Local and Regional Development and Transportation Needs

Notice

Contents

Environmental Planning and Design for Rapid Transit Facilities

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The National Environmental Policy Act of 1969 and related environmental laws mandated certain environmental considerations for major federal actions. The principal tool for documenting these considerations was the environmental impact statement. This requirement, interpreted and implemented by each federal agency, has given environmental planning concerning federally funded public improvements, such as transit facilities, its scope. This paper discusses the environmental planning studies and methodologies involved in preparing an impact statement for rapid-transit projects under the Urban Mass Transportation Administration. Emphasis is given to major issues, including alternatives analysis, environmental-impact analysis, and analysis of parklands and historic properties. The primary considerations in each subject area and specific approaches to an analysis that would satisfy the requirements of the National Environmental Policy Act of 1969 and related environmental directives are examined. The Metropolitan Dade County Rail Rapid Transit System is used as an example.

The environmental impact statement (EIS) requirements stem from section 102 of the National Environmental Policy Act (NEPA) of 1969. This act mandates that each federal agency give full consideration to environmental impact as part of its decision-making process and identify and develop methods and procedures to carry out this mandate. To ensure that environmental considerations are an integral part of the federal decision-making process, section 102 requires that all federal agencies

Include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible officials on (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Due in part to the broad application for which section 102 was intended, interpretation of the procedural provisions of NEPA has differed from agency to agency. The Urban Mass Transportation Administration (UMTA) as a federal agency has interpreted NEPA's procedural provisions and promulgated guidelines for the EIS process for projects under its jurisdiction.

In addition to the NEPA-mandated planning and before approving any application for funding, UMTA is required by section 14 of the Urban Mass Transportation Act of 1964 to determine that "either no adverse environmental effect is likely to result from such a project, or there exists no feasible and prudent alternative to such effect and all reasonable steps have been taken to minimize such effects." Given these legislative requirements, the scope of this paper involves UMTA's approach to the EIS process. The specific focus concerns the environmental assessment methodologies used to satisfy the NEPA requirements for federal actions, in this case rail rapid transit. Environmental planning for the Dade County (Florida) Rail Rapid Transit Project is used in

this paper to illustrate the central issues.

Rapid transit projects have a potentially great effect on an urban area and the natural environment because of their permanence and irreversibility. An EIS is required to enable UMTA (a) to ensure that environmental impacts are adequately considered when planning and designing not only the total project, but also the specific project elements, and (b) to ensure that the social, economic, and natural resource impacts of the project are considered relative to the alternatives available (1). Toward this end, UMTA has developed an EIS sample outline for use on rail projects that evolved from several environmental impact statements, including the Dade County Rail Rapid Transit Project. The Dade County impact statement, developed by Schimpeler-Corradino Associates working in a five-firm joint venture known as the Kaiser Transit Group, fulfilled UMTA's mandate under NEPA.

ALTERNATIVES ANALYSIS

One of the substantive requirements of NEPA is the analysis of alternatives, including the proposed action. Implementing this policy, the regulations of the Council on Environmental Quality (CEQ) for EIS preparation require that agencies explore and evaluate all reasonable alternatives. Environmental impact is intended to be a primary decision-making element. For any action, in this case a transportation improvement program, alternatives to a particular action must be considered. NEPA requires that the decision-making process by which a particular alternative is selected consider thoroughly environmental impacts of alternative actions, including that of no action (the null alternative). The impact statement must document the process by which the analyses have been conducted.

The alternatives-analysis process for the Dade County project was somewhat different from that currently required by UMTA. Prior to EIS development and during preliminary engineering, system alternatives were studied, developed, evaluated, and thoroughly documented in the Environmental Impact Analysis (EIA) for grant application. A complete summary of the alternatives analysis was prepared and included in the EIS. As established by UMTA's Major Urban Mass Transportation Investments Statement of Policy (Sept. 2, 1976), the EIS process now includes alternatives analyses.

Systemwide Selection Process

The first step in the preliminary engineering of Dade County's rapid transit system was the development of systemwide alternatives. Systemwide transportation alternatives were defined as those total transportation alternatives that were consistent with overall transportation goals and objectives and that provide feasible, regionwide solutions to the current and projected transportation needs of an area. These systemwide transpor-

tation alternatives were relatively general in nature, because it was intended that the feasible alternatives would be narrowed to a select set of alternatives before detailed data generation and alternatives analyses would occur.

The planning process used to generate the systemwide alternatives was an iterative one beginning with the early phases of system concept definition through the evaluation of alternative courses of action, to the development of the specific rapid transit alternatives. Evaluations were structured in order to provide a systematic analysis of the opportunities and consequences of each of the several system alternatives considered. The elements and steps used in the planning process fell into 10 general categories: state transportation goals and objectives; develop plan alternatives; define system elements, concepts, and relationships; develop evaluation process; develop evaluation data; develop system alternatives; evaluate alternatives; solicit public response; reassess; and prepare draft of the environmental impact analysis.

The systemwide alternatives presented in the Dade County EIS evolved as a result of investigating various alternative approaches and analyzing inputs from the citizens' participation program and local agencies. The planning was conducted at three levels. At the first level, alternative concepts were developed by the consultant and presented and discussed at 24 public forums. Comments and recommendations were received at each of the public discussions. Following the forums, seven citizens' panels, comprised of the officers of the forums within each panel, met and developed recommendations representing a consensus of the public and panel discussions. During this first level of analysis, 41 alternative concepts were considered. These included alternatives such as null, low capital-intensive alternatives, high capital-intensive alternatives, and combinations of each.

At the second level of analysis (sketch planning), 14 alternatives were identified as worthy of investigation. The process of identifying, defining, and culling the candidate systems alternatives involved the following primary task elements:

1. Preparation of a Miami urban system profile and environmental inventory that included the documentation of demographic, socioeconomic, political, and environmental data and an analysis of these data from the point of view of the influence on transit system design and impact of the proposed system concepts on the environment;

2. Study of existing and proposed land-use patterns and activity centers as developed by the Dade County Planning Department;

3. Visual inspection of candidate rapid transit corridors and routing possibilities throughout Dade County;

4. Preparation of aerial photo maps to allow the synthesis and development of corridor alternatives;

5. Identification of physical and engineering problem areas, such as the Miami River and Bay crossings, aerial structure intrusion into sensitive community areas, and existing major structural facilities;

6. Performance of a general soils and utilities survey to establish any major utility relocation requirements and any geologic problem areas;

7. Comprehensive review of existing and projected travel demands, volumes, and characteristics, including investigation of the characteristics of users and potential users of transit services and modal choice behavior patterns;

8. Preparation of preliminary service criteria and standards; and

9. Investigation of a wide range of vehicle technologies and the synthesis of specific operational concepts based on the application of candidate general technology types in various operating modes.

Corridor segments, station locations, alignments, and general operational concepts comprised the major elements of the various system alternatives. Patronage estimates for the alternatives were developed using sketch-planning techniques. The principal objective of the alternatives analysis effort was to investigate the consequences of implementing low to high capital-intensive systems such as nongrade separated transitways (bus, trolley, or trolley bus), grade-separated busways, and fixed-guideway grade-separated rapid transit.

Evaluation Criteria

The basic evaluation approach used included the following:

1. The establishment of a set of criteria and characteristics deemed appropriate and relevant to the measurement of the desirability of any system alternative,

2. The generation of values (or ratings, where only judgmental analysis could be made) for each criterion or characteristic for each of the system alternatives, and

3. The qualitative and quantitative evaluation of each alternative system leading to the selection of a preferred alternative.

To provide a consistent and systematic framework for evaluating the transit alternatives, a set of evaluation criteria was developed. Table 1 indicates the criteria deemed appropriate and relevant. Seven major categories and the subfactors in each category were developed.

Table 1. Evaluation criteria.

|	Weight	
Criterion	Subfactor	Major Factor
Service		1.54
Projected ridership	2.14	
Directness of service	0.68	
Residential accessibility	0.76	
Employment accessibility	1.00	
Special activity accessibility	0.42	
Urban planning		1.19
Conformance with existing land uses	0.72	
Compatibility with adopted plans and policies	1.53	
Urban design considerations (function, form, scale)	0.75	
Community disruption and displacement		0.91
Residential displacement	1.44	
Business displacement	1.11	
Special disruptions	0.45	
Environment		0.84
Air	1.29	
Noise	1.05	
Water, microclimate, vegetation, and wildlife	NR	
Visual and aesthetic	0.66	
Energy		0.63
Implementation energy	0.51	
Propulsion efficiency	1.03	
Energy savings due to diversion from automobiles	1.47	
System characteristics		0.77
Capacity increase potential (expandability)	0.68	
Network extension potential (extensibility)	0.60	
Safety from accidents	1.36	
Reliability	1.36	
Security		
Cost		1.12
Capital cost	0.74	
Annual operating and maintenance costs	1.26	

Note: NR = not reported.

The subweights show the relative importance of items within each major category. The generation of values or ratings for each criterion for each system alternative was a comprehensive process. This process involved a broad range of analytical techniques and professional judgments based on substantial experience and substantial exposure to and study of the Dade County urban area and transit-planning framework.

Development of the Service Network

The definition of system requirements at the first level and sketch-planning analysis at the second level led to the development of a service network (Figure 1). This development was based on the following:

1. The quantitative evaluation of the original 14 networks developed by the consultant;
2. The unification and quantitative evaluation of the corridor segments contained in all 41 networks developed by the consultant, the citizens' panels, and public agencies;
3. The independent evaluation and analysis of all 41 networks made by a subcommittee of the Transit Advisory Committee, comprised of county commissioners from Dade, Broward, and Palm Beach Counties; the presidents and vice presidents of the seven citizens' panels; appointed county officials; representatives of city, state, and federal agencies; and members of special interest groups; and
4. Conformance with the proposed 1985 Metropolitan Development Pattern of the Dade County Planning Department that shows corridors deemed suitable for mass transit improvements and activity centers within the county.

Figure 1. An illustration of the 1985 service network.
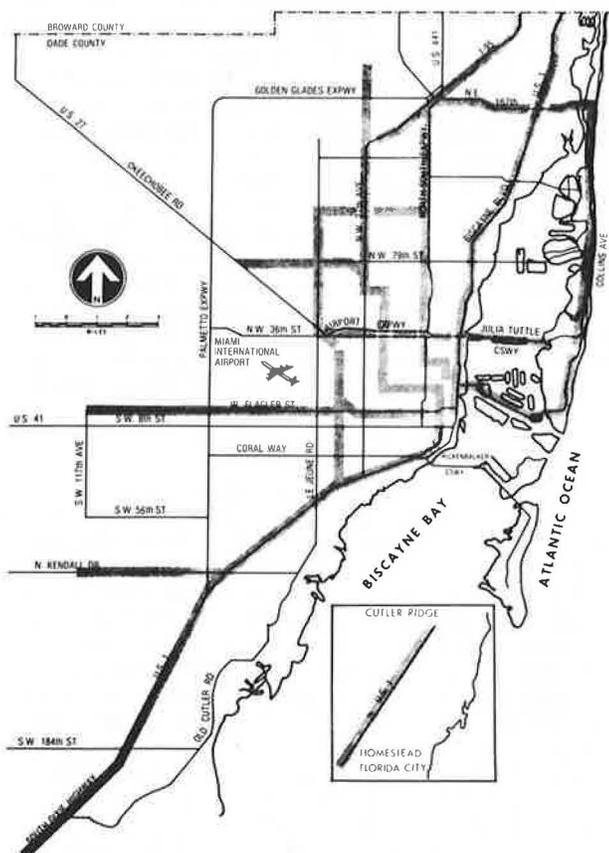
The process described in this section resulted in the development of a number of service corridors that appear to reflect the choice of the citizens' panels and technical, engineering, and planning personnel from the consultant and county organizations. In connecting these corridors to form the service network, a number of key objectives were kept in mind. These objectives included the desire to provide service to and, thus, reinforce the principal special and diversified activity centers within the county and to provide service between these activity centers. A second key feature of the service network is that it will promote and support the other land-use and development policies of the county, particularly as they relate to the inception and growth of cohesive patterns of land use for 1985 and the year 2000.

Development of the Core System

The final product of the sketch-planning level of analysis was the core system. Numerous alternatives were developed at the first level of analysis; these were evaluated and the viable alternatives were combined during the second level of analysis to form the service network. Additional analyses were conducted to define that portion of the service network that would require grade-separated rapid rail service to meet the projected 1985 travel demands. The core system was defined as the minimum rapid transit network that would sustain an integrated system for the 1985 travel requirements of Dade County.

The extensive analysis of alternatives that led to the development of the service network has provided a basis for the establishment of various objectives that support the definition of the core system. These objectives fall into three categories and are described and discussed here:

1. Service and cost-effectiveness: (a) Accessibility—the core system should be within a 10-min feeder bus ride of 60 percent or more of the 1985 resident population of Dade County; (b) Modal split—the core system should achieve projected ridership of 20 percent or more of the 1985 home-based work trips (80 percent confidence level), plus 10 percent or more of the 1985 nonwork trips (80 percent confidence level); and (c) Radial corridor limitation—grade-separated rapid transit should not be extended to segments of the service network that are projected to carry less than 6000 passengers/h, peak load, peak direction (50 percent confidence level).
2. Engineering and network continuity considerations: (a) Operational viability and expandability—the core system must be operationally viable and capable of expansion to include the entire service network with minimum disruption; (b) Key link inclusion—the core-system network continuity and integrity must be maintained by the inclusion of key links between segments that may not otherwise meet core-system objectives; and (c) Current programs—the core system must include use of the I-95 busway currently under construction (since completed) by the Florida Department of Transportation.
3. Land use and development: (a) Activity center service and reinforcement—the core system should serve the county's principal major activity centers and should promote the reinforcement of such areas; and (b) Conformance with the support of other elements of land-use and development plan—the core system should support, conform with, and sustain the extension of the land-use and development plan so as to promote the inception of a cohesive pattern of land use in the county.

Evaluation of Systemwide Alternatives

The third and final level of planning analysis during preliminary engineering involved detailed evaluations of both the core system and the null alternative. The approach

used in this section of the EIS was to provide a comparison between the early alternatives and the core system that was the end product of a long evaluation process. To allow a true comparison of the null, core, and selected systemwide alternatives, all alternatives were measured and judged equally. The details of the core and null alternatives were developed during the final level of planning analysis.

A discussion of a limited set of alternatives, in addition to the core and null alternatives, was presented in the EIS as a summary of the data prepared previously during preliminary engineering. The alternatives selected for presentation reflected the spectrum of alternatives analyzed. They included low- and high-cost all-bus alternatives and low-, medium-, and high-cost alternatives containing varying levels of transitway and grade-separated (fixed-guideway and busway) service. A complete description of all alternatives analyzed was published in a separate document and made available to the public.

Stage 1 System

The end product of the preliminary engineering working within fiscal restraints was the definition of the stage 1 or initial-stage system (Figure 2). The route of the system begins in the vicinity of Dadeland, southwest of Miami, and follows northeasterly along the Florida East Coast Railway right-of-way, generally parallel to South Dixie Highway and the central business district of Miami, thence northerly to N.W. 79th Street, and then along N.W. 79th Street through Hialeah to the terminal at the Okeechobee Station, a distance of 32.8 km (20.5 miles). The system is to be a fixed-guideway, heavy rail system. Most of the system is elevated, i.e., 32 km (20 miles),

Figure 2. Stage 1 rapid transit system with station locations.

LEGEND

━━━ RECOMMENDED ALIGNMENT

STATION LOCATIONS

1 - DADELAND SOUTH		11 - CULMER
2 - DADELAND NORTH		12 - CIVIC CENTER
3 - SOUTH MIAMI		13 - SANTA CLARA
4 - UNIVERSITY		14 - ALLAPATTAH
5 - DOUGLAS ROAD		15 - EARLINGTON HTS.
6 - COCONUT GROVE		16 - BROWNSVILLE
7 - VIZCAYA		17 - GLADEVIEW
8 - BRICKELL		18 - NORTHSIDE
9 - GOVERNMENT CENTER		19 - HIALEAH
10 - WASHINGTON HEIGHTS		20 - OKEECHOBEE

although some sections will be at grade of 0.8 km (0.5 mile). A yard and shop site west of Hialeah and 20 stations are planned for the system. The stage 1 system provides maximum service for funds to be expended and can operate as a complete system or can be extended when additional funds become available, all within the service network. Figure 3 presents a conceptual flow diagram of the phase 2 alternatives-analysis process used to define the first construction increment.

