanisms were evaluated for general applicability in measuring an individual's tolerance for stress. Portions of these existing devices and new material developed in this research were combined into a preliminary stress prediction device. This device was pilot tested at 6 sites but was not validated for general use. 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 were also 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 are adaptable by an individual transit agency so that through property-specific modifications they can be made part of existing training programs.

A listing was also developed 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 has been completed. NCTRP Research Results Digest 3 announces the availability of a 3-volume report prepared by Group Associated Management Services, Inc. The first volume, "Predicting and Dealing with Transit Bus Operator Stress," includes the research report and the preliminary stress prediction device. Because the device has not been validated and is, therefore, not appropriate for use by operating agencies, this volume is not being widely distributed. However, copies are available on a loan basis from NCTRP, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, to afford interested researchers access to the findings as background for future developmental work.

The second volume, "The Stress Connection—A Stress Management Program for New Bus Operators and Supervisors," contains the training modules, and the resource guide is contained in the third volume entitled, "Transit Bus Operator Stress—Resource Guide." Both Volumes II and III can be ordered from the Publications Office, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, at a cost of \$10.00 and \$5.00, respectively.

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: February 29, 1984
Funds: \$97,821

The political and fiscal environment of transit agencies was in a period of significant change. Scarcity of funds meant an emphasis on productivity and efforts to retain and motivate quality employees. New federal policies stressing local initiative encouraged management to be more sensitive to innovative ideas, and a changing work force made different demands. Although the transit industry is highly labor-intensive, a great deal of emphasis had 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 was the development and management of human resources. Quality-of-work-life (QWL) programs provide such an opportunity by stressing the importance of the individual through human development as well as the productive gains to the agency.

Under this research, the feasibility of QWL programs for application by transit agencies was assessed. Although QWL programs may focus on particular employees and groups of employees, the initiation and success of a program many times depend on the attitude and environment created by upper management and, if unionized, the interaction between management and the affected unions. Therefore, recommendations on the potential application of quality-of-work programs required consideration of

both transit agencies as a whole and individual employees.

The results of this study have been published in two reports. NCTRP Report 5, "An Assessment of Quality-of-Work-Life Programs for the Transit Industry—Research Report," is the main research document and includes an overview of the summary of findings; a main text that thoroughly documents the study effort and recommendations; and several appendixes that provide a master list of references, a selected annotated bibliography, case studies and summary results of a survey of transit agencies. A single table conveniently documents current activity in various industries. *NCTRP Report 6*, "An Assessment of Quality-of-Work-Life Programs for the Transit Industry—Model Programs," provides specific guidance for initiating and maintaining programs within a transit agency.

Project 33-2(2) FY '82/'83

Quality-of-Work-Life Programs for the Transit Industry—Regional Seminars

Research Agency: Public Administration Service
Principal Invest.: George Greisinger
 Dr. Susan G. Clark
Effective Date: December 1, 1984
Completion Date: March 1, 1986
Funds: \$49,454

Under NCTRP Project 33-2, recommendations were made on the potential application of quality-of-work-life programs to transit agencies. These recommendations and the supporting research were documented in two reports: NCTRP Report 5, "Quality-of-Work-Life Programs for the Transit Industry—Research Report," and NCTRP Report 6, "Quality-of-Work-Life Programs for the Transit Industry—Model Programs." In order to ensure proper consideration of these findings and recommendations, a second project is under way to disseminate the results to the transit industry. Regional seminars, based on the previous research, are addressing issues facing management, practitioners, labor, and others concerned with the development of human resources.

The objective of Project 33-2(2) is to conduct at least four regional seminars at locations geographically distributed across the nation. Maximum use is being made of volunteer, local sponsors and support in arranging and conducting the seminars. To accomplish the project objective the agency is:

1. Providing the lead in organizing and conducting the seminars including arrangements with local sponsors for support.
2. Providing the agenda and preparing all seminar material, such as audio-visual aids, lesson plans, and handouts.
3. Turning over to the NCTRP, at the conclusion of the project, all seminar materials and a brief summary description of the seminars conducted. The seminar material will be in a form suitable for use

by others in conducting additional group seminars and as instructional information for individuals. The seminar material and summary will be treated as the final report for the project.