ENVIRONMENTAL IMPACT ANALYSIS

Impact studies focus on the nature and extent to which the natural and human environments will change as a result of the proposed action. They are predicated on a knowledge of existing conditions in the study area—information that would be developed earlier in the EIS process. To determine the level of significance of each environmental impact, the analysis procedures involve comparative evaluation. Predicted environmental impacts are commonly compared to and evaluated on the basis of (a) future environmental quality with and without the proposed project and (b) conformance with adopted standards, plans, guidelines, regulations, and so forth. Probable impacts are usually time referenced, i.e., either short-term (construction) or long-term (operations and maintenance) impacts.

Opinions among professionals and citizens vary as to which issues should be included in an impact statement and how they should be evaluated. The issues discussed here are examples of impact assessments in the UMTA EIS process and are not intended as a complete listing. Issues vary with the type of system and geographic location.

Land Use and Urban Development

The impact on land use and urban development in a study area as a result of the proposed project should focus on the relation of the transportation improvement to current and projected land-use trends and adopted plans and policies. Land-use impact analysis for Dade County's rapid transit system involved considering each project's influence on existing land-use patterns, compatibility with existing plans, and opportunities for new development. The influence on existing land use was presented by discussing what influence the transit system would have on countywide land-use trends, based on the experiences of other heavy rail systems. To determine the compatibility of the system with existing plans, the proposed project was evaluated in terms of how it would support and complement the Comprehensive Development Master Plan adopted by Dade County in 1975. Opportunities for new development were calculated based on the existing character of the land, the probable impact of the transit stations, and the land-use trends in the area.

One of the major issues of the Dade County project was the selection of the yard and shop site. Sites selected along the original proposed stage 1 system became impossible to construct because of strong objections by citizen groups and homeowners. A second study sought sites removed from the original line. Considerations were given to land availability, citizen satisfaction, operational characteristics, environmental impacts, cost to reach the site, patronage additions to the line extension, and other factors. After exhaustive studies, public meetings, consultations with UMTA, and special funding from the City of Hialeah, the 6.4-km (4-mile) extension through Hialeah to the yard and shop was selected and subsequently approved by UMTA.

Mitigation measures for land-use impacts involved a
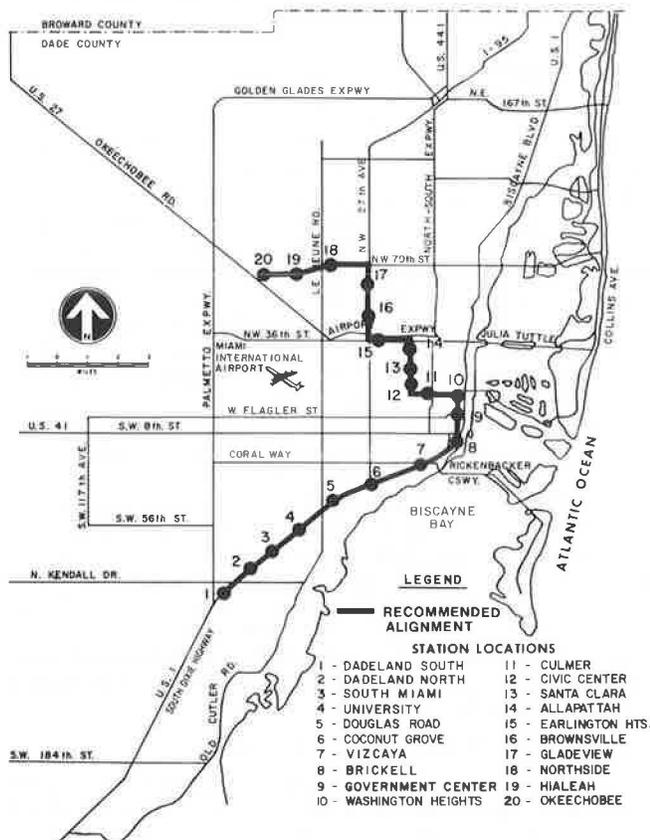
Figure 3. Conceptual flow diagram of the phase 2 alternatives-analysis process.
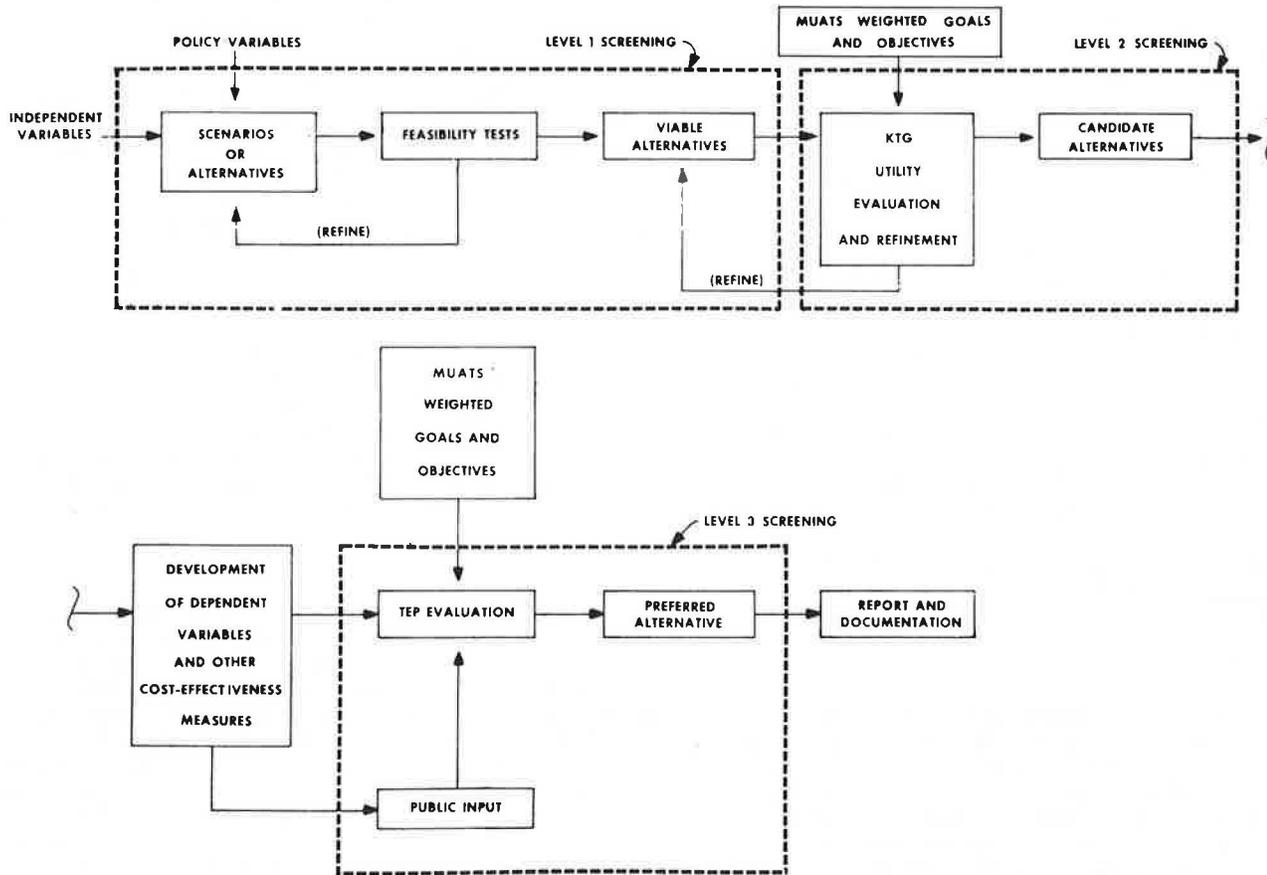
discussion of the planning efforts to be undertaken to assist Dade County and the affected municipalities in maximizing the effectiveness of their land-use controls. The Station Area Design and Development (SADD) program, a planning program, was begun in September 1977 to examine in detail land-use planning issues in areas adjacent to and near the transit stations in order to maximize land use. Development would be subject to local control.

Air Quality

The probable air-quality impacts of project implementation are commonly predicted by application of one or more air-pollution-modeling techniques. Based on background data of the study region, models can be used to predict future air-pollutant concentrations for a region as well as specific sites.

To estimate concentrations of nonreactive pollutants (carbon monoxide) for highway traffic in the vicinity of the rapid transit alignment, the EPA HIWAY model was applied. In the analysis, 1- and 8-h average pollutant concentrations at six selected receptor sites along the stage 1 route were calculated. Receptor locations were in high-volume traffic areas. The results were then discussed in relation to Florida's 1- and 8-h carbon monoxide (CO) standards to ascertain the magnitude of impact.

Analysis of predicted CO concentrations also included parking lots for those proposed transit stations with parking facilities. For large-capacity parking facilities, this analysis will be continued in compliance with the Complex Air Source Rule of the Florida Department of Environmental Regulation.

To assess the impact of the rapid transit system with respect to the National Ambient Air Quality Standards and Florida's State Implementation Plan, hydrocarbon and nitrogen oxide emissions from 1970 to 2000, within and without the transit system, were estimated. Emission factors, reflecting the Clean Air Act Amendments of 1977, were calculated based on the EPA Mobile Source Emission Factor Model (January 1978). In addition to long-term impacts, the short-term impacts created by project construction were presented with a discussion of appropriate mitigating measures for the control of air, water, and noise pollution.

Water Quality and Hydrology

Adverse water quality and hydrologic impacts may occur from project implementation. As such, the EIS process requires a thorough analysis of the potential short- and long-term impacts on the water resources of the study area. Depending on the type of project and specific ecology of the locale, emphasis will vary as to the priority of water-quality issues.

Water-quality degradation is the most predominant environmental problem in Dade County because the county is almost entirely underlain by the Biscayne Aquifer at a shallow depth. This aquifer, the primary source of potable water for the county, has an extremely porous surface, allowing run-off pollutants to readily enter the subsurface and degrade water quality.

Analysis of short-term water-quality impacts of the Dade County project in the EIS involved discussion of the potential problems from construction activities. The probable impacts discussed were sedimentation, erosion, spillage of petroleum products, river and canal crossings,

dewatering, and water supply sources. In addition to determinations regarding the probable magnitude of each impact, analysis outlined relevant mitigation measures including retention basins for trapping sediment, temporary erosion-control techniques (grassing, mulching), and grouting to prevent water-table fluctuations during dewatering.

The major, long-term water-quality and hydrologic impacts analyzed in the impact statement were runoff pollution from the increased amount of impervious surface (parking lots), the spillage of petroleum products at various system facilities, and potential impacts to the Biscayne Aquifer from system operations and maintenance.

Each major and minor impact was evaluated in terms of the location and extent of the problem. Separate analyses included probable impacts as a result of system operations in station areas, along the guideway, and at the yard and shop site. The most in-depth analysis was performed concerning the yard and shop, due to the anticipated magnitude of the impact from the activities to occur there. For each water-quality impact delineated in the EIS, appropriate mitigation and control methodologies were presented, emphasizing nonpoint-source pollution-control options, appropriate facility location in relation to water resources, and water supply systems.

Noise Pollution

Implementation of a transportation improvement plan creates a new noise source in the urban environment that can adversely affect communities traversed by it. A noise-impact analysis is then an essential part of environmental planning for rapid transit facilities.

Numerous noise exposure schemes have been developed to evaluate noise from transportation sources and to provide a basis for determining noise-level design goals and acceptability criteria. The noise exposure scheme considered most applicable for rapid-transit environmental planning in Dade County was the maximum permissible single-event noise level. Train noise levels, because of their short duration, may appear acceptable on a calculated exposure-level basis, but due to possible large differences between maximum pass-by levels and average community ambient noise, train noise may be unacceptable. Single-event noise-level design goals avoid masking adverse noise impacts.

The noise impact on the urban environment is dependent on the land-use activities adjacent to the transit improvement. Noise-impact studies should relate predicted wayside levels along transit corridors to land uses traversed. Noise-level guidelines used for train operations in Dade County were those of the American Public Transit Association (APTA). These consider five general categories of community areas: low-density residential, average residential, high-density residential, commercial, and industrial or highway. They also set maximum single-event noise level design goals for each.

Analysis to determine noise impacts of the rapid transit system first involved classification of the land uses along the transit corridor into one of the area categories to set noise guidelines for each route segment. This was accomplished by plotting the transit alignment on aerial photographs and then classifying abutting land uses. Subsequently, overlays with the anticipated noise contours from system operations were added to the photographs. Adverse impacts were identified by comparing the land-use classifications with the anticipated pass-by noise levels. Where noise levels were determined to be in excess of APTA guidelines, sound barriers were recommended to attenuate noise to acceptable levels.

Noise-impact evaluations devoted particular attention to noise-sensitive land uses. Hospitals, schools, parks, libraries, and theaters, for example, are land uses whose activities could be disrupted by excessive noise.

Graphic presentation of noise contours was not included in the Dade County EIS because of the extremely large number of pages required to portray this feature at a meaningful scale. Sound-barrier locations and adverse noise-impacted structures were shown on line diagrams. In addition, a table was prepared to indicate noise impacts above 75 dB(A). Noise contours were available for inspection by anyone visiting the project office.

Socioeconomic Environment

A wide range of social and economic impacts results from transportation improvements. Impact statements should consider both the short-term (direct) and long-term (indirect) effects of project implementation. While relevant socioeconomic issues will vary from project to project depending on its nature, topics that meet impact statement requirements are summarized in this section.

Visual Impact

The nature and extent to which the visual landscape will be altered by a transit project deserves thorough study. Dade County's impact analysis used a rating scheme, developed by professionals in architecture and urban design, to gauge the probable visual effects of the rapid transit system. The process developed required (a) review of the preliminary engineering reports that indicated the design configuration of some of the principal elements of the system, (b) field observation of the transit corridor, (c) the development of typical situations that would occur along the system and the attempt to predict the visual impact of different configurations, and (d) a field survey applicable to typical situations and problem areas. Impacts were divided into eight categories exhibiting a range of impacts that may add to, or detract from, the use of nearby properties. The range of impact included situations in which the transit system would make a positive contribution to the environment or would replace existing negative features and improve the overall visual environment. The design included mitigating measures for situations of negative visual impact. Landscaping of the transit system was part of the design used to present a visually pleasing appearance.

Displacement Impact

A major socioeconomic impact of transit improvements is the displacement of residences and businesses. Environmental planning for rapid transit facilities should involve analysis of the affected residences and businesses and should delineate available mitigation measures.

The information collected and analyzed for the Dade County rapid transit system displacement impact included the number and location of residences and businesses to be displaced; an estimate of the percentage of minority families, low-income families, and elderly; and the median income of those displaced in each impact area. A frequent source of demographic information is the population census of the U.S. Bureau of the Census. However, depending on the date of the census and the level of accuracy required for impact analysis, such data can be inadequate. More recent data can often be obtained from local agencies involved in planning, economic development, housing, and so forth.

The displacement impact on an urban area is dependent on the magnitude of relocation and the ease with which those displaced can be relocated. As such, sources of

replacement housing should be evaluated. For EIS purposes, this evaluation should be of sufficient depth to uncover potential relocation problems. The Dade County EIS also evaluated relocation problems for commercial and industrial properties due to the magnitude of the business impacts.

Mitigating measures for displacement impact are those developed in accordance with the required project relocation plan. Impact statements should discuss those elements of the plan concerning available relocation assistance. The discussion of mitigating measures would delineate applicable federal, state, and local programs and policies for relocation assistance and the services and payments available through them. In addition, the mechanisms by which available assistance will be provided (i.e., relocation program and staff) should be presented.

Community Cohesion

Fixed-facility transit improvements, with appropriate design considerations, can minimize significant disruption of community cohesion and stability. The impact statement should assess the extent to which project implementation would cause neighborhoods to undergo socioeconomic change or create a barrier to existing activity patterns. Particularly important are station areas as the potential for development and redevelopment is strongest in these areas.

Minimal impacts to community cohesion and stability were anticipated in the Dade County EIS as the system will follow established transportation rights-of-way (railroad and highway) in most areas, and the system will be elevated over most of its length, allowing existing activity patterns to continue.

Access to Services and Facilities

The construction of transit improvements, the completed project, or both can affect accessibility to services and facilities. Construction-related effects would include the hindrance of access by such activities as temporary street closings and construction activities. Impacts of the completed project would involve the disruption or obstruction of existing movement patterns from increased traffic volumes in station areas, at-grade system facilities, and permanent street closings.

Dade County's rapid-transit system, almost entirely grade separated, is anticipated to have minimal overall adverse impacts on accessibility. Transit station areas, especially at those stations with large-capacity parking, are anticipated to experience slight impacts from increased traffic volumes, particularly during peak hours. Planning efforts, therefore, have been directed toward maintaining pedestrian and vehicular access through appropriate design considerations.

Safety and Security

This section of the impact statement should discuss those elements of system design, engineering, and operation that will provide for the safety and security of transit patrons. Safety criteria would include, among other provisions, station accidents, boarding and alighting accidents, onboard accidents, collisions, fires, structural failures, and construction accidents. Security criteria would discuss deterrence of criminality, detection of criminal activity, and limitation of injuries and losses due to criminal activity. The information presented in the impact statement should indicate how safety and security goals will be achieved. As delineated in the Dade County EIS, the goals for the project are to be ac-

complished by developing comprehensive safety and security plans.

Effect on Business Activity

The expenditures for a major transit project and their impact within the general business and industry sector of the study area should be investigated. Discussion would involve the multiplier effect on the regional economy from material, labor, and service purchases. The induced effects on business activity from project construction should be examined and mitigation measures noted.

Effect on Employment

Economic impact analysis of the project would reflect the project's effects on employment levels and employment distribution within the regional economy. The anticipated number of jobs lost from business dislocation and the predicted number of jobs created, both from project construction and operation, should be indicated. Employment distribution would be assessed in terms of how project implementation will reinforce or alter existing employment patterns. For the Dade County EIS, an estimate of employment impact was developed by locating the businesses to be displaced and estimating the number of employees for each business. Results were presented in terms of impact on each employment sector (retail, wholesale, service, manufacturing).

Property Tax Base Impacts

An estimate of the impact to the property tax base from the removal of land from the tax rolls for the system would be included in the economic analysis. For the Dade County EIS, tax displacement was derived by determining the total property value in each municipality and in unincorporated Dade County by adding the assessed value of all parcels to be taken by the rapid transit system. Residential property values were discounted to allow for Dade County's homestead exemption. The appropriate county or municipal tax rate was then applied to derive the tax assessment for residential and commercial property, which were then totaled to find the annual property tax revenue loss.

Discussion of mitigating measures would include the retrieval of revenue loss through various value-capture methods, such as the leasing of space for commercial uses within the project right-of-way and for redevelopment and development of station areas.

ANALYSIS OF PARKLANDS AND HISTORIC PROPERTIES

Section 4f of the U.S. Department of Transportation Act of 1966 mandates that the Secretary of Transportation shall not approve any project or program that requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance as determined by the federal, state, or local officials who have jurisdiction over them, or any land from a historic site of national, state, or local significance as so determined by such officials unless (a) there is no feasible and prudent alternative to the use of such land and (b) such program includes all possible planning to minimize harm to the section 4f land resulting from such use. In accordance with this legislation, if a project proposes to take or seriously impact park and recreation lands, a section 4f statement must be prepared that adequately addresses the stated preconditions for the use of such lands. Projects that impact, but do not take section 4f lands, do not usually

require such a statement. UMTA prefers to include a draft statement in the draft EIS and to include the final section 4f statement in the final EIS.

Briefly, statements related to section 4f lands should include the following information:

1. Description of land—type of area, location, size, activities, existing and planned facilities, use, vehicle and pedestrian access, ownership, and title restrictions;

2. Involvement of land—the location and extent of the land to be taken, whether the section 4f land acquisition will be temporary or permanent, the type of facilities that will be built there and on surrounding land, and detailed discussion of the impact of the project on the land;

3. Alternative locations that avoid the section 4f land—these should be discussed in sufficient detail to clearly support a judgment of not feasible or prudent; and

4. Mitigation measures to be used to minimize the impact of the project on section 4f lands.

The planning efforts for the Dade County transit system were directed at the avoidance of section 4f land acquisitions. Beginning in the early stages of system development, such lands were located within the study area, their significance determined by appropriate officials, and the potential impacts, if the land were to be taken, assessed. A statement of section 4f involvement was presented in the draft EIS relating to a proposed land taking for transit station parking at the Hialeah Station. However, subsequent architectural and engineering studies provided an alternative solution to the taking of such land, and a formal statement was not necessary in the final EIS.

Section 106 of the National Historic Preservation Act of 1966 requires that the federal agency with jurisdiction over a proposed federal or federally assisted project shall, prior to the approval of the expenditure of any federal funds on the project, take into account the effect of the project on any district, site, building, structure, or object listed on or eligible for the National Register of Historic Places. The act created the Advisory Council on Historic Preservation that promulgated procedures for the protection of historic and cultural properties to implement the act.

To comply with these requirements the impact assessment process must involve identification of all properties of historical, architectural, archeological, and cultural significance within the project impact area. Although National Register properties are easily identified by consulting the National Register and monthly supplements, eligible properties should be determined by applying the National Register criteria included in the latest advisory council procedures. Eligible properties must be determined in coordination with the state historic preservation officer (SHPO). If the eligibility of a particular property for inclusion in the National Register is questionable, the keeper of the National Register, U.S. Department of Interior, should be consulted for a determination of eligibility. UMTA attempts, in the draft EIS, to identify all National Register and eligible properties and to make a determination of effect for each property. Such determination is accomplished in consultation with the SHPO by applying the advisory council's criteria of effect. If the project will have any effect on National Register and eligible properties, the advisory council's criteria of adverse effect should be applied in consultation with the SHPO. Determinations of no adverse effect must be submitted to the advisory council for review with adequate supporting documentation. The advisory council review was accomplished simultaneously with the draft EIS circulation. The draft EIS documented that the advisory council's procedures had been followed. The close coordination between project planning with the SHPO and UMTA, along with the advisory council, made this process relatively easy.

In compliance with these requirements a survey was undertaken by the Dade County Historic Survey, Department of Parks and Recreation, to locate National Register and eligible properties within the rapid transit system impact area. One problem did develop when the historical and archeological survey team discovered a structure considered eligible for the National Register. This occurred during the draft EIS circulation period. Consequently, a consensus determination of eligibility, a 10-day process, was obtained from the advisory council. This was documented with a special report and later included in the final EIS.

CONCLUSION

The environmental planning issues discussed in this paper are considered major in the development of an EIS for rapid transit facilities under UMTA guidelines. The development of the Dade County EIS was very closely coordinated with UMTA. In effect, it was the result of a three-party effort by UMTA, the Dade County Office of Transportation Administration, and the consultant.

The basic scope of each issue and the impact methodologies presented serve to indicate one approach in fulfilling NEPA and related environmental law considerations for the planning of rapid transit facilities. Because of the nature of the project this EIS will be of benefit to other fixed-facility transit projects. The experiences gained should be helpful in assessing the impacts of similar projects, including downtown people movers.

REFERENCE

1. U.S. Department of Transportation, Office of the Secretary. Procedures for Considering Environmental Impacts. Federal Register, Vol. 39, No. 190, Sept. 30, 1974.

Estimating Socioeconomic Impacts of Transportation Systems

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This study develops a methodology to estimate the socioeconomic impacts of multimodal transportation plans and programs in Maryland. The impacts include government expenditures of plan implementation, socioeconomic impacts of expenditures (i.e., personal income, employment, and population), displacement of businesses and households, and land use, accessibility, safety, and socioeconomic impacts of new transportation services and facilities (i.e., personal income, employment, and population). The programs evaluated include the Port of Baltimore; Baltimore-Washington International Airport; general aviation airports; rail (commuter and intercity) facilities; mass transit (bus and rail rapid transit); Interstate, primary, and secondary highway systems; low-capital improvements; and operating programs. The methodology consists of 26 impact-estimating equations, each of which was developed for statewide, regional, and county levels of detail. As a test application, the equations were used to evaluate the impacts of a 20-year $10-billion Maryland transportation plan. Socioeconomic impacts related to expenditures and new facilities or services were shown to generate $18 billion in personal income over this period with an average annual employment impact of 48 000 jobs and an average annual population impact of 100 000 people. The Baltimore region experienced the largest impact (83 percent of total statewide impacts). The Baltimore city and Baltimore County areas experienced 60 percent of the Baltimore region's impact.

The value of a transportation system is measured by the ultimate social and economic benefits, as well as the negative effects, the system contributes. Both citizens and public officials are demanding information concerning personal income, employment, economic growth, population, mobility, community disruption, and other potential impacts of proposed transportation systems before implementation decisions are made. These items are known as socioeconomic effects.

Recognition of the usefulness of socioeconomic impact analysis in evaluating transportation investments has increased dramatically. This impact information helps citizens and public officials to understand the implications of proposed and ongoing transportation system plans and programs. Socioeconomic information facilitates decisions concerning how a transportation system should be operated, maintained, and expanded to attain national, state, and local social and economic objectives. It also facilitates the integration of programs for transportation system change with those of other public and private organizations to preserve and promote desired social and economic conditions.

To date, socioeconomic impact analyses have focused on evaluating proposed transportation changes at the project and corridor levels. Although effective techniques have been developed for these levels, the demand for socioeconomic impact analyses in state transportation system planning has not been satisfied. The current state of the art fails to accommodate the requisite attributes of an effective state system-level socioeconomic impact assessment methodology in the following respects:

1. Most socioeconomic impact models have been developed for the regional or local levels of planning; few have been applied or are applicable to state planning processes.

2. Most models consider only the highway mode; none incorporate all modes of transportation.

3. Few models consider transportation programs other than capital improvement programs or provide

the capability to integrate the effects of various programs.

4. Most models focus on determining the demand for transportation facilities and services, given exogenous inputs of population and economic activity distribution; few models determine the population and economic-activity impacts of transportation.

5. The models that do provide estimates of the effect of transportation (highway mode) on population and employment distribution fail to account for growth induced by transportation. Models that do account for this aspect are applicable only at the multistate regional level or are prohibitively expensive to use as an ongoing planning tool, or both.

6. Most techniques that assess the socioeconomic effects of transportation were developed for and are currently applicable to project planning only.

7. No universally acceptable framework for the integration of the complex of socioeconomic impacts and their application to the evaluation of proposed transportation programs is available.

The study discussed in this paper was designed to develop a methodology capable of providing estimates of the potential socioeconomic impacts of transportation system plans and programs at the state, multicounty-region, and county levels of detail.

The methodology resulting from this study was developed in three steps: (a) identification of essential characteristics of an effective methodology, (b) review of existing techniques for measuring socioeconomic impacts of transportation services and facilities, and (c) improvements in existing techniques. Finally, the methodology's capability was illustrated by applying it to estimate the socioeconomic impacts of a proposed Maryland transportation system plan alternative. The impacts analyzed included government expenditures involved in plan implementation, socioeconomic impacts of expenditures (i.e., personal income, employment, and population), land use impacts, displacement of businesses and households, accessibility impacts, safety impacts, and the socioeconomic impact of new transportation services and facilities (i.e., personal income, employment, and population). The programs evaluated included the Port of Baltimore; Baltimore-Washington International (BWI) Airport; general aviation airports; rail (commuter and intercity) facilities; mass transit (bus and rapid rail); Interstate, primary, and secondary highway systems; low-capital improvements; and operating programs.

STUDY RESULTS

This study may make a significant contribution to the transportation system planning process in Maryland as a result of the development of a socioeconomic impact analysis requirements matrix. The matrix, which is presented in Figure 1, identifies the components of an effective socioeconomic impact methodology by specifying which impacts should be considered in Maryland's system planning process.

The responses obtained from interviews conducted for

Figure 1. Impacts that the methodology can estimate qualitatively and quantitatively.

PROGRAMS TO BE EVALUATED	Govt. Responsibility for Implementing the Plan	Personal Income[b]	Employment[b]	Population[b]	Land Use Impact	Business Displacement	Household Displacement Impact	Accessibility Impact	Safety Impact	Personal Income[c]	Employment[c]	Population[c]
Port of Baltimore MCP[a]	QN	QN	QN	QN	QN	QN	QN	QN	QL	QN	QN	QN
BWI Airport MCP	QN	QN	QN	QN	QN	QN	QN	QN	QL	QN	QN	QN
General Aviation MCP	QN	QN	QN	QN				QN	QL	QN	QN	QN
Rail MCP	QN	QN	QN	QN	QN	QN	QN	QL	QL	QN	QN	QN
Mass Transit MCP	QN	QN	QN	QN	QN	QN	QN	QN	QL	QL	QL	QL
Interstate and Primary Highway System MCP	QN	QN	QN	QN				QN	QN	QN	QN	QN
Secondary Highway System MCP	QN	QN	QN	QN				QN	QN	QN	QN	QN
Low-Capital-Improvement Program	QN	QN	QN	QN								
Operating Program	QN	QN	QN	QN								
All MDOT Programs	QN	QN	QN	QN								

Notes: QN = The methodology developed during this study provides for the quantitative estimation of this program impact.

QL - The methodology developed during this study provides for the qualitative estimation of this program impact.

Blank - This program impact is not amenable to either quantitative or qualitative estimation.

[a] MCP = Major Capital Program.

[b] Impact of expenditures to implement the programs.

[c] Impact of new transportation facilities and services.

this study represent a major contribution to the matrix. An interview instrument was developed and administered to 10 key public officials in Maryland. This interview instrument, or a modification of it, is useful in obtaining valuable information about the range and characteristics of opinions concerning the relative values of socioeconomic impacts. The determination of these relative values significantly improves trade-off analyses among state transportation plans and programs.

The socioeconomic impact methodology developed during this study is responsive to the components of the analysis requirements matrix. The extent to which the methodology provides for the estimation of relevant socioeconomic impacts is summarized in Figure 1. The symbols QN and QL that appear in this matrix identify whether the methodology provides quantitative or qualitative estimates of the impacts by program, respectively. Several cells in the matrix are blank to indicate program impacts that are not amenable to either quantitative or qualitative estimation.

The methodology proposed for use in Maryland's transportation system planning process is comprised of a set of measurement techniques. Each technique is designed to estimate a specific impact for a specific transportation program or set of programs. An impact estimate represents the difference in a socioeconomic characteristic that would occur if a program were implemented versus if it were not implemented. The methodology is designed to generate annual impact estimates for the 1978-2000 planning period. Impact estimates are reported by program or sets of programs in the matrix format. This format was used because interviews conducted for this study indicate that impact estimates for a system plan or program are not amenable to objective aggregation, such as a benefit/cost ratio or other single index of worth. Consequently, a disaggregate presentation of impact estimates, such as the matrix, is the most understandable and useful format for reporting impact analyses.

The methodology is documented in two parts to facilitate its use by the Maryland Department of Transportation and other parties. First, the measurement techniques are summarized in equation form. These equations and the definitions of the variables and constants are reproduced in Figures 2 and 3. Second, the methodology is documented in a set of working papers. A working paper describes each technique's derivation. It also describes the assumptions and major limitations of the techniques and presents the sources of data used to estimate the variables and constants for applying it.

Application of the measurement techniques requires collection of data to estimate the variables and constants that appear in the equations and, subsequently, performance of the mathematical operations specified in the equation. Figure 4 presents the equation used to estimate the personal income impact of the Port of Baltimore as an illustration of how the measurement techniques are applied.

The methodology presented in this report is a significant improvement to the state of the art. Specifically, these improvements include the following:

1. Development of a measurement technique where none previously existed;

2. Development of a complete set of socioeconomic impacts relevant to Maryland Department of Transportation system planning;

3. Generation of data previously available to permit use of existing techniques or to improve the accuracy of their estimates;

Figure 2. Socioeconomic impact-estimating equations.

Impacts	Equations
Government Financial Responsibility	$G_{nh} = X_{nph}G_{ph}$ (1) $G_{sh} = X_{sph}G_{ph}$ (2) $G_{ch} = X_{cph}G_{ph}$ (3)
Personal-income Impact of Expenditures to Implement each Program	$Y_{psh} = k_i G_{psh} - k_i b_s T_{psh} + k'_i c_f G_{pfh}$ (4) $Y_{prh} = \dfrac{1}{1-(a_r b_r)}\left[G_{prh} - b_r T_{prh}\right] + A_{prh}$ (5) $Y_{pch} = Y_{prh}\dfrac{Y_{ch}}{Y_{rh}}$ (6)
Employment Impact of Expenditures to Implement each Program	$E_{psh} = \left(\dfrac{E_{sh}}{Y_{sh}}\right)Y_{psh}$ (7) $E_{prh} = \left(\dfrac{E_{sh}}{Y_{rh}}\right)Y_{prh} + A_{prh}$ (8) $E_{pch} = E_{prh}\left(\dfrac{E_{ch}}{E_{rh}}\right)$ (9)
Population Impact of Expenditures to Implement each Program	$P_{psh} = E_{psh}\left(\dfrac{P_{sh}}{E_{sh}}\right)$ (10) $P_{prh} = E_{prh}\left(\dfrac{P_{rh}}{E_{rh}}\right) + A_{prh}$ (11) $P_{pch} = P_{prh}\left(\dfrac{P_{ch}}{E_{rh}}\right)$ (12)
Land Use Impacts for the Port. BWI Rail and Mass Transit MCP's	$LU_{psh} = \sum\limits_q L_{qh} - 1978$ (13) $LU_{prh} =$ (same as LU_{psh} except $\sum\limits_q$ refers to the projects in the region) (14) $LU_{pch} =$ (same as LU_{psh} except $\sum\limits_q$ refers to the projects in the county) (15)
Business Displacement Impact of the Port. BWI, Rail and Mass Transit MCP's	$RB_{psh} = \sum\limits_q DB_{qh} - 1978$ (16) $RB_{prh} =$ (same as RB_{psh} except $\sum\limits_q$ refers to the projects in the county) (17) $RB_{pch} =$ (same as RB_{psh} except $\sum\limits_q$ refers to the projects in the county) (18)
Household Displacement Impact of the Port, BWI Rail and Mass Transit MCP's	$RH_{psh} = \sum\limits_q DH_{qh} - 1978$ (19) $RH_{phr} =$ (same as RH_{psh} except $\sum\limits_q$ refers to the projects in the region) (20) $RH_{pch} =$ (same as RH_{psh} except $\sum\limits_q$ refers to the projects in the county) (21)
Accessibility Impact of the Port MCP	$AC_{2sh} = \left(\dfrac{D_{2sh} - D_{sh}}{D_{sh}}\right)P$ (22) $AC_{2rh} =$ not amenable to estimation (23) $AC_{2ch} =$ not amenable to estimation (24)

Figure 2. Continued.