To December 31, 1985, two seminars have been held—the first in Flint, Michigan, and the second in Washington, D.C. Additionally, two seminars are scheduled for 1986 in Los Angeles and a site to be named.

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 by using such simple ratios as buses per mechanic or maintenance man-hours per miles of operation that are based heavily on past experience and guess work. Often they are not appropriate for transit agencies experiencing major changes in services, equipment, or facilities.

The principal objective of this project was to develop a methodology for establishing labor estimates required for maintaining specific vehicle systems.

The methodology developed accounts for the effects of miles of bus operation, accident rate, climate, type of bus, and type of transmission on maintenance labor-hour requirements for the following subsystems; servicing and cleaning, inspections, engine/fuel, braking, electrical, air/steering/suspension, air conditioning and heating, drivetrain, cooling, accessories, wheels and tires, fare-boxes, destination signs, and wheelchair lifts. Total maintenance manpower requirements are determined from a summation of subsystem labor hour requirements, modified by overtime and unavailable time considerations.

Labor-hour requirements found in the research, together with the methodology for estimating manpower requirements will be published in NCTRP Report 10, "Public Transit Bus Maintenance Manpower Planning."

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

Since 1975, the Urban Mass Transportation Administration (UMTA) 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.

Since the advent of the alternatives analysis requirements, a significant number of urban areas have been involved in some aspect of the process. Concerns have been expressed with the process, particularly regarding the extensiveness of the study requirements, the delays caused in implementing transit improvements, the role that UMTA staff has played in managing the studies, and the use of the study results in UMTA's decision-making process. NCTRP Project 36-1 was initiated because of a recognized 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.

The general objective of this research has been to assess the federal, state, and local decision-making process for major urban mass transportation investments by evaluating recent alternatives analysis and related study experiences. The purpose of the assessment has been to identify potential improvements in policy, procedures, and use of technical information, and to formulate recommendations on planning procedures for use by federal, state, and local agencies.

The first part of the findings deals with the quality of the various components of the technical work programs with emphasis on their role in the decision-making process. Both the state of the art and general practice in the field have improved enormously over the last several years. The relative levels of adequacy, however, differ significantly among the specific technical elements of the process.

Improvements in the quality of input data for demand analysis and in considering transit operations planning were identified as technical needs. On the other hand, environmental impact studies were thought to involve more work than necessary where environmental impact issues are not important in the decision-making process.

From examining the overall structure of the planning and decision-making process, it was recommended that Phase I system-planning studies be eliminated if urban areas can provide a well-supported basis for determining priorities among regions. With regard to Phase II studies

and finding agreements, it is recommended that such finding agreements follow the local decision on a preferred alternative as soon as possible, notwithstanding that this would normally require some preliminary engineering work in Phase II.

Recommendations for federal programs were made in three categories: (1) changes in the alternatives analysis and related regulations, (2) administration of the program, and (3) possible changes in the grant program.

The need for immediate change in regulations was judged to be minimal. The existing policy statements and regulations were considered flexible enough to permit accomplishment of most, but not all of the recommendations without change.

It was recommended that UMTA clarify its policy regarding its own decision-making process and the way in which the results of alternatives analyses are used in this process. This should involve more clearly defined guidelines for overall evaluation, including the manner in which economic investment evaluation measures, benefit-cost ratios, or cost-effectiveness are to be developed. It should also involve a commitment by UMTA to state the basis on which its decisions are made in each grant application case.

Furthermore, it was recommended that consideration be given to the development of a policy statement that would place greater emphasis on long range transit system planning issues that might be important in alternatives analyses, including such factors as:

1. Operational plans for areawide transit systems.
2. Impacts of the transit development program on future operating costs and subsidy requirements.
3. Land development impacts.
4. Commitments of local officials to land development policies to enhance the transit-orientation of corridors.
5. Commitments of the private sector to major development projects in corridors in accord with policies adopted by local officials.
6. Areawide bus service needs and deficit implications.
7. Need for, and location of, maintenance facilities and other major systemwide considerations that may have different solutions when seen from an areawide basis as compared to the corridor level.

With regard to administration of the program, it was recommended that greater effort should be devoted to achieving common FHWA and UMTA administration of major corridor studies. Far more could be done to train field staff to have common understanding of regulations and policy, and to be prepared to represent U.S. DOT as a whole.

With regard to possible changes in the grant program, a recommendation was made to combine earlier highway and transit capital grant programs into a single formula grant program so that highway/transit trade-offs can be made.

The results are published in NCTRP Report 4, "Im-

proving Decision-Making for Major Urban Transit Investments."

Project 36-1(2) FY '84

Assessment of Current Planning Practice for Major Transit Investments

Research Agency: System Design Concepts, Inc.
Principal Invest.: Joseph R. Stowers
Effective Date: February 1, 1986
Completion Date: October 31, 1986
Funds: \$30,000

Over the past 10 years, the Urban Mass Transportation Administration has developed and applied a structured process for planning of major transit projects proposed for Federal funding assistance. The process is used by both local and Federal officials to make a series of decisions on the location, nature, and design of major new transit facilities.

Ideally, the technical work conducted in each phase of the process yields the information necessary to permit informed judgments at each decision point. However, integration of the technical work into decision-making has proven to be challenging. While the basic premises and structure of the process have remained unchanged, it has evolved as UMTA has made revisions in an effort to both streamline the technical work and clarify the decision points. Furthermore, the accumulated experience in the various technical fields has improved the quality and efficiency of many aspects of the analysis.

In an effort to examine the degree to which the technical work actually contributes to informed decision-making, *NCTRP Report 4*, "Decision-Making for Major Urban Transit Investments," examined a series of case studies that included projects developed within and outside of UMTA's early process. The report examined the extensiveness of study requirements, the role of technical information in decision-making at the local level, and the management and costs of studies in various phases of the process. While the report was generally supportive of the requirements, it also provided a series of recommendations to improve the process and the relevance of the information produced and to promote more efficient and timely analysis.

Because of the focus on case studies in *NCTRP Report 4*, its results and recommendations reflect UMTA's requirements as they were several years ago. Meanwhile, the process has continued to evolve as set forth in more recent references:

1. May 18, 1984, Federal Register policy statement.
2. "Procedural Guidelines for Alternatives Analysis," January 1984.
3. "Sample Outline for DEISs Produced in Alternatives Analysis," January 1984
4. "Technical Guidelines for Alternatives Analysis," January, 1984.

Taken together, these documents reflect a matured technical process that strives to embrace "best practice" in all aspects of the analysis. The documents establish, for the first time, a clear benchmark with which to examine UMTA's recommendations on the process, the scope of the technical work, and the structure of the reports. They provide an opportunity to evaluate what has become standard planning practice in the field, to examine its consistency with the recommendations in *NCTRP Report 4*, and to recommend any further improvements that may be needed.

The general objective of this research is to evaluate the state of the art of technical work undertaken throughout the planning process for major urban transit investments with emphasis on the alternative analysis phase. The evaluation should lead to recommended improvements in UMTA's alternatives analysis guidelines (specifically the technical guidelines and sample DEIS outline for DEIS) that will allow them to stand for the coming years without major modification. The development of evaluation criteria should consider at least four areas of concern: (1) methods to produce, during alternatives analysis, capital and operating cost estimates that are more likely to be confirmed rather than substantially revised during preliminary engineering; (2) guidelines on the depth of environmental analyses appropriate to the stage in the process; (3) measurement of benefits; and (4) assessment of the financial implications of both construction and operation of each alternative.