Accessibility Impact of the BWI MCP	$AC_{2sh} =$ (25)

$$\sum_c \left[\frac{\left(TT_{xy'} - \left[TT_{xy}\left(\frac{DM_h - CP_b}{DM_h}\right) + TT_{xy'}\left(\frac{1 - DM_h\ CP_b}{DM_h}\right)\right]\right)}{\left[TT_{xy}\left(\frac{DM_h - CP_b}{DM_h}\right) + TT_{xy'}\left(\frac{1 - DM_h - CP_b}{DM_h}\right)\right]}\left(\frac{DM_{ch}}{\sum_c DM_{ch}}\right) \right]$$

$AC_{3rh} = $ (same as AC_{3sh} except $\sum_c$ refers to the counties in each region) (26)

$$AC_{3ch} = TT_{xy'}\ \frac{TT_{xy}\left(\frac{DM_h - CP_b}{DM_h}\right) + TT_{xy'}\left(\frac{1 - DM_h - CP_b}{DM_h}\right)}{TT_{xy}\left(\frac{DM_h - CP_b}{DM_h}\right) + TT_{xy'}\left(\frac{1 - DM_h - CP_b}{DM_h}\right)}$$ (27)

Accessibility Impact of the General Aviation MCP	$AC_{4sh} =$ (28)

$$\sum_c \frac{\left(TT_{xy'} - \sum_{xy}\left[(TT_{xy})(Q_{xy})\left(\left[\frac{DM_{Bh} - CP_{Bb}}{DM_{Bh}}\right] + \left[TT_{xy'}\left(1 - \frac{DM_{y'h} - CP_{y'b}}{DM_{y'h}}\right)\right]\right)\right]\right)}{\sum_{xy}\left(\left[(TT_{xy})(Q_{xy})\left(\frac{DM_{y'h} - CP_{y'b}}{DM_{y'}}\right)\right] + \left[TT_{xy'}\left(1 - \frac{DM_{y'h} - CP_{y'b}}{DM_{y'h}}\right)\right]\right)}$$

$AC_{4rh} = $ (same as AC_{4sh} except $\sum_c$ refers to the counties in each region) (29)

$AC_{4ch} =$ (30)

$$\frac{TT_{xy'} - \sum_{xy}\left[(TT_{xy})(Q_{xy})\left(\frac{DM_{y'h} - CP_{y'b}}{DM_{y'h}}\right) + \left[TT_{xy'}\left(1 - \frac{DM_{y'h} - CP_{y'b}}{DM_{y'h}}\right)\right]\right]}{\sum_{xy}\left(\left[(TT_{xy})(Q_{xy})\left(\frac{DM_{y'h} - CP_{y'}}{DM_{y'h}}\right)\right] + \left[TT_{xy'}\left(1 - \frac{DM_{y'h} - CP_{y'h}}{DM_{y'h}}\right)\right]\right)}$$

Accessibility Impact of the Mass Transit MCP	

$$AC_{6rh} = \sum_c \frac{\sum_a\left[TT_{cah}\left(\frac{L_{cah}}{\sum_a L_{cah}}\right)\right] - \sum_a\left[TT_{cab}\left(\frac{L_{cab}}{\sum_a L_{cab}}\right)\right]}{\sum_a\left[TT_{cab}\left(\frac{L_{cab}}{\sum_a L_{cab}}\right)\right]}$$ (31)

$$AC_{6ch} = \frac{\sum_a\left[TT_{cah}\left(\frac{L_{cah}}{\sum_a L_{cah}}\right)\right] - \sum_a\left[TT_{cab}\left(\frac{L_{cab}}{\sum_a L_{cab}}\right)\right]}{\sum_a\left[TT_{cab}\left(\frac{L_{cab}}{\sum_a L_{cab}}\right)\right]}$$ (32)

Figure 2. Continued.

Accessibility Impact of the Interstate, and Primary and Secondary Highway System MCP's combined	$$AC_{7sh} = \frac{\sum\limits_{c}\left[TT_{xy}\left(\dfrac{P_y}{\sum\limits_{y}P_y}\right)\right]_h}{\sum\limits_{c}\left[TT_{xy}\left(\dfrac{P_y}{\sum\limits_{y}P_y}\right)\right]_b} \quad (33)$$ $$AC_{7rh} = \text{(same as } AC_{7sh} \text{ except } \sum\limits_{c} \text{ refers to sum of the counties } (34)$$ $$\text{in the region)}$$
	$$AC_{7ch} = \frac{\left|TT_{xy}\left(\dfrac{P_y}{\sum\limits_{y}P_y}\right)\right|_h}{\left|TT_{xy}\left(\dfrac{P_y}{\sum\limits_{y}P_y}\right)\right|_b} \quad (35)$$
Safety Impact of the Interstate/Primary and Secondary Highway Systems MCP's combined	$$I_{sph} = (IR_{sh} - IR_{sph})\,MVM_{sh} \quad (36)$$ $$F_{sph} = (FR_{sh} - FR_{sph})\,MVM_{sh} \quad (37)$$
Personal-Income Impact of the New Port Facilities and Services	$$Y_{2sh} = k_i\left[\sum\limits_{e}\left(d_e\left[DM_{eh} - \left(CP_{eh} - CP_{2eh}\right)\right]\right)\right] + k_i VP_{2sh} + A_{2sh} \quad (38)$$ $$Y_{2rh} = \left(k_r\right)\left(Y'_{2rh}\right) + A_{2rh} \quad (39)$$ $$Y_{2ch} = Y_{2rh}\left(\dfrac{Y_{ch}}{Y_{rh}}\right) \quad (40)$$
Personal-Income Impact of New BWI Transportation Facilities and Services	$$Y_{3sh} = k_s\left[\sum\limits_{e}\left(d_e\left[DM_{eh} - \left(CP_{eh} - CP_{3eh}\right)\right]\right)\right] + k_s VP_{3sh} + A_{2sh} \quad (41)$$ $$Y_{3rn} = \left(k_r\right)\left(Y'_{3rh}\right) + A_{3rh} \quad (42)$$ $$Y_{3ch} = Y_{3rh}\left(\dfrac{Y_{ch}}{Y_{rh}}\right) \quad (42)$$
Personal-Income Impact of New General Aviation Transportation Facilities and Services	$$Y_{4sh} = \sum\limits_{c} Y_{4ch} \quad (43)$$ $$Y_{4rh} = \sum\limits_{c} Y_{4ch} \quad \text{for all counties within the region} \quad (44)$$ $$Y_{4ch} = k_c\left(\left[\dfrac{CP_{4ch}}{CP_{ch}}\right]\left[\sum\limits_{i}\left(v_i\left[EY_{cih} - EY_{cib}\right]\right)\right]\right) + A_{4ch} \quad (45)$$

14

Personal-Income Impact of New Rail Facilities and Services	$Y_{5sh} = k_s \left(\sum_c \left[\left(\dfrac{Y_{ich}}{Y_{icb}} \right) \left(Y'_{i5cb} \right) + f_c TC_{5cb} \right] \right)$	(46)
	$Y_{5rh} = k_r \left(\sum_c \left[\left(\dfrac{Y_{ich}}{Y_{icb}} \right) \left(Y'_{i5cb} \right) + f_c TC_{5cb} \right] \right) + A_{5rh}$	(47)
	$Y_{5ch} = k_c \left[\left(\dfrac{Y_{ich}}{Y_{icb}} \right) \left(Y'_{i5cb} \right) + f_c TC_{5cb} \right] + A_{5ch}$	(48)
Personal-Income Impact of New Inter-state Primary and Secondary Highway Systems Facilities and Services	$Y_{7sh} = S_{sh} \left[\left(M_t A_{h-h'} + M_{t'} A_{h-h''} + M_{t''} A_{h-h'''} \right) \left(H'_f \right) \right] +$ $S_{sh} \left[\left(1 + C_{h-5} \right) \left(M_{t'} A_{h-h''} H_f + M_{t''} A_{h-h''} \right) \left(H_f \right) \right]$	(49)
	$Y_{7rh} = S_{rh} \text{ (same as } Y_{7sh}) \qquad\qquad + A_{7rh}$	(50)
	$Y_{7ch} = S_{ch} \text{ (same as } Y_{7sh}) \qquad\qquad + A_{7ch}$	(51)
Employment Impact of New Port Facilities and Services	$E_{2sh} = B_{si} \left[\sum_e \left(g_e \ DM_{eh} - \left(CP_{eh} - CP_{2eh} \right) \right) \right] + B_{si} EP_{2sh} + A_{2sh}$	(52)
	$E_{2rh} = Y_{2rh} \left(\dfrac{E_{rh}}{Y_{rh}} \right) + A_{2rh}$	(53)
	$E_{2ch} = E_{2rh} \left(\dfrac{E_{ch}}{E_{rh}} \right) + A_{2ch}$	(54)
Employment Impact of New BWI Facilities and Services	$E_{3sh} = B_{si} \left[\sum_e \left(g_e \left[DM_{eh} - \left(CP_{eh} - CP_{3eh} \right) \right] \right) \right] + B_s EP_{3sh} + A_{2sh}$	(55)
	$E_{3rh} = Y_{3rh} \left(\dfrac{E_{rh}}{Y_{rh}} \right) + A_{3rh}$	(56)
	$E_{3ch} = E_{3rh} \left(\dfrac{Y_{3ch}}{Y_{3rh}} \right)$	(57)
Employment Impact of New General Aviation Facilities and Services	$E_{4sh} = \sum_c E_{4ch}$	(58)
	$E_{4rh} = \sum_c E_{4ch} \text{ for all counties within the region}$	(59)
	$E_{4ch} = Y_{4ch} \left(\dfrac{E_{ch}}{Y_{ch}} \right)$	(60)

Figure 2. Continued.

Employment Impact of New Rail Facilities and Services	$E_{5sh} =$ (61) $$\left[Y_{5sh} - \sum_c \left(f'_c \quad TC_{5cb} \right) \right] \left[\frac{E_{sh}}{Y_{sh}} \right] - \sum_c \left[\frac{\left(1-f'_c\right)\left(TC_{5cb}\right)}{w} \right]$$ $E_{5rh} =$ (62) $$\left[Y_{5rh} - \sum_c \left(f'_c \quad TC_{5cb} \right) \right] \left[\frac{E_{rh}}{Y_{rh}} \right] - \sum_c \left[\frac{\left(1 - f'_c\right)\left(TC_{5cb}\right)}{w} \right] + A_{5rh}$$ $E_{5ch} =$ (63) $$\left[\left(Y_{5ch} - f'_c \quad TC_{5ch} \right) \left(\frac{E_{ch}}{Y_{ch}} \right) \right] - \left[\frac{\left(1 - f'_c\right)\left(TC_{5cb}\right)}{w} \right]$$
Employment Impact of new Interstate, Primary and Secondary Highway Systems, Facilities and Services	$$E_{7sh} = S_{sh}\left[\left(M_t A_{h-h'} + M_{t'} A_{h-h''} + M_{t''} A_{h-h'''} \right) \left(H'_f \right) \right] +$$ (64) $$S_{sh}\left[\left(1+C_{h-5}\right) \left(M_{t'} A_{h-h''} H_f + M_{t''} A_{h-h'''} \right) \left(H_f \right) \right]$$ $E_{7rh} = S_{rh}$ (same as E_{7sh}) $+ A_{7rh}$ (65) $E_{7ch} = S_{ch}$ (same as E_{7sh}) $+ A_{7ch}$ (66)
Population Impact of the new Port, BWI and Rail Facilities and Services	$P_{psh} = E_{psh} \quad \dfrac{P_{sh}}{E_{sh}}$ (67) $P_{prh} = E_{prh} \quad \dfrac{P_{rh}}{E_{rh}} + A_{prh}$ (68) $P_{pch} = E_{pch} \quad \dfrac{P_{ch}}{E_{ch}} + A_{pch}$ (69)
Population Impact of New General Aviation Facilities and Services	$P_{4sh} = \sum_c P_{4ch}$ (70) $P_{4rh} = \sum_c P_{4ch}$, for all counties in the region (71) $P_{4ch} = E_{4ch} \left(\dfrac{P_{ch}}{E_{ch}} \right)$ (72)
Population Impact of New Facilities and Services for Mass Transit	$$P_{6ch} = \left(n_{ch} - \frac{PM_{ch}}{\sum_c PM_{ch}} \right) \left(\sum_c \left[\left(m_{ch} \quad PM_{ch} \right) + A_{ch} \right] \right)$$ (73)

Figure 2. Continued.

Population Impact of New Interstate, Primary and Secondary Highway Systems, Facilities and Services	

$$P_{7sh} = S_{sh}\left[\left(M_t A_{h-h'} + M_{t'} A_{h-h''} + M_{t''} A_{h-h'''}\right)\left(H'_f\right)\right] + \tag{74}$$

$$S_{sh}\left[\left(1+C_{h-5}\right)\left(M_{t'}A_{h-h''}H_f + M_{t''}A_{h-H''}\right)\right] H_f$$

$$P_{7sh} = S_{rh} \text{ (same as } P_{7sh}) + A_{7rh} \tag{75}$$

$$P_{7ch} = S_{ch} \text{ (same as } P_{7ch}) + A_{7ch} \tag{76}$$

Figure 3. Variables for socioeconomic estimation equations.

A = Adjustment factor
B = Employment multiplier
C = An impact growth rate
CP = Capacity
CV = Percent of firms in the industry sector i for which access to aviation facilities are of "critical value"
D = Travel distance
DB = Business establishments displaced
DH = Households displaced
DM = Demand
E = Employment
EP = Employment of port dependent firms
EY = Industry earnings
F = Fatalities
FR = Fatalities rate
G = Government expenditures
H = An endogenous estimate of employment, personal income and population
I = Injuries
IR = Injury rate
L = Land in hectares (1 hectare = 2.47 acres)
LU = Land used in hectares
M = Kilometers of selected highway improvements (1 km = 0.6 mile)
MVM = Millions of vehicle kilometers traveled on the state highway system
P = Population
PM = The number of persons who will move into or within the county in a given time period
Q = Percent of over flow accommodated
RB = Business relocation impact
RH = Household relocation impact
S = Maryland's share of the BEA region impacts
T = Statewide revenue collections used to implement MDOT programs
TC = Transportation cost
TT = Travel time
VP = Value added of port dependent firms
X = Share of government expenditures
Y = Personal income
Y' = Direct personal income

a = Percent of consumer expenditures made locally
b = Marginal propensity to consume
c = Maryland share of BEA region's personal income
d = Direct expenditures per unit
f = The difference between the percent of county residents ownership of firms which would have experienced transportation cost increase and the per cent of increased transportation expenditures which would have accured to county transportation providers as personal income.
f' = Proportion of transportation costs which would have been absorbed by county residents
g = Direct employment impact rate
k = Income multiplier
k' = Indirect plus induced income multiplier
m = The percent of PM who will select a county in which to locate their residence on the basis of relative rail rapid transit service to employment by county.
n = An index of a counties' relative attractiveness as a residential location based on its rail rapid transit access to employment relative to other counties.