The following tasks are being performed:

Task 1. Participate in a two-day project panel workshop conducted to critique the UMTA alternatives analysis guidelines. The workshop will involve assessments of the nature and level of effort of technical work that should be accomplished, to ameliorate the areas of concerns, during alternatives analysis for each of the seven technical areas covered in the guidelines (definition of alternatives, conceptual engineering and capital costs, operations planning and operating costs, patronage, environmental impacts, financial planning, and evaluation). Because of their interface with alternatives analysis, the technical work done in both systems planning and preliminary engineering may also be considered, though only to the extent necessary to clarify appropriate efforts during alternatives analysis. The findings of the workshop will lead to the development of a panel consensus on potential improvements to the guidelines that could be expected to result in more appropriate levels of technical work by transit agencies.

Task 2. Amplify the working plan to accomplish Tasks 3 through 5. Prepare potential improvements to guidelines.

Task 3. Evaluate the proposed improvements to guidelines.

Task 4. Survey appropriate transit agencies to document success or probable success of potential improvements.

Task 5. Develop recommendations to UMTA on changes to guidelines for technical work and to transit and other local agencies that will enable them to program appropriate technical work levels and otherwise improve the quality of alternatives analysis studies.

Progress to December 31, 1985 includes the conduct of the panel workshop and the preparation of an amplified working plan. A start has been made on establishing the contacts necessary to do Task 4 parallel to Task 3.

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: January 31, 1985
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. There was a need 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 would 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.

A Directory in preliminary draft form has been developed as part of a Phase I for this project. It is in the form of a Catalog, an Operating Manual, a Programming Guide, and a listing of program descriptions, all bound separately. The Directory in this form is not available. A Phase II is underway to recast the program descriptions by type of hardware and to make them available upon request from the research agency. Furthermore, the Directory will be operated and augmented with additional programs, by the research agency during the course of Phase II.

Project 38-1(2) FY '82/'83

National Transit Computer Software Directory—Phase II

Research Agency: COMSIS Corp.
Principal Invest.: Ellen Krett

Effective Date: April 1, 1985
Completion Date: March 31, 1986
Funds: \$50,000

Project 28-1 has produced a National Transit Computer Software Directory containing almost 300 transit application programs. These programs are listed in a catalog by: (1) the function they perform, (2) the submitting organization, and (3) the type of hardware on which the program operates. The catalog is accompanied by full-page descriptions for each of the approximately 300 programs. Furthermore, software has been developed to retrieve programs meeting various specifications. The software for this search process is described in a third document, "A Programming Guide." It is the full-page program descriptions that will be of greatest interest to transit agencies. These full-page descriptions need to be disseminated through the industry in an effective way. Furthermore, additional programs are known to UMTA which are believed to be of sufficient importance to add to the Directory immediately.

The general objective of this continuation research is to supplement the Directory and disseminate program descriptions among interested parties in the transit industry. Through dissemination of the program descriptions, it is envisioned that additional programs will be requested of agencies and subsequently added to the Directory. The following tasks are being performed.

Task 1. Categorize the full-page program descriptions by hardware type into six major groupings as follows:

<u>Hardware Type</u>	<u>Approximate Number of Programs</u>
IBM 360/370	38
IBM 30xx Series (3033,3081)	
AMDAHL	
BURROUGHS 1855, 1955	29
IBM 43xx Series (4331,4341)	50
IBM SYSTEM 3x Series (System 34, 338)	45
ALL OTHER MAINFRAME & MINI (CDC, DG, VAX, DEC, HP3000, IME, UNIVAC)	64
ALL MICROCOMPUTERS (Apple, PC, XT, TRS)	54

Within each of these hardware types, programs could be classified by functional type. Each of the six hardware types should be bound separately and produced in sufficient quantity to satisfy user request. Furthermore, each type should have an appendix containing the program documentation forms to be used for submitting new programs for the Directory.

Task 2. Prepare a Research Results Digest of not more

than 10 printed pages to describe the accomplishments of Phase I, the availability of the six Directory material groupings, and the opportunity to request program descriptions meeting more specific criteria.

Task 3. Contact should be made with UMTA to identify those programs known to UMTA that are not presently included in the Directory. Documentation for these programs should be obtained and added to the Directory.