Figure 3. Continued.

p = Percent of metric tons passing through the Port of Baltimore usingPublic MPA facilities

t = Tax rate

v = Percent of Maryland firms for which air passenger and/or air freight service is of "critical value" in location choice.

w = annual average truckers wage

Subscripts:

b = Base year
c = County
e = Cargo type, i.e., freight or passenger
f = BEA region
h = Horizon year
h' = 1985
h'' = 1992
h''' = 1998
i = Industry sector
n = Federal government
p = MDOT program
q = MDOT project
r = Maryland region
s = State
t = 1978 - 1985
t' = 1986 - 1992
t'' = 1993 - 1998
x = Maryland county population centroid
y = A specified location
xy = Between x and y

2 = Port of Baltimore MCP
3 = Baltimore Washington International Airport MCP
4 = General Aviation MCP
5 = Rail MCP
6 = Mass Transit MCP
7 = Interstate and Primary Highway MCP
8 = Secondary Highway MCP
9 = Low Capital Program
10 = Operating Program

Figure 4. An example of how the measurement techniques are applied.

STEP 1: Identify the measurement technique to estimate the personal income impact of new Port of Baltimore services and facilities

$$Y_{2sh} = k_i \left[\sum_e \left(d_e \left[DM_{eh} - \left(CP_{eh} - CP_{2eh} \right) \right] \right) \right] + \left(k_i \right) \left(VP_{2sh} \right) + A_{2sh}$$

Note: • If $CP_{eh} > DM_{eh}$ enter 0 for the expression $\left[DM_{eh} - \left(CP_{eh} - CP_{2eh} \right) \right]$

• The result of $\left[DM_{eh} - \left(CP_{eh} - CP_{2eh} \right) \right]$ cannot exceed DM_{eh}

STEP 2: Define the variables, constants and subscripts

A_{2sh} = Adjustment factor.

CP_{eh} = Port of Baltimore public pier capacity by cargo type "e", in year "h".

CP_{2eh} = Port of Baltimore public pier capacity by cargo type "e", in year "h", added by the Port of Baltimore capital improvement program (program #2)

Figure 4. Continued.

DM_{eh} = Demand for use of Port of Baltimore public piers by cargo type "e", in year "h".

VP_{2sh} = Value added to the state economy in year "h" by industry dependent on the new Port of Baltimore public pier capacity.

Y_{2sh} = State personal income impact of the Port of Baltimore capital improvement program (program #2) in year "h" in dollars.

d_e = Direct expenditures in Maryland per metric ton resulting from cargo passing through the Port of Baltimore by cargo type "e" in dollars.

k_i = Income multiplier of type "i".

subscript e = 1, general cargo
= 2, container cargo
= 3, automobiles

subscript i = 1, type I mulitplier associated with industries experiencing direct expenditures resulting from cargo passing through the Port
= 2, type II multiplier associated with value added of Port dependent industries

STEP 3: Estimate the values of the variables and constants

A_{2sh} = 2% of Y_{2sh} before adjustment DM_{1h} = 2,871,000 metric tons d_1 = 41.27

CP_{1h} = 2,997,000 metric tons DM_{2h} = 7,384,000 metric tons d_2 = 26.90

CP_{2h} = 8,838,000 metric tons DM_{3h} = 315,000 units d_3 = 77.04

CP_{3h} = 500,000 units VP_{2sh} = 158,000 k_1 = 1.48

CP_{21h} = 0 k_2 = 2.97

CP_{22h} = 5,580,000 metric tons

CP_{23h} = 311,000 units

STEP 4: Perform the indicated mathematical operations

$$Y_{2sh} = k_1 \left[\sum_{e=1}^{3} \left(d_e \left[DM_{eh} - \left(CP_{eh} - CP_{2eh} \right) \right] \right) \right] + \left(k_2 \right)\left(VP_{2sh} \right) + A_{2sh}$$

$$Y_{2sh} = 1.48 \left[\begin{array}{l} \$41.27 \; [2,871,000 - (2,997,000 - 0)] \\ + \; \$26.90 \; [7,389,000 - (8,838,000 - 5,580,000)] \\ + \; \$77.04 \; [315,000 - (500,000 - 311,000)] \end{array} \right] + (2.97)(\$158,000) + A_{2sh}$$

$$Y_{2sh} = 1.48 \, [120,830,940] + 469,260 + A_{2sh}$$

$$Y_{2sh} = 179,299,050; \therefore A_{2sh} = (-.02)(179,299,050) - \$3,585,980$$

$$Y_{2sh} = 179,299,050 - 3,585,980 = 175,713,070$$

STEP 5: Record estimate

$$Y_{2sh} = \$175,713,070$$

4. Modification of existing techniques to permit their application in Maryland and to the types of system improvements being considered in Maryland;

5. Adaptation of existing techniques that estimate current impacts to provide estimates of future impacts, net impacts, and impacts of changing the mix of capital or operating programs;

6. Clarification and improvement of assumptions underlying existing measurement techniques to ensure more accurate and comprehensible results;

7. Elaboration of an existing measurement technique to make it more comprehensive in its consideration of relevant variables and, consequently, more accurate in its results;

8. Modification of existing techniques to provide for impact estimation at the state, Maryland region, and county levels of detail; and

9. Capability of impact estimation at the single-project, multiple-project, and system levels of detail.

At the same time, the improvements made during this study do not resolve all methodological deficiencies in long-range socioeconomic impact analysis of transportation system plans or programs. Indeed, significant and perhaps insurmountable deficiencies remain. Major among these are the following:

1. Incomplete understanding of the cause-and-effect relationship between transportation system change and economic development,
2. Lack of techniques to accurately determine the combined impacts of a set of transportation programs,
3. Insufficient detail of impact estimates,
4. Lack of techniques to estimate system-level impacts of a set of individually minor projects that compositely may be of large significance,
5. Difficulties in determining the incidence of impacts,
6. Uncertainties associated with long-range projections of variables critical to impact estimation, and
7. Incomparable impact-estimating capabilities among types of system change.

These deficiencies mean that the results of using this methodology must not be regarded as accurate predictions of impacts. Nonetheless, the results can certainly be regarded as indicative of the general direction and order of magnitude of impacts that may be experienced. This type of information is inadequate to make unqualified decisions regarding optimal transportation system development. However, the results of this methodology do provide relevant information that should stimulate debate of state transportation plans and programs from the socioeconomic-impact perspective.

A case study performed with the methodology supports this conclusion. The methodology was used to estimate the socioeconomic impacts of a proposed Maryland statewide transportation system plan. This application generated the following types of socioeconomic impact information:

1. The cost of implementing the proposed plan will exceed $10 billion (1976 dollars). This cost will be shared by state, federal, and local governments. The respective shares of total cost will be 60, 39, and 1 percent. This funding arrangement differs from current arrangements in that the state will assume a significantly larger share of the costs to implement highway capital improvement programs. The state's share for financing the primary highway program and the secondary highway program will increase from current 30 percent to 86 and 66 percent, respectively.
2. To finance its share of plan implementation costs, the state will need to obtain $1.8 billion more than the current revenue structure will provide during the implementation period, 1978-1997. However, the $6 billion requirement represents a smaller portion of the gross state product than the Maryland department currently spends on transportation. Consequently, the tax burden to implement the plan will be less than the current level, despite the need for altering the existing funding structure to finance plan implementation.
3. The largest share of federal, state, and local plan expenditures will be used to carry out the operating program (30 percent of total expenditures). The mass transit and Interstate and primary highway programs will require similar funding levels for implementation (27 and 21 percent of total expenditures, respectively). At the other end of the spectrum are the Port of Balti-

more (2.4 percent), BWI Airport (0.6 percent), general aviation (0.5 percent), and rail (0.9 percent) improvement programs. Together, the capital improvement programs will require 70 percent of total expenditures to implement.
4. Other costs of plan implementation include land taken from other productive uses such as agriculture. Land of recreational, scenic, or cultural value also may be taken to implement the plan. Business and household displacement will take place, and some community disruption may consequently occur. However, the methodology is not able to generate complete estimates of these potential impacts due to the lack of relevant data and inadequacies of available measurement techniques.
5. The total net personal-income impact of plan implementation is estimated to be almost $18 billion over the 1978-2000 period. This figure excludes the $10 billion that will be expended to implement the plan. The BWI Airport capital improvement program contributes over 50 percent of this cumulative impact. The mass transit, Port of Baltimore, and Interstate and primary highway programs are expected to account for 14.3, 12.4, and 9.2 percent of the total impact, respectively. It is significant to note that the Port of Baltimore impact estimate is based only on consideration of new public services and facilities. The impact would be substantially larger if private pier facilities were considered as well. For example, in 1974, public piers accounted for only 10 percent of cargo processed at all piers in the Port. Only public pier impacts were estimated because private investment in the Port is not part of the plan analyzed.
6. The impact trend over the analysis period basically exhibits steady growth in absolute terms and in terms relative to the state economy. In 1985, the net income effect of plan implementation is expected to be approximately $262 million. By the year 2000, it is estimated that this impact will reach $1864 million. The 1985 net income effect represents 0.5 percent of the projected gross state product in that year. This percentage is expected to increase steadily to 1.7 percent by the year 2000. Thus, the plan's personal-income impact is expected to grow more rapidly than gross state product and, consequently, will act as a steadily increasing stimulus to state economic activity.
7. The plan's impact on state employment and population also exhibits steady growth over time. In 1985, plan implementation may create the equivalent of 12 000 jobs that could support 26 000 people. By the year 2000, those figures may increase to 81 000 and 154 000, respectively. Thus, in 1985, the plan's impact may represent 0.5 percent of projected total state employment and 0.6 percent of total state population. In 2000, these percentages may climb to 3.2 and 2.8 percent, respectively.
8. Implementation of the plan may have a redistribution effect on the location of economic activity in the state. The Baltimore region is expected to receive a share of the plan's personal-income impact that is over twice as large as its current share of total state personal income. All other regions' shares of the estimated impact may be below their current shares of state personal income. Of these regions, the Washington region would fare the worst. All regions in the state, however, will experience net positive income, employment, and population impacts from plan implementation.
9. Personal-income impact distribution among counties within the Baltimore region is similar to the current distribution of total personal income in the region. Consequently, plan implementation is not expected to cause a redistribution of income among counties in the

region. Baltimore-region county impacts were estimated to illustrate the methodology's capability to generate county-level impact estimates. Impact estimates for counties outside of the Baltimore region were not made.

10. Plan implementation will result in accessibility improvements throughout the state. Travel time to port and commercial and general aviation services and facilities will decrease by 1, 75, and 15 percent, respectively, by the year 2000 with the implementation of these programs. Intrastate highway travel times may be reduced by 8 percent by the year 2000. Quantitative measures of state-level accessibility improvements resulting from the rail and mass transit programs could not be calculated. However, it is obvious that accessibility improvements of significance will occur as a result of implementation of the rail program. Without the program, rail freight service to some areas of the state would be discontinued. The personal-income impact of the program (an annual average of $10 million) attests to the potential significance of maintaining this accessibility. Significant accessibility improvements may be experienced as a result of the mass transit program as well. The program includes construction of a rail rapid transit system in the Baltimore region and completion of the 160-km (100-mile) Metrorail system. It also provides financial assistance to nonurbanized areas for the purchase of vehicles and equipment. This may provide transit dependents in these areas with new social and economic opportunities. Because a large percentage of the transit-disadvantaged reside in nonurbanized areas, the program may be of tremendous significance to persons residing in these areas of Maryland.

11. The primary safety impact of plan implementation will occur in the highway area. A conservative estimate is that 19 300 highway injuries and 270 highway deaths may be prevented with implementation of the plan.

SUGGESTIONS FOR FURTHER RESEARCH

As previously noted, several systems-level, socioeconomic-impact methodology deficiencies remain. The deficiencies described in this report provide several areas for potentially fruitful research. However, it is recommended that, before this type of research is conducted, the credibility and usefulness of the methodology in Maryland's transportation system planning process should be determined. Specifically, the researchers recommend that the following additional research be conducted.

First, determine the methodology's sensitivity to plans and programs. The methodology is designed to provide impact estimates of alternative plans and programs including alternative implementation-staging assumptions. However, this capability cannot be fully tested by evaluating a single plan. The transportation department could carry out this test by applying the methodology to estimate the socioeconomic impacts of the other two system plans it is considering for adoption. In addition, the detail of the impact estimate could be refined to permit the estimation of the incidence of the impacts for different socioeconomic or geographic areas.

Second, clarify the accuracy of the methodology's output. The methodology could be applied by using reasonable alternative assumptions concerning the values of constants and variables used in the case-study analysis. This could reveal the change of values the impact estimates could take and further test the accuracy of the results provided by the methodology. One of the alternative assumptions could be the use of historical expenditure patterns and analysis of their consequences to validate the accuracy of the equations used in this model.

Third, establish the credibility and usefulness of the methodology's output in state transportation planning and programming. This is the most important "next step" in establishing an effective system-level socioeconomic analysis capability. The case study suggests that the methodology output is responsive to the socioeconomic impact concerns of Maryland citizens, public officials, and planners in evaluating state transportation system plans and programs. Thus, it suggests that the methodology will be useful in deciding transportation system changes in Maryland. The extent to which the methodology and its output will actually be used for these purposes, however, is a major question. It will be answered only when the methodology is actually applied in planning and in public debate of alternative state transportation plans and programs. These steps will determine if additional basic research to develop improved measurement techniques is required, or if the present methodology is satisfactory for the state's purposes. They also would reveal the deficiencies in the methodology that, if resolved, would be most beneficial to socioeconomic impact analysis and evaluation of transportation system plans and programs.

ACKNOWLEDGMENT

Residential Dislocation: Costs and Consequences

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This study investigated methods for predicting the dislocation consequences of alternative highway route and design proposals. It also assessed existing compensation practices in light of significant consequences. Data for these purposes were primarily derived from two household surveys before and after relocation. Interviews were conducted at six sites that represented a variety of project characteristics and geographic

regions. The study found that specific dislocation consequences of alternative route and design proposals cannot be accurately predicted using data concerning the characteristics of the displaced households, the communities, or the projects. Compensation practices and relocation procedures have more effect on the nature and extent of changes incurred by those relocated than do demographic or geographic characteristics. Thus, current compensation practices, which constitute significant improvements over previous practices, do not discriminate for or against any particular population subgroup. However, the elderly are more likely to be in a worse position after the move than others due to essentially noncompensable factors rather than compensation practices. Therefore, planning procedures to avoid disrupting large concentrations of the elderly are required. The study concluded that, although the relocation process works well for many persons, certain improvements are still required.

Residential dislocation is one of the major direct consequences of urban highway projects, and some of the recent opposition to specific urban highway proposals is based on the fear of citizens that they might be inadequately compensated for the effects of being dislocated from their homes. In light of these considerations, the primary objective of the study (1) discussed in this paper was to improve the highway planning process (a) by increasing the planner's ability to forecast the dislocation consequences of particular location and design decisions and (b) by suggesting techniques for more adequately compensating persons adversely affected by right-of-way acquisition.

BASIC CONCEPTUAL OVERVIEW

Inputs to Policies and Procedures

Procedures and techniques for predicting the socioeconomic consequences of residential dislocation should be principally directed toward satisfying the requirements of the Federal Aid Highway Program Manual (FHPM), Volume 7, Chapter 5, Section 1 (formerly FHWA IM 80-1-71, particularly paragraphs 14 and 15). They should also consider the role of dislocation and relocation prediction and planning in satisfying the requirements of other directives, such as those outlined by FHPM 7-7-1 and 7-7-5.

The first prediction step in either the conceptual stage or right-of-way stage is the estimation of the socioeconomic consequences of the proposed right-of-way dislocation. In general, they can be grouped in the following three categories:

1. Changes to wealth and cash flow, including asset position before and after relocation, one-time expenses, ongoing income and expense items (e.g., rental and travel expenses), and housing expenditures as a proportion of income;
2. Changes to social status and interactions, including social status as a member of a community, interactions with and support from other members of that community, and relationships with friends; and
3. Changes to psychological status, including happiness and life satisfaction, sense of personal efficacy, psychic benefits derived from a familiar location, and overall physical and mental health.

Once the probable impacts are quantified, one must determine the compensation or alternative courses of action required to eliminate, alleviate, minimize, or avoid adverse consequences. Compensation can be made available to those affected in three ways (2): money, in-kind replacement, and services. The applicability, effectiveness, and efficiency of each method in any given dislocation and relocation situation depends on the following factors (3, 4): (a) whether dollar values may be attached to the consequences incurred; (b) whether the individual, family, or neighborhood can by itself convert monetary compensation into an effective replacement; and (c) whether it is more effective to replace in kind or to provide services instead of monetary payments.