Task 4. A follow-up should be made of requestors for program descriptions to evaluate the usefulness of the information sent them and to request programs that they might have that would be useful additions to the Directory.

Task 5. Prepare a final report that will update the preliminary draft report from Phase I. This report will be reviewed by the NCTRP.

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

Progress to December 31, 1985 includes the completion of Tasks 1, 2, and 3 and substantial work on Task 4. Many requests for information have been serviced as a result of publicity provided by NCTRP Research Results Digest 4.

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: August 31, 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 was to develop requirements and implementation guidelines for the use of automated on-board passenger/fare information collection systems. The system hardware had to be constructed on a modular basis so that one module or component is compatible with another regardless of manufacturer. Requirements for modules or components needed to depend on the decisions a transit property must make, which, in turn, determined the level of detail the data collection system must provide. The levels of detail ranged from systemwide information to detailed stop-by-stop information. The system was designed so that a transit property can choose, in modular fashion, the level and type of hardware needed for the data desired.

Research is complete; the final report has been published as NCTRP Report 9, "Modular Approach to On-Board Automatic Data Collection Systems." The final report documents the activities and findings on research to develop and deploy a standardized modular system including any possible constraints. An Appendix I contains an implementation manual to assist transit agencies in designing, selecting, and implementing a cost-effective automatic data collection system. An Appendix II contains technical specifications for the modules and a com-

mon interface. Appendix II should provide assistance in procuring systems and components.

Project 39-1(2) FY '81

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

Research Agency: The MITRE Corporation
Principal Invest.: Lawrence E. Deibel
Effective Date: August 12, 1985
Completion Date: May 11, 1986
Funds: \$26,141

NCTRP Project 39-1 demonstrated the potential for using a modular approach to automatically collect data on board transit buses. The findings of this project have been published in NCTRP Report 9, "Modular Approach to On-Board Automatic Data Collection Systems." The report contains technical specifications for various modular units and for the totally configured system on board a bus. Guidelines to help the practitioner evaluate the utility of automatically collecting data and to assist in the design and implementation of automatic data collection on a systemwide basis are also provided.

The recommended modular configuration is intended to provide flexibility to transit agencies and encourage competition in the marketplace. A truly modular system permits step-by-step implementation, which may be required by budget constraints or perceived present needs. A modular approach also provides the capability to accommodate unforeseen future data requirements or to update modules without the need to redesign or purchase an entirely new system. However, because a universally applicable modular approach is not now standardized, implementation of the concept will require agreement among at least several transit agencies or manufacturers, or preferably both. Specific agreement will also be necessary on a standard interface to allow the greatest degree of flexibility in the selection of the various modules.

The objective of Project 39-1(2) is to provide a forum for the discussion and advancement of the planning techniques and the modular approach for on-board automatic data collection systems for transit buses as reported in National Cooperative Transit Research & Development Program Report 9. A seminar in March 1986 is anticipated.

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: October 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, 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).

The objective of this research was 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.

Guidelines were developed using the best available techniques to describe how to handle both priceable and non-priceable factors. Equity and distribution questions of who pays and who benefits are considered. The guidelines were 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 were as-

sembled that have applicability to the evaluation of alternatives for public transit. Information requirements, availability, and sources used in existing analysis techniques were assessed in relation to the actual needs of small areas.

In addition, a presentation package was developed for use in demonstrating the analysis procedures and the factors considered in evaluating transit improvements and alternatives. The package is suitable for presentations to city councils and transportation planning boards and is adaptable to local situations.

The final report has been published as NCTRP Report 8, "Simplified Guidelines for Evaluating Transit Service in Small Urban Areas," and the presentation package is available from the NCTRP (see final page of this document for ordering information).

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: January 31, 1986
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.