Finally, the consequences of proposed acquisitions must be compared to the maximum relocation compensation and program services that can be made available. This step identifies the effects that can only be partially compensated or avoided or that cannot be compensated or avoided at all. It is possible that the uncompensated adverse consequences for a particular highway location or design will be great enough to be unacceptable and, therefore, will result in a decision not to build.

Prediction of Effects

To predict the major consequences that will result from a specific highway plan, one must be able to answer these questions: Who is most likely to be affected by the relocation process and in what ways?, What will be the magnitude of the effect experienced?, and Under what circumstances will the effect occur? In attempting to answer these questions, one must analyze the complex interrelationships that exist between relocation effects (considered dependent variables for the purposes of analysis) and three sets of independent variables—highway characteristics, community characteristics, and household characteristics.

Relocation Effects

A review of the existing literature on relocation (5-12) was used to identify the consequences most worthy of attention in terms of frequency of occurrence or severity of impact on certain persons. These high-priority effects may be grouped as follows:

1. Economic effects—moving costs (actual costs of moving to a new location), transportation costs from new location to work or business, changes in housing costs (all housing costs, including rents or mortgages, utilities, and taxes);
2. Overall household effects—price and quality changes in housing, long-run expectations;
3. Social effects—changes in neighborhood social interaction, changes in relations with friends, attitudes concerning effects on the old neighborhood; and
4. Psychological effects—changes in overall level of happiness, changes in life satisfaction.

Factors Influencing Relocation Effects

The independent variables that were tested for their influence on relocation effects are listed below:

1. Description of the project (highway characteristics)—(a) numbers of units displaced, as determined by factors such as width of highway planned, type of highway (e.g., elevated, depressed), location of interchanges and (b) relocation practices (2-4), such as monetary compensation provided, availability of additional nonmonetary assistance, and time available for relocation.
2. Description of the environment—(a) individual and family (household) characteristics, such as age of head of household (5, 6, 11, 13, 14); race and ethnicity of household (11, 16); amount and source of household income (3, 6, 17); employment (location, continuity, skill level) (5, 6); household composition, including sex of head, number of members, and relationships between members (5, 6, 17); social class, a composite measure

that includes education, occupation, income, and lifestyle of the household (5, 6, 12); household's transportation mode (public or private) (18); length of residency (19, 20); tenure (owner, renter) (17, 21) and (b) community characteristics—neighborhood cohesiveness (19, 20) and tightness of housing market (18, 21).

According to the various sources consulted, these independent variables are among the most important in analyzing the relocation experience of an individual household. But previous research studies have ascribed different weights to them. For example, Key (6) and others (11, 13, 14) found a significant relationship between the age of the household head and the household's difficulty with relocation; Mogey (5) found no such relationship. However, Mogey did find age correlated with other important dependent variables.

RESEARCH APPROACH

Data-Collection Strategies

The overall approach to resolving the basic objectives of this research effort centered on interviews with persons who had actually been through the relocation process. It was decided to interview persons both before and after relocation to collect information on changes in their status and to see which changes could be attributed to the relocation process itself. The sample of persons interviewed was large enough to be statistically representative of persons being relocated at sites that, in turn, generally represented the relocation experiences of the country as a whole. Because particular sites tend to have unique characteristics (some of which are created by state policies and procedures), information was also collected about each site and about the relocation process occurring there. Statistical analyses of the combination of survey and site data were used to develop conclusions with nationwide validity about the predictability of dislocation consequences and the adequacy of current compensation practices.

Six sites were studied intensively for over 2 years. Data were collected concerning dislocation compensation provided (monetary, in-kind replacement, services) in terms of both quantity and quality; the relocation process, including its mechanics, extent, and adequacy; and the net consequences of dislocation and relocation. Data were gathered from household surveys and secondary sources. Only those dislocated were reinterviewed due to constraints on the study's budget. The sites included several different neighborhood types and socioeconomic groups. The details of the sampling strategy are summarized below:

Factor	Description
Universe	Federally assisted urban highway projects in those states in compliance with the Uniform Relocation Assistance and Real Property Acquisition Act.
Number of sites	6
Stratification	National regions (5 categories); number of households displaced (3 categories).
Number of interviews	First wave—549 (390 scheduled to be relocated and 159 to remain near the highway right-of-way); second wave—190 (chosen from the 390 displaced households interviewed in first wave).
Sampling strategy	Two one-half size independent systematic samples per wave; three callbacks were made for persons not at home.
Questionnaire	Personal 45-min interview administered in respondent's home.
Statistical validity	±10 percent at the 90 percent confidence limit, assuming the true proportion is 50 percent, for the 190 households.

Two surveys were conducted. The first survey was conducted in both the area contained in the proposed right-of-way and in the band adjacent to the right-of-way. The second survey traced the individuals and families who were relocated; they were reinterviewed to assess the consequences of their relocation and their attitudes toward the relocation process and agency. Much of the household socioeconomic data collected in the second survey was identical to the data collected in the first survey and included income, tenancy, housing characteristics, family composition, employment, and family shopping, business, and social activities. Additional data were collected concerning the contacts and relations with the relocation agency, attitudes toward the mechanics of the relocation process and the relocation agency, problems and issues encountered in the relocation process, attitudes and reactions to the quality and sufficiency of the compensation received, and the families' long-run condition and prospects at their new location.

Timing of Interviews

The two surveys were conducted at the six sites approximately 18 to 24 months apart. The initial survey was conducted after specific locations had been determined and the right-of-way requirements had been detailed. Relocation was scheduled to take place no later than 6 to 8 months after the first survey to give relocatees 4 to 6 months in which to become oriented to their new location before the reinterview survey. In fact, the second wave was conducted much later than initially planned because relocation did not take place on schedule at several sites.

Within these general timing conditions, a range of time variations was included in the interview and reinterview scheme. Thus, surveys at the six sites were conducted differently in relation to five variables: length of time after specific right-of-way was officially decided, length of time before actual relocation of residents would occur, proportion of residents already relocated (ranging from none to approximately 50 percent), type and scope of relocation program and services, and presence or absence of an on-site relocation office. Additional variables in the site selection included socioeconomic groups and neighborhood characteristics.

Field Sites for Case Studies

Some 22 sites in 11 states that could have been used for this study were identified. This was a much smaller number than originally expected because of the large number of urban highway projects delayed for various reasons, including the preparation and adequacy of project environmental impact statements, reduced levels of funding, unavailability of sufficient replacement housing to meet the demand of the dislocated person, and previous system urban projects. From the list of available sites, six were selected as case studies because of the sufficiently large numbers of relocated persons there and conformance to the other site-selection criteria. Details of these sites are presented in Table 1. Interviews were also conducted with the residents of the remaining neighborhoods at two of the sites where interviews with those relocated also took place.

Interviews Obtained

A total of 390 valid questionnaires were obtained from households to be relocated before their dislocation; 190 of the same households were reinterviewed after they

had established themselves at new locations. Also, 159 residents of the remaining neighborhood were interviewed at the same time as those households about to be dislocated.

Achieving the quota for the second-wave sample was more difficult than expected. The primary reason was that households were not relocated as quickly as expected, thus substantially reducing the number of households available for interviewing. This problem was especially serious in Birmingham, Alabama, where only 39 of the original 101 respondents (less than 40 percent of the sample) had moved at the time of the survey. This was also a problem—although not to such a large extent—in Fresno, California, where only 75 percent of the sample had moved at the time of the second wave of interviews. Besides those who had not moved, 12 percent of the sample could not be located. This meant that mail sent to the new address (obtained from the state highway department) was returned, that the person had moved and no one in the area knew where, or that there was no such address. Another 9 percent of the sample had moved more than 24 km (15 miles) from their previous residences; these persons were not reinterviewed. Thus, approximately 54 percent of the original sample was available for interviewing, and 49 percent furnished valid interviews (a completion rate of 90 percent of available respondents).

EXPERIENCES OF RELOCATED HOUSEHOLDS

Most of those persons who were displaced and relocated had never experienced such a situation before and did not know what to expect. Afterwards, many persons had positive feelings about the relocation process. This section discusses their experiences in terms of the study's specific list of dislocation effects, the relocated person's view of the compensation and assistance received, and personal evaluations of the relocation process.

Dislocation Effects

Economic Effects

The study considered (a) search costs, that is, time spent searching for a new home (both total search time and time off from work); (b) moving costs, that is, actual costs of transferring possessions from the old location to the new; and (c) compensation constraints, that is, if the amount of compensation available significantly constrained the choice of a new location, then the extent of this influence should be counted as a cost of relocation. As expected, these costs were found to be much less significant in the eyes of those relocated than other monetary issues (3). None of the households contacted after the move felt that search costs were a burden to them (although most would not have incurred such costs on their own volition) and only 1 percent of the sample reported that the current moving allowances were inadequate for them.

Several significant compensation constraints now operate in the relocation process. Although most persons felt that they had sufficient time to find their new homes, 16 percent felt that the time available was not adequate. One-quarter of this group felt that they would move again within the next 2 years. Thus, the insufficient time available forced them into a situation that was so unsatisfactory that they planned to change it, thus incurring additional moving expenses that would not be paid by the highway department. Another problem was the slowness in payments due those relocated. This created temporary hardships for 6 percent of the sample.

There was no evidence of a substantial change in transportation costs for the households in the sample after they had been relocated. This was not surprising;

Table 1. Summary of sites selected for case studies.

State	City	Highway and Project Type	Socioeconomic Characteristics	Location Within Standard Metropolitan Statistical Area	City Size	No. of Qualified Families to Be Displaced
California	Fresno	CA-41 and CA-180 (arterial)	CA-41: 85% white, 10% Mexican-American, 2% black, 3% other nonwhite; low-to-middle income; single-family housing	Urban		244
			CA-180: 65% white, 30% Mexican-American, 2% black, 3% other nonwhite; low-to-middle income; single and some multiple-family housing	Urban		84
			Total site[a]	Urban	310 000	328
Alabama	Birmingham	I-59, I-65, I-459	Mixed areas: I-59 and I-65—old and new neighborhoods and housing, low and middle income	Urban		84
			I-459—mostly new areas, middle and some high income	Suburban		62
			Total site[b]	Urban, suburban	590 000	146
Arkansas	Little Rock	I-630	Predominantly white; single-family old and new housing; income predominantly middle, some low, some high	Suburban	259 000	100+
New York	Auburn	NY-5 (arterial)	Old area; housing prices $5000-$15 000; heterogeneous multiple-, duplex-, and single-family housing; low-to-middle income	Urban	40 000	100+
California	Gardena	CA-91 and CA-111 (arterial and freeway)	71% white, 25% Oriental, 3% American-Indian, 1% Mexican-American; single-family housing prices, $20 000-$40 000; rental, $200-$300; apartment rental, $175-$200	Urban	Metropolitan area	50
Florida	St. Petersburg	I-275 (freeway)	Mixed racial area; low-to-moderate income; single and multifamily housing; some commercial uses; high proportion of elderly	Urban	216 000	278

[a] Two contiguous highway projects to be combined as one site.
[b] Five project segments combined as one site.

the average household relocated moved only 4.8 km (3 miles) from their previous locations—excluding the 8.5 percent of the prerelocation sample who moved more than 24 km (15 miles) away and the 12.1 percent for whom there was no known address. Distances traveled generally decreased, even though people traveled outside the neighborhood more often than before. Trip frequencies tended to decrease slightly, but trip purposes per household increased.

For those relocated, the average work trip decreased in length by 16 percent, but three times as many persons worked in their neighborhood before the move compared to afterwards. This suggests that fewer of both the longest and shortest work trips occurred after the move. Frequencies and costs were the same before and after. Grocery shopping trips also decreased in distance and increased in the percentage of trips outside the neighborhood. There was a substantial decline in the frequency of trips to the doctor and for religious services. Visiting trips decreased by 27 percent, and it was in this area that those relocated suffered a measurable loss. Walking trips decreased by one-third, and trips within the neighborhood decreased by one-half.

Overall Household Effects

A relocation dilemma has remained unresolved for some time. If, as experience shows, a household is in a better house after relocation but is paying a greater proportion of the household's income for housing than before the move, is that household in a better or worse condition (7, 8)? The possible combinations of price and quality changes are given in Burkhardt, Kent, and Martin (1).

The relocated persons were asked, "Considering all the things about your new home—how much it costs, how big it is, the neighborhood, and everything—would you say that you are better off, the same, or worse off than you were in your old home?" Some 60 percent of the respondents were more pleased with their new homes than with their old homes; the reverse was true for 27 percent. The results varied considerably from city to city. Improvements in housing welfare were significantly correlated with perceptions of the new neighborhood as better than the old, the sufficiency of relocation information, the positive effect of the total compensation package, and the positive long-run effects of the move. Improvements in housing welfare were not significantly correlated with basic demographic variables, including age, income, sex, education, or race. Location (the specific city) was also a significant variable.

For homeowners, it was possible to establish a statistically significant relationship explaining half of the variance in housing welfare using age, income, satisfaction with the house itself, and the assessment of relocation assistance and adequacy of information. Age and income were negatively related to increases in housing welfare; that is, older persons tended to fare worse in relocation as did those with higher incomes.

Of the respondents, 70 percent felt that they would be better off in the long run, 20 percent thought they would be worse off, and 10 percent did not know. Age, race, income, satisfaction with the new home, sufficient assistance from the relocation department, and clear information from the relocation department were significant variables in explaining long-run expectations. Together, these variables accounted for 38 percent of the variance in overall household welfare. Because the standard error of the estimate was relatively low, it may be possible to predict with some degree of certainty whether households will be better or worse off under a particular relocation program. As indicated by the nature of the variables entering the equation, the way in which the relocation process was actually carried out on the local level made a strong difference in the resulting long-run expectations.

Social Effects

Social impacts are impacts on people. The basic unit of measurement is the number of people affected. Most social impacts focus on how people interact with others and how the interaction patterns change over time (5, 6, 9, 10, 15, 20).

The analysis of social interaction changes focuses on each of the components of the Neighborhood Social Interaction Index (19). It was found that

1. Neighboring decreased to about one-half of its prerelocation level;
2. The use of local facilities decreased substantially, especially in terms of neighborhood-oriented work trips, doctor visits, religious services, and visiting;
3. Participation in neighborhood activities declined slightly (the percentage of households participating remained the same but the number of organizations they participated in declined);
4. Identification with the neighborhood as a place of shared customs, beliefs, and aspirations dropped 30 percent;
5. Commitment to staying in their new neighborhood was not different from their commitment to stay in the old one;
6. Evaluation of the neighborhood as a place for persons like themselves to live showed a 25 percent drop after relocation.

Although it is possible that neighborhood social interaction will increase over time and return to its prerelocation levels, some negative feelings toward relocation do not change over time (23).

After relocation, the percentage of persons with all or most of their friends in the neighborhood declined dramatically from 23 to 8; the percentage of persons with none of their friends in the neighborhood increased substantially, from 27 to 43. Of the 22 percent of those relocated who expected to keep in touch with all of their friends, 22 percent did so. However, 6 percent had not expected to keep in touch with any of their friends from the old neighborhood, but 22 percent actually had no contact with their former friends after moving.

Before they moved, more than half of those relocated felt that the changes to their old neighborhood were for the worse; one-quarter said that there was no significant change. After relocation, half of the respondents felt that the highway-related changes had a negative effect on the neighborhood, 17 percent felt that the neighborhood had improved, almost as many thought that it had stayed the same, and the rest did not know. Persons who felt that the neighborhood had deteriorated tended to feel that way strongly, which is consistent with findings by Fried (22) that many relocated persons felt a strong sense of grief concerning the loss of their homes and neighborhoods.

Changes in Psychological Well-Being

The framework for representing the level of psychological well-being of an individual consisted of two dependent variables (life satisfaction and happiness-unhappiness) and also included four factors (independent variables) that could be expected to influence the level of psychological well-being following relocation—three

sets of individual characteristics (socioeconomic, psychological, and stress) and the relocation project characteristics.

The measure of life satisfaction showed a very slight increase (2 percent), while the measure of happiness showed a 10 percent decline for those relocated. These changes were difficult to explain or predict, but certain socioeconomic characteristics and relocation project constraints had more influence than other factors, especially level of income, source of income, education, age, the adequacy of payments received, size of the new dwelling and whether or not it was owned or rented, the desirable features of the new neighborhood, and differences in project sites. To avoid negative psychological effects, the relocation agency should maximize the relocation process factors shown to be significant: payments for the previous dwelling, the quality of the post-relocation neighborhood, and the amount of information available to those relocated. The number of elderly persons being relocated should be minimized.

Compensation and Assistance

The relocated persons reported generally favorable reactions to the compensation and assistance received, just as they had concerning the dislocation effects. Within this generally positive response there were, however, some substantial site-to-site variations.

The expectations of homeowners did not often match the actual payments for dwellings owned by the respondents. Expectations most often matched the payments in Fresno and Gardena, California, where 60 percent received what they expected. More persons in St. Petersburg, Florida, and Fresno than in the other sites got more than they expected, while three-quarters of the owners in Birmingham got less than they expected.

In response to one question asked, "Did the payments you received for moving and everything else make your new housing situation better, worse, or the same as your old housing situation?", 58 percent said it was better, 19 percent said it was the same, and 22 percent reported a worse situation. Persons in Fresno and Auburn, New York, more often reported better housing, while persons in Gardena and St. Petersburg more often reported a worse housing situation after the move.

When asked how they felt about the total amount of compensation received, the responses varied widely from site to site. Overall, 35 percent said they "came out as good as possible," 39 percent "came out even," and 26 percent "lost money." The ranges are 5 to 63 percent, 11 to 53 percent, and 4 to 68 percent, respectively. Persons in Fresno were the most pleased with the compensation received and those in Birmingham were the least pleased.

These factors stand out as key variables in the responses to various questions about compensation: satisfaction with the new dwelling, adequacy of assistance and information, clarity of information, attitudes of highway personnel, price paid for the former dwelling, total funds received, and future expectations. These factors indicate the importance of the so-called subjective aspects of relocation in determining attitudes toward the so-called objective factor—that is, money. The general lack of demographic variables in the correlations and regressions indicates that compensation is being equally distributed among all types of people. To the extent that they are required, compensation changes should focus on practices and prices.

Personal Evaluations

Many of those displaced found themselves better off as a result of the move. In fact, the relocation process seems to have worked well for almost two-thirds of those interviewed both before and after relocation. However, some people complained bitterly about changes in their lives that they attributed to their uprooting. The responses indicate that, although the Uniform Relocation Act of 1970 made many significant improvements to relocation practices, substantial room for improvement still exists in both the letter of the law and its application. Responses to specific questions appear below:

Question	Response
Do you feel that enough information and assistance were made available to you and your family to allow you to obtain financial help from the highway department?	76 percent, yes
Was the information you received clear and understandable?	82 percent, yes
In general, what was the overall attitude of the highway relocation people—positive, neutral, or negative?	80 percent, positive
Did anything particularly good happen in your dealing with the highway department?	50 percent, yes (in Fresno, 80 percent, yes)
Did you have any particularly bad incidents with the highway department?	20 percent, yes (in Birmingham, 50 percent, yes)
Following notification, do you feel that you had too much, too little, or just about the right amount of time to relocate?	80 percent, about right
Did the relocation office assist you in finding this place?	80 percent were offered assistance (75 percent declined)
Do you think the average person is capable of dealing with the highway department in all this without legal or other professional assistance?	70 percent, yes
In the long run, do you think you and your family will be better off for having moved?	71 percent, yes

The intercorrelations of the relocation process variables were examined, and it was found that, if a person had received enough money for relocating and had moved to a better neighborhood, then everything else seemed to be positive. The overall adequacy of compensation received and the adequacy of information and assistance were also often associated with the values of other process variables. Once again, it is remarkable that demographic characteristics were not significantly correlated with relocation process assessments, as was also true for assessments of compensation. The long-run expectations were dependent on a greater variety of factors than were the other factors. The bad events and attitudes of the relocation personnel also had high correlations with a number of factors.

Several lessons are apparent here. The first is the interrelated nature of many of the relocation process variables. The second is the significance of monetary payments in shaping attitudes toward the relocation process. The third is the importance of post-relocation satisfaction with the new house and neighborhood. If outcomes pertaining to these factors can be successfully managed, relocation can work well for most people.

The long-run effects of the relocation process appear to be somewhat predictable given commonly available data. The particular results should not be surprising to anyone familiar with relocation problems. Relocation is a burden for the elderly. Many of them have a great attachment to their homes and neighborhoods that is difficult, if not impossible, to reestablish in other

locations. Similarly, the more affluent have established individualistic patterns of satisfaction that are hard to re-create elsewhere. The tightness of the housing market is probably an excellent proxy for the probability that a given household will be pleased with its new dwelling following relocation. This fact is well recognized in current highway practice. Finally, given current patterns of residential distribution of nonwhite subgroups of the population, it is possible that a well-managed relocation program can significantly upgrade the housing and general welfare of nonwhite families.

CONCLUSIONS AND RECOMMENDATIONS

This study showed, with one notable exception, that specific dislocation consequences of alternative route and design proposals are not predictable using data concerning the characteristics of the community or the nature of the highway improvements. The best predictive equations explained only one-half of the variance in the dependent variables. Fine details of relocation and compensation practices had much more effect on the nature and extent of changes incurred by those relocated than did demographic or geographic characteristics. This conclusion is a credit to the equity of current compensation practices in that it indicates these practices do not systematically treat particular groups of people very much better or very much worse than others.

The one exception to this general pattern of equity concerns the elderly. Despite increased attention and services at the project level, age is a statistically significant factor in explanatory relationships for a variety of changes. The elderly suffer the most. The negative effects experienced by them do not appear amenable to changes in relocation procedures or amounts of compensation. One is forced to conclude that, all other factors being equal, a highway location and design plan that displaces fewer elderly is far preferable to one that displaces more.

This study examined economic, social, and psychological consequences of residential dislocation. It has concluded that the policies implementing the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 represent a very significant advance over previous relocation policies. The economic consequences of dislocation are now basically covered by existing compensation techniques, but social and psychological consequences remain, for the most part, not compensated at all. Despite this disparity, the few currently uncompensated or undercompensated economic effects cause more concern to the relocated persons than do the generally uncompensated social and psychological effects. This is a clear indication that immediate policy improvements should focus on economic issues. Certain modification, or "fine tuning," of the current law and procedures could raise the present assessment of generally good treatment and compensation for displaced households to generally excellent treatment and compensation.

A great deal has been written about the suffering of disadvantaged persons faced with relocation either by urban renewal or highway projects. The results of this study do not support such contentions. It was found that the overall housing status of nonwhites improved more than that of whites and that nonwhites were more satisfied than whites with the overall changes (including the cost of housing). In addition, it was found that persons dissatisfied with relocation tended to be of higher rather than lower incomes.

From this analysis of the experiences of those relocated, certain changes in relocation policies and practices are recommended. These changes fall into three categories: compensation, relocation practices, and the highway planning process.

Compensation Changes

No factor caused as much upset and anger as the price paid to homeowners for their former dwellings. The heart of the matter is the so-called "additive payment," and the problems include confusion and apparent inequities.

Under the 1970 act, if payment of the fair market value for a person's home is not sufficient for the purchase of a comparable dwelling unit, then that person is to receive an additive payment equal (within limits) to the difference between the cost of the comparable dwelling and the payment for the dwelling acquired by the highway department. In fact, the practice of receiving fair market value plus an additive is confusing to many relocated persons. Homeowners who were interviewed often felt that the fair market value offered for their home was too low, not realizing that their concern should have been the total compensation payment. Some persons were willing to pursue court action concerning the fair market value of their former home. They went to court, even though it caused them to lose money in lawyer's fees, because the total compensation to be received was fixed by the cost of the comparable replacement dwelling.

Current practice should be changed to allow an owner to receive, as payment for the taking of his or her dwelling, the cost of a comparable replacement dwelling. The legal basis for the amount to be paid will be the fair market value of the individual's former home plus the additive payment.

The second issue is one of equity. Some persons apparently received more of an additive payment if they moved into a larger home after displacement (and some persons moving to apartments from homes reportedly received no additive at all). Such practices were a source of extremely bitter complaints. Persons in essentially similar situations before displacement should receive approximately equal payments. More of a focus on a locally determined standard for a comparable replacement dwelling would rectify this situation.

The relocation payments are too slow. This results in a substantial inequity for persons of limited financial means or others who are "cash poor," when it comes to matters such as down payments or closing costs on a new home. Procedures should be changed so that either (a) the money is available more quickly, or (b) the highway department will guarantee and pay the interest charges on short-term loans that can be used to expedite the purchase and occupancy of the new dwelling.

Some persons may have invested considerable money, labor, and time in ancillary improvements to their property such as gardens, special trees and shrubs, and other unique features. Such improvements are generally considered part of the property and therefore become owned by the highway department when acquisition is final. However, assessors seldom feel that such improvements add as much to the value of the property as it would cost to replace or repurchase these improvements. This turned out to be a particularly serious problem at one site, where the prevalence of such improvements and their lack of compensation created more dissatisfaction with relocation than would otherwise have been expected. These improvements should either be compensated at their replacement cost or the relocatee should be permitted to move as much of them as possible at government expense.

The separation in the law between residential and

business relocation neglects the actual commingling of these activities in many instances. For example, persons who rent a portion of their home to another household are likely to be worse off after dislocation under current compensation practices. Replacement dwellings are located and priced according to the space currently occupied by the household as a household, despite the fact that other space in the structure may be owned and rented to a second household. This income-producing aspect of a basically residential unit may be of critical importance to a household in terms of cash flow. To the extent possible, such persons must be relocated in a comparable structure (returned to their former position) for them to be treated equitably. Specific changes should include increased payments for the former property or cash payments to finance construction of improvements to the new property.

The survey conducted for this study showed that the $300 moving allowance (or other scheduled allowance) was considered sufficient by all but 1 percent of those interviewed. However, those relocated felt that not enough of the cost of reestablishing a residence was covered. Increasing the dislocation allowance to more than the currently available $200 should be considered.

The 4-year limitation on rent supplements is insufficient for a small but significant number of households. An extension of the time and dollar limits is warranted, but there does not appear to be a clear means of determining how long and how much would be equitable.

Changes in Relocation
Practices

The attitudes and assistance of the relocation personnel were crucial—and nearly as significant as monetary payments—in determining a relocated person's attitude toward the process. Most of those relocated reported excellent dealings with highway personnel, but some reported encounters with rude, belligerent, or arrogant relocation agents. Additional care, training, and professionalism on the part of the relocation agents will substantially reduce the number of such complaints. Early acquisition programs have substantially increased the number of occupied housing units owned by highway departments. This is looked on with extreme disfavor by those who remain in such dwellings after they no longer own them. Rerenting acquired property, with rents established on current fair market values, often results in the practice of charging the former owners more per month than they had paid as owners. Those who suffer this practice view it as extremely unjust. Such persons are trapped between two homes; they are forced to remain in their current homes at higher rents and are not yet allowed to reinvest the equity they had in their former dwellings.

The practice is especially burdensome for elderly persons and others who have already paid off a mortgage because it creates a substantial (and noncompensable) financial hardship. Acquisition of the property should not occur until the owner-occupants can be relocated and can receive full compensation.

Changes in the Highway Planning
Process

The consideration of displacement effects can be brought into the highway planning process by avoiding areas of potentially serious uncompensated impacts, such as neighborhoods with a high proportion of elderly people. These and other social-impact calculations should be brought to bear on decisions concerning route location by mapping demographic characteristics of subareas (census tracts, enumeration districts, or blocks) in relation to proposed route locations. It is proposed that highways not be built through areas where more than 16 percent of the population is elderly, and that great caution be used where the proportion of elderly is between 6 and 16 percent of the population. (There are differences of opinion as to an appropriate definition of "elderly." The numbers used in this paper refer to the proportion of the population that is 65 years old or older. In the United States, 10.3 percent of the population is 65 or older according to a 1974 census estimate.) The effect of this suggestion would be to narrow the possible routes for highway locations at the corridor planning level.

A great discomfort to many persons to be dislocated and to remain in areas near the highway was that they simply did not know what was going on or what to expect. Psychological research has shown that persons can more readily accept adverse decisions if they have been a party to the decision-making process. Highway agencies should publicize their plans as much as possible and should establish "hot lines" for persons with questions about the relocation process.

SUMMARY

The study found that specific dislocation consequences of alternative route and design proposals cannot be accurately predicted using data concerning the characteristics of the displaced households, the communities, or the projects. Compensation practices and relocation procedures have more effect on the nature and extent of changes incurred by relocatees than do demographic or geographic characteristics. Our conclusion from this particular finding is that current compensation practices do not discriminate for or against any particular population subgroup. However, the elderly are more likely to be worse off after the move than others, not because of compensation practices, but because of factors that are essentially noncompensable. Therefore, planning procedures to avoid disrupting large concentrations of the elderly are required.

The relocation process appears to work well for about two-thirds of those forced to move. Almost one-half of those relocated feel that the relocation process is as good as possible. The actions of the relocation agency personnel significantly influence the average satisfaction level upwards or downwards. The elderly and higher-income households feel that relocation has made them worse off overall more often than other persons.

In conclusion, although the relocation process works well for many persons, certain improvements are still required.

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Dynamic Social and Economic Effects of the Connecticut Turnpike

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This paper summarizes the findings of a study of the long-term social and economic impacts of the Connecticut Turnpike on the eastern Connecticut region. Data developed in a 1965 report, The Connecticut Turnpike—A Ribbon of Hope, were updated and the dynamics of change in the highway corridor were investigated. Changes in population, manufacturing employment, retail sales, and assessed property values were related to increases in accessibility afforded by the Connecticut Turnpike and were compared for towns adjacent to the turnpike and for control towns in the eastern Connecticut region that were not located on the turnpike. Findings from the study indicate that the Connecticut Turnpike has had a continuing influence on the level and distribution of population and economic activity in the eastern Connecticut region. During the first 6

years the turnpike was in operation, only the eastern Connecticut towns located directly on the turnpike grew faster in population than the state as a whole. Since then, towns throughout the entire eastern Connecticut region have grown faster than the rest of the state. Although increases in population were widespread throughout the region, increases in manufacturing employment, retail sales, and land values were concentrated in towns along the turnpike. Moreover, among the turnpike towns significant differences in impact were found. The study concludes that the Connecticut Turnpike has had a significant long-term impact on the eastern Connecticut region, but that not all towns in the region have shared equally in that growth.

Highways are usually constructed in response to increased traffic demands associated with economic development. The Connecticut Turnpike, however, was constructed primarily to stimulate development in eastern Connecticut, an area that had become economically depressed following the demise of the textile industry in the northeastern United States. The textile industry had dominated the economy of eastern Connecticut until the 1950s when the textile mills began to move south. Large pockets of unemployment developed, wages fell below the state average, and there were extended seasonal layoffs. Attempts to attract new industries were not successful. In 1957, the Connecticut General Assembly authorized the construction of the Connecticut Turnpike in an attempt to stimulate the region's economic growth. A research project, undertaken by the University of Connecticut in cooperation with the Connecticut State Highway Department and the U.S. Bureau of Public Roads, measured the impact of the new facility on the economy of eastern Connecticut in the years following the opening of the turnpike.

The final report of that project, entitled The Connecticut Turnpike: A Ribbon of Hope (1), made several conclusions about the effects of the Connecticut Turnpike on persons and businesses in the region. This study found that towns along the Connecticut Turnpike had relatively greater economic growth than either control towns in the region or other towns around the state. It also found that the turnpike had reversed the sentiment of eastern Connecticut's inhabitants from one of pessimism to optimism. They perceived the Connecticut Turnpike as enhancing the economic development of the region, particularly after its prior downward trend.

The turnpike also improved both intraregional and interregional accessibility, making existing job opportunities more accessible and stimulating creation of additional jobs, particularly those in manufacturing. The study found that labor-market areas for firms within the region became more elliptical following construction of the turnpike; the major axis generally followed the turnpike. The accessibility afforded by the turnpike thus affected the firms' labor-market areas. Workers were able to commute from greater distances; but the longer the commute, the nearer the employee lived to the highway.

Differences were found in the rate of economic development among the turnpike towns. It was hypothesized that these relative differences were the result of each community's capacity to respond to the potential economic stimulus of a major infrastructure investment such as a highway. The study concluded that the benefits of a new transportation facility can be enhanced if construction of the facility is planned and coordinated with other local development initiatives.

The Ribbon-of-Hope study contained data from 1957 through 1963. Since the Connecticut Turnpike was opened in January 1958, the study could only analyze the short-term socioeconomic effects of the highway. The report noted that "the full impact of the Connecticut Turnpike ... will not be known for several years" (1, p. 5). This

paper reports on a study conducted by Paul Weiner of the University of Connecticut for the Federal Highway Administration to update data in the original study and to assess the long-term social and economic impacts of the Connecticut Turnpike (2).

SCOPE AND OBJECTIVES

The overall objective of this study was to analyze the long-term social and economic impacts of the Connecticut Turnpike on the eastern Connecticut region. The Connecticut Turnpike was chosen because it is one of the few major highway projects constructed primarily to stimulate economic growth and development. The Connecticut Turnpike is divided, for purposes of this study, into two sections—the section designated CT-52, which goes from the Rhode Island border to the junction with I-95, and the section of I-95 from the Connecticut River, which is the western edge of the study area, to CT-52 (Figure 1). Because the eastern portion of I-95 was anticipated to have an impact on the area as well as the Connecticut Turnpike portion of the highway, it was included in the study.