Through December 31, 1985, Tasks A through D and part of Tasks E and F have been completed. Important cost concepts and their relationship to costing problems faced by transit agencies have been defined. An overview of available models, including those developed as part of a recently completed UMTA-sponsored study, has been provided. The results of a survey of transit agencies, which was conducted for Task B, have also been provided. Among other things, the survey developed information on methods currently in use, problems with these methods, and suggestions for improvements. Simplified procedures have been developed as part of Task C. These include three procedures for estimating the effects of bus route service changes on driver costs and a fourth procedure for estimating nondriver incremental costs associated with service changes. A testing plan for the four procedures, plus the operating agency's procedure, was designed and is implemented. Testing is being conducted at three agencies who will not be supported by UMTA funds as previously planned. Consequently, tests for all models contemplated will not be possible.

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 becomes 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 were frequently lost, however, because they were not an important consideration in the planning and design phases (i.e., in the location and design of routes and stations).

There was 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 was 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 was to assist transit agencies in implementing benefit-sharing. Results suggest that benefit-sharing strategies generally fall into these types:

1. Provision of facilities or amenities to enhance the transit facility with no direct financial benefit, but with other benefits in terms of aesthetics, environment, security, convenience, and sound long-range planning;
2. Cost recovery, in which parties share construction or operating costs based on a proration of costs incurred by each;
3. Value capture, in which the transit agency seeks a financial return based on the *value* of the transit benefit provided, as opposed to measures of cost.

Of these types, most benefit-sharing experience has occurred in the first two categories. Furthermore, it is concluded that a transition from a philosophy of using federal funds as a catalyst for urban revitalization to using private funds to decrease the federal share is likely to be difficult in most urban areas. Consequently, major increases in funding for transit in the third area is judged to be unlikely. The report, which includes recommendations to transit agencies to increase private/public participation in the sharing of benefits, is published as NCTRP Report 12, "Strategies to Implement Benefit-Sharing for Fixed-Transit Facilities." (See final page of this document for ordering information.)

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: September 30, 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 was 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.

Research has been completed with accomplishment of the objective. Survey forms were used to collect information on low-level fault current detection practices and electrical system characteristics from rail transit systems and electrical industry organizations worldwide. Several types of equipment appear to be performing well on transit systems outside the United States. However, each of these devices has particular characteristics and operational constraints. A field test program is recommended to evaluate the performance and economics of the most promising equipment identified by this study for low-level fault current detection. The test program should be conducted in cooperation with one or more rail transit systems.

Research has been completed and the report published as: NCTRP Report 7, "Detection of Low-Current Short Circuits."

AREA 46: GENERAL DESIGN

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: May 1, 1984
Completion Date: September 30, 1985
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 transmission 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).

The agency final report has been submitted and is now being reviewed by the NCTRP. The study shows that both fiber-optic and broadband coaxial cables are suitable for the single-cable concept. The researchers prefer the fiber-optic alternative and state their reasons. To accommodate radio transmissions in tunnels and still maintain the single-cable concept, the researchers propose placing the fiber-optic cable in the core of a leaky coaxial cable. However, this hybrid system will require further development.

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: November 30, 1985
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.

Research has been completed with accomplishment of project objectives in terms of confirming the premise that increases in brake lining temperature have resulted in reduced brake life and of identifying procedures for reducing brake lining temperature on existing buses. However, the retrofitting of existing buses with air blowers to reduce brake temperatures was found to be only marginally cost effective and the further development of brake lining materials having better temperature wear properties should continue to be explored. The final report is in the editorial and publication process.

AREA 48: SPECIFICATIONS, PROCEDURES, AND PRACTICES

Project 48-1 FY '84

Corrosion Attributed to DC Powered Transit Systems

Research Agency: IIT Research Institute
Principal Invest.: J. J. English
Effective Date: September 1, 1985
Completion Date: December 1, 1986
Funds: \$200,000

Structural damage to transit system properties and neighboring underground facilities due to corrosion caused by DC stray currents is a significant, persistent problem. Existing procedures and materials for prevention or mitigation are not sufficiently effective. The transit industry needs authoritative work that summarizes existing knowledge of damage caused by DC stray currents. Furthermore, there is a need to demonstrate the enormity of the problem and to design a research program that can provide cost-effective prevention and mitigation procedures.