Impact indicators chosen for the study were changes in population, employment, retail sales, and property values in eastern Connecticut towns over a 15- to 20-year period. Two groups of towns were analyzed—23 turnpike towns within 8 km (5 miles) of the turnpike or I-95, and 13 control towns not adjacent to either of these two highways. The two groups are the same as those used in the earlier Ribbon-of-Hope study. Because the earlier study found that the effect of the turnpike on different communities in eastern Connecticut was not uniform, the Weiner study examines the 23 turnpike towns in greater detail. Three groups of turnpike towns are analyzed—those bordering CT-52, those bordering I-95 (including the nonturnpike portion), and three of the larger cities in the region—Groton, New London, and Norwich. Grouping the towns in this manner was expected to enhance the analysis of the differences in the degree and timing of social and economic change in the region and to assist in identifying whether or not there are specific actions that towns can take to enhance the development potential created by major highway improvements.

IMPROVED ACCESSIBILITY AND
ECONOMIC DEVELOPMENT

The link between highway improvements and economic development is improved accessibility. Reduced travel time and transport costs contribute to economic development by expanding the markets for both goods and labor. Businesses benefit by being able to transport factors of production and finished products more safely, cheaply, and reliably and by being able to draw on a larger labor market. Workers in the region benefit by having a greater number of job opportunities accessible to them, particularly when new businesses are attracted to the region because of improved accessibility.

To measure the increase in accessibility provided by the Connecticut Turnpike and I-95, an accessibility index was constructed for towns in the eastern Connecticut region. The index focused on accessibility to employment and may be calculated as follows:

$$A_i = \Sigma E_j \cdot 1/F_{ij} \tag{1}$$

where

A_i = accessibility index for town i,
E_j = employment in town j, and

F_{ij} = travel time in minutes between towns i and j.

This accessibility index measures only intraregional accessibility and, thus, is insufficient to explain location decisions of firms moving into the region. However, it does provide a measure of the relative accessibility benefits afforded turnpike and control towns by the Connecticut Turnpike and helps explain changes in population, retail sales, and property values among eastern Connecticut towns.

Table 1 compares the aggregate accessibility index
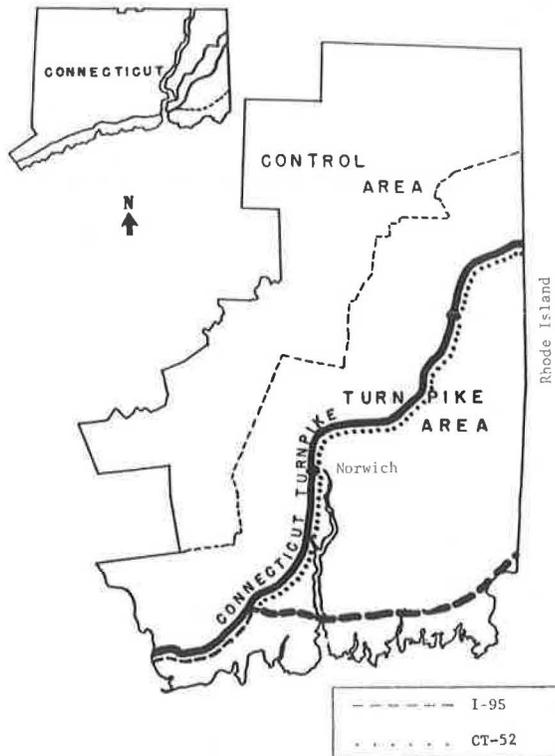
Figure 1. Eastern Connecticut study area.

Table 1. Changes in accessibility following construction of the Connecticut Turnpike.

| Area | Accessibility Index Values | | |
	Without I-95 and CT-52	With I-95 and CT-52	Change (%)
Control towns	37 815	39 002	3.1
Turnpike towns	69 576	78 076	12.2
I-95 towns	47 524	62 383	31.3
CT-52 towns	44 915	47 276	5.3
3 cities	130 267	246 100	88.9

values for turnpike and control towns before and after CT-52 and I-95 were opened. Even without CT-52 and I-95, the turnpike towns enjoyed greater accessibility to employment than control towns within the region. Construction of the turnpike increased the locational advantage of the turnpike towns relative to the control towns, but even the control towns realized benefits from the turnpike with respect to accessibility-to-employment opportunities. Among the turnpike towns, the new highway produced the greatest increase in the accessibility index for the three large cities followed by the towns along I-95. In towns along the CT-52 section of the turnpike, the increase in accessibility to employment was only slightly greater than that for the average of all control towns.

Table 2 relates changes in employment accessibility among turnpike and control towns in eastern Connecticut to changes in employment, manufacturing employment and wages, population, retail sales, and grand lists (assessed property values). These variables all increased faster in turnpike towns than in control towns, and among turnpike towns those located along I-95 performed better than those along CT-52, reflecting the greater increase in accessibility among I-95 towns.

MANUFACTURING EMPLOYMENT

Because the Connecticut Turnpike was constructed primarily to stimulate the declining economy of eastern Connecticut, the change in manufacturing employment in the region is a good indicator of the performance and effectiveness of the turnpike. Table 3 shows percentage changes in manufacturing employment in turnpike towns, control towns, the eastern Connecticut region, and the state for selected years between 1954 and 1975.

In the 4-year period before the turnpike was opened to traffic, the region showed a slight decline in manufacturing employment, but this decline was not as great as experienced by the state as a whole. The towns that were to be located along the turnpike fared better than other towns in the region; they showed a slight increase in manufacturing employment even before the turnpike opened. In the 4-year period after the turnpike was completed, manufacturing employment recovered; the state had a 9.2 percent increase in manufacturing employment and the eastern Connecticut region showed a 20.2 percent increase. Turnpike towns in the region again performed better than control towns, but the control towns showed a remarkable recovery with a 15.5 percent increase as compared to a 7.3 percent decline during the previous 4-year period. Long-term impacts of the Connecticut Turnpike on manufacturing employment are reflected in the relative rates of growth between 1962 and 1975. Although manufacturing employment in the entire state declined by almost 6 percent, manufacturing employment in towns located along the turnpike increased by 14.2 percent. Manufacturing employment in the eastern Connecticut region increased

Table 2. Percentage changes in socioeconomic characteristics of turnpike and control towns.

| Area | Socioeconomic Characteristics | | | | | | |
	Accessibility	Employment (1960-1970)	Manufacturing Workers (Nontextile, 1958-1975)	Manufacturing Wages (Nontextile, 1958-1975)	Population (1960-1974)	Retail Sales (1962-1974)	Grand Lists (1958-1974)
Control towns	3.1	27.6	10.9	126.7	21.1	93.5	180.6
Turnpike towns	12.2	43.2	60.7	233.7	29.9	126.4	357.9
I-95 towns	31.3	68.9	-	-	63.0	171.9	640.7
CT-52 towns	5.3	25.9	-	-	38.7	140.0	370.1
3 cities	88.9	37.0	-	-	8.8	103.8	189.3

by 8 percent, but in the control towns in the region it declined by almost 20 percent. For manufacturing, which is heavily dependent on good transportation, the benefits of the turnpike thus accrued predominantly to towns closest to the turnpike.

POPULATION

Another important indicator of the effect of the Connecticut Turnpike on the development of the eastern Connecticut region is population. Population changes are, of course, related to changes in manufacturing employment, but also reflect changes in secondary employment generated by manufacturing employment. Furthermore, because the turnpike increases accessibility within the region, it allows greater freedom of residential choice for persons working in the region. Even though they may work in a large manufacturing town, persons preferring to live in smaller towns may more easily do so. Thus, although a close correlation would be expected between regional changes in employment and population, this correlation does not hold on a town-by-town basis.

Table 4 shows that before construction of the turnpike the eastern Connecticut region was growing slower than the state as a whole. The towns that were to become turnpike towns were growing faster than other towns in the region, but not as fast as the rest of the state. During the first 6 years the turnpike was open to traffic,

Table 3. Percentage change in manufacturing employment, 1954-1975.

Area	1954-1958	1958-1962	1962-1975	1958-1975
Control towns	-17.3	15.5	-19.7	-7.3
Turnpike towns	4.3	21.3	14.2	38.5
Region	-0.6	20.2	8.0	29.8
State	-8.2	9.2	-5.8	2.8

Table 4. Annual percentage change in population, 1950-1974.

Area	1950-1958	1958-1964	1964-1970	1970-1974
Turnpike towns	2.14	2.50	2.10	1.01
Control towns	1.37	1.71	2.18	1.35
Region	1.98	2.34	2.13	1.06
State	2.57	2.04	1.49	0.72
I-95 towns	-	3.20	4.01	1.59
CT-52 towns	-	1.82	2.56	1.68
3 cities	-	0.88	0.51	0.02

Table 5. Net migration for control towns, turnpike towns, and the state, 1950-1970.

Area	1950-1960	1960-1970	Change (%)
State	233 000	215 019	-7.7
Control towns	951	6 474	680.7
Turnpike towns	15 553	18 035	16.0
I-95 towns	13 300	19 700	48.1
CT-52 towns	1 300	9 300	715.4
3 cities	-2 300	-7 100	-208.7

the eastern region grew faster than the state as a whole, with the fastest rate of population increase occurring in the turnpike towns. From 1964 to 1970 the control towns grew faster than the turnpike towns, and both groups in the eastern Connecticut region grew faster than the state. During this period, the rate of population increase accelerated from the rate for the previous period for the group of control towns. However, the rate of population growth declined from the previous period in the turnpike towns, the region, and the state as a whole. Between 1970 and 1974, the state population grew only 0.72 percent/year compared to 1.01 percent/year for turnpike towns and 1.35 percent/year for control towns.

While the population growth rate of control towns has exceeded that for all turnpike towns since 1964, if the three cities of Groton, New London, and Norwich are removed from the turnpike group, the growth rate for the turnpike towns exceeds that for the control towns. As have many older industrial cities, Groton, New London, and Norwich have recently suffered declining economies that require more than highway improvements to reverse.

The turnpike thus appears to have had two major long-term impacts on population in the eastern Connecticut region. First, it has stimulated total population in the region to a growth rate exceeding that of the state as a whole. Second, it has allowed greater choice in residential location for those living in the region. The population growth rate in the control towns has been rising faster than manufacturing employment, and the same is true for the turnpike towns along CT-52. The growth rate in manufacturing employment has been fastest in the I-95 turnpike towns, but all towns in the region with the exception of the three large cities have attracted new residents. Table 5 supports this conclusion. It shows that net migration to the control towns and CT-52 towns has been significantly greater than to the I-95 towns. It appears that many persons, because of good intraregional accessibility, are choosing to live in the smaller control towns and CT-52 towns while working in the larger manufacturing towns along I-95.

OTHER INDICATORS OF ECONOMIC IMPACT

Several other factors were examined in this study to assess the economic impact of the Connecticut Turnpike. Changes in retail sales, grand lists (assessed property values), building-lot values, and house values are shown in Table 6.

Retail sales data are somewhat difficult to interpret. Before the turnpike was constructed, sales in the turnpike towns were increasing faster than in the control towns. However, in the first four years after the turnpike was opened, sales in the control towns grew faster than sales in the towns adjacent to the turnpike. Possible explanations for this are that the control towns were building upon a smaller base or that there was a lag time before retailing in the turnpike towns realized its potential. Since 1962, however, retail sales in the turnpike towns have grown much more rapidly than in the control towns, reflecting the accessibility advan-

Table 6. Percentage changes in grand lists, building-lot values, and house values for control towns and turnpike towns, 1954-1974.

Area	Grand Lists			Building Lot Values	House Values
	1958-1968	1968-1974	1958-1974	1958-1973	1958-1973
Control towns	52.4	84.2	180.6	209.9	85.9
Turnpike towns	123.4	99.7	357.9	336.2	94.5
I-95 towns	184.4	160.5	640.7	510.5	110.6
CT-52 towns	121.5	112.2	370.1	224.8	75.9
3 cities	98.0	46.1	189.3	248.4	94.4

tages that the turnpike towns realized. Even the three cities that grew very little in population experienced significant increases in retail sales.

Grand lists, building-lot values, and average house values are also generally higher in towns with greater accessibility. In all three categories, the turnpike towns show greater percentage increases than control towns, and I-95 towns show the greatest increases within this group. Data on the grand lists indicate that the short-term impacts of the turnpike on property values were much greater for turnpike than control towns. In the long run, however, the turnpike has increased property values throughout the region. Between 1968 and 1974 the grand lists in control towns rose almost as fast as those in the turnpike towns, demonstrating the ripple effect major highways can have on towns located some distance away.

CONCLUSION

Some 13 years after the 1965 Ribbon-of-Hope study, the socioeconomic effects of the Connecticut Turnpike continue to be significant. Except for retail sales, the short-term impacts examined in the 1965 study were concentrated in the towns along the turnpike. In the long run, some of the impacts have spread throughout the region. Manufacturing employment has remained concentrated in the turnpike towns, reflecting the interregional accessibility afforded by the turnpike. Impacts on nonmanufacturing employment, population, retail sales, and property values appear to have spread over time to the control towns within the region, reflecting the improved intraregional accessibility that allows persons to live in one town but to work or shop in another. The benefits of the turnpike remain greater in the turnpike towns, but not all turnpike towns have shared

equally in these benefits. Generally, those towns along I-95 have benefited more than those along CT-52. The I-95 towns were growing faster than towns along CT-52, even before the turnpike was constructed. In addition, the improved accessibility provided by the turnpike reinforced their economic and locational advantages.

Thus, it appears that the economic impacts of highways are dynamic and continue to influence the level and distribution of economic activity over a long period of time. The impacts of highways on towns within a corridor are not uniform, however, and depend to a large extent on past trends, future potential, and the present actions that the town takes to exploit the development potential offered by a new highway.

ACKNOWLEDGMENT

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Abridgment

Rural Road-Closure Planning Program to Preserve Agricultural Land

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A dominant feature of counties in rural Michigan is the grid of roads. Except if interrupted or diverted to accommodate natural features, the road pattern generally runs north to south and east to west. The regularity and intensity of the pattern are significant. The grid usually conforms to 1.6-km (1-mile) spacing. An occasional major route will appear as a diagonal, but even these tend to be part of the 1.6-km (1-mile) grid.

The regularity and density of the road network evolved after much debate in the U.S. Congress, which enacted the Ordinance of 1785 (1, p. 161). This act established townships and the 1.6-km (1-mile) survey grid. From this evolved the 1.6-km grid of section line roads. The act's objective was to open up the land for settlement and various other uses.

The United States had vast tracts of undeveloped land suitable for farming. Early accessibility was provided by waterways; however, vast areas were unreachable without very difficult travel. Roads were needed to open up the area. The issue that confronts the country today,

200 years later, is whether or not the objective of opening up the countryside is still valid. Today the U.S. road network may be a double-edged sword for the farmer; i.e., it provides good accessibility but also facilitates the spread of urbanization.

Some impacts of the 1.6-km (1-mile) grid on the farmer, the county road commission, and providers of public services are discussed here. One impact of urbanization is illustrated by the change in the number of farms by size category. From 1969 to 1974, farms under 19.6 hm^2 (49 acres) have increased by 9 percent; farms of more than 200 hm^2 (500 acres) have increased by 31 percent. However, farms in the 20- to 199-hm^2 (50- to 499-acre) category have decreased by 20 percent (2, p. 148). Thus, some midsized farms are being split into smaller units, while others are being accumulated into units of more than 200 hm^2 (500 acres).

Putting together large contiguous agricultural production areas is inhibited by a dense road network. Therefore, crossing or traveling a road to go from one field

to another is common. Today's farmer is working many scattered fields, transporting equipment, and traveling long distances to these locations.

County road commissions are also impacted by the 1.6-km grid. For example, Clinton County, which covers an area of 1492 km^2 (576 miles^2) has approximately 1760 km (1100 miles) of county roads. However, very few of the county roads are more than 16 km (10 miles) long. The mean is about 12.8 km (8 miles); the mode is 1.6 km (1 mile). This represents a widely disparate road distribution.

Trying to service many short and discontinuous roads is inefficient. Route maintenance is expensive and time consuming. Limited maintenance funds must be expended to maintain many low-volume roads. What has resulted is a network of poorly maintained roads.

Studies have shown that low-volume rural roads have a disproportionately high volume of accidents, partly due to the low level of maintenance (3). Also, poor maintenance contributes to increased vehicle operating