The primary objectives of this research are to document and call attention to the severity of the corrosion problem caused by DC stray currents in terms of its economic, public safety, institutional and liability dimensions; to develop practical recommendations to transit agencies based on today's knowledge; and to design a research

program to provide cost-effective solutions. Emphasis should be given to quantifying the dimensions to develop credibility. Furthermore, the research should stimulate coordination between key institutions involved in the DC stray current corrosion problem.

The following tasks are being conducted.

Task 1. Review, together with significant unpublished reports in rail transit agencies, published literature from both North America and abroad. Such a review will include literature concerned with stray current corrosion problems stemming back to the turn of the century for DC powered rail transit systems. Significant issues with respect to economics, public safety, institutions, and liability will be identified and priorities developed. From the review, elements of effective practice in such areas as track and structure construction, power system configuration, negative return and grounding, and corrective methods to reduce stray current magnitudes will be identified and evaluated. Prepare a report synthesizing this information for use by transit agencies.

Task 2. Conduct an indepth study of four transit agencies, and neighboring underground facilities, to document the severity of the problem in terms of economics, public safety, involved institutions, and liability. Furthermore, the study will identify agency practices to prevent or mitigate the problems. Consideration will be given to Boston, Chicago, Washington, and Toronto to provide a range of age and type of rail systems.

Task 3. Integrate the results of Task 2 into the report developed in Task 1.

Task 4. Develop a plan and conduct a workshop to serve the following purposes:

- a. Promulgation and review of the report.
- b. Development of practical recommendations to transit agencies.
- c. Development of a research action plan that reflects problems faced by neighboring institutions (such as utilities and agencies owning underground structures) affected by stray currents. Identify means and stimulate joint institutional support for such research. The plan will identify research projects and provide estimates of times and costs.

Task 5. Prepare reports to serve the following purposes:

- a. To call to the attention of transit and business executives, governmental officials, and the media, the stray current corrosion problem.
- b. To present practical recommendations for improving transit industry practice for preventing and mitigating stray current corrosion.
- c. To provide an annotated bibliography defining areas of importance for important engineering references on the subject matter.
- d. To present the research action plan that identifies means for interagency coordination and institutional support together with the identification of research projects.

Progress to December 31, 1985 includes completion of Task 1 and substantial progress on Tasks 2 and 4. Questionnaires to transit agencies have been distributed and site visits have begun. Workshop planning is well underway.

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: March 5, 1984
Completion Date: December 31, 1985
Funds: \$150,000

There was increasing pressure to provide more cost-effective operation of heavy-rail rapid-transit trains. A major candidate for improving productivity was believed to be reduction of crew size to one person. This had 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
- Baltimore—Mass Transit Administration

Miami will start operating with one person.

The older rapid transit systems, however, continued to require a second crew member aboard at least some trains. These systems included 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

The objectives of this research were (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 identified nine issues or problems concerned with conversions to one-person operation:

1. Car side door safety and Union opposition.
2. Fire and emergency evacuation between stations.
3. Reduced train operational performance resulting from increased time to recover from equipment, particularly door, failures and increased station dwell time.
4. Security including perceived security.

5. Communication between train operator and central control, passengers on train and train operator, and passengers on station platforms and central control and possibly police.
6. One less on-board crew member to provide passenger information and assistance and detect problems.
7. Between car and end-door safety.
8. On-board fare collection, operator training, and incapacitation of train operator.
9. Increased operator stress and loss of a position to which to assign medically disqualified train operators.

In addition to the above issues or problems, there was some concern that new cars were still being delivered without provisions for future conversion to one-person operation. Also, while in most cases the reduced labor costs associated with one-person train operation should exceed the costs of conversion from two- to one-person operation, some systems were concerned that the costs of improving equipment reliability and upgrading facilities would in some cases offset such savings.

Potential solutions to most of the foregoing issues or problems have been successfully demonstrated at European and/or U.S. one-person operation systems and are presented in the report. However, the systems, lines, or services converted to date generally have reliable rolling stock with full-width or convertible full-width operator cabs. Also, while new one-person operation systems in the United States have demonstrated satisfactory door operation for trains up to 700 ft in length (i.e., BART), those systems generally have straight, unobstructed, relatively uncrowded station platforms. Many of the older U.S. two-person operation systems have less-reliable rolling stock, antiquated facilities, curved, obstructed, and crowded platforms and more severe security problems, thus increasing the difficulty of conversion.

While conversion of many of the six older U.S. heavy-rail rapid-transit systems with two-person train operation to one-person operation is believed to be feasible, it is believed that such conversion will generally follow an evolutionary process. That is, rather than system-wide conversion of all services and lines at one time, systems will most likely convert those services and/or lines that are most compatible to one-person operation first, followed by conversion of less compatible services and/or lines over time. The most compatible services include new lines, lines or services with new or rehabilitated cars and/or facilities, and off-peak service with shorter trains, fewer passengers, and longer headways. Such a process would reduce the possibility of layoffs and provide for continued employment for all train operators wishing to continue working.

Before proceeding with conversion of a specific system, line, or service to one-person operation, a comprehensive assessment of the economic worth of the conversion should be made. For such an assessment, investment or

capital costs include all of the costs required to convert that specific system, line, or service from two- to one-person operation. Likewise, the future savings (or losses) resulting from that investment include the sum of all the differences in operating and maintenance costs between the two- and one-person operation versions of the specific system, line, or service over its useful life.

For comprehensive detailed analyses of the economic worth of conversion of specific heavy-rail transit systems, lines, or services from two- to one-person operation, the "net present value" measure of investment worth is preferred. The net present value of an investment is the net present value of the expected cash flows associated with the investment over the life of the investment.

However, regardless of the specific measure of investment worth chosen, there are certain cost elements that are common to all. In general, these cost elements are related to the differences in costs between continued two-person operation and conversion to one-person operation. Listings of the cost elements that must be considered in a site specific economic analysis are presented in the report.

Where a new line or cars or overall rehabilitation of cars or facilities are being evaluated, it may be difficult to identify the marginal costs associated with one-person operation. In fact, in some instances and for some cost elements there may be little or no difference in the capital cost of the one- and two-person operation versions.

No recommendations that any specific transit agency or agencies be converted from two- to one-person train operation are made. That decision is left to the individual agencies to make after careful analysis of their specific conditions and needs. The report will be published early in 1986 as NCTRP Report 14.

AREA 60: SPECIAL PROJECTS

Project 60-1 FY '80

Synthesis of Information Related to Transit Problems

<i>Research Agency:</i>	Transportation Research Board
<i>Principal Invest.:</i>	Thomas L. Copas
<i>Effective Date:</i>	November 7, 1980
<i>Completion Date:</i>	Continuing
<i>Funds:</i>	\$660,000

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 1985, research has been completed on seven assigned topics. The reports have been published as:

NCTRP Synthesis of Transit Practice 1, "Cleaning Transit Buses: Equipment and Procedures";

NCTRP Synthesis of Transit Practice 2, "Enforcement of Priority Treatment for Buses on Urban Streets";

NCTRP Synthesis of Transit Practice 3, "Diesel Fuel Quality and Additives"; and

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

NCTRP Synthesis of Transit Practice 5, "Extraboard Management Procedures and Tools."

NCTRP Synthesis of Transit Practice 6, "Transit Bus Fare Collection: Problems with and Alternative to Paper Currency."

NCTRP Synthesis of Transit Practice 7, "Passenger Information Systems for Transit Transfer Facilities."

Research is in progress on the following topics selected for study under the FY '82/'83 program: TS-6, "Traffic Control and Regulation at Transit Stops," and TS-7, "Bus Communication Systems." Research is in progress on the following four topics selected for study under the FY '84 program: TS-10, "Rucus and Part-Time Assignments"; TS-11, "Marketing Techniques That Work"; TS-12, "Use of Incentives to Attain Specified Performance Standards in Collective Bargaining for Mass Transit"; and TS-13, "Bus Inspection Guidelines." Reports on these six topics are expected to be published during 1986.

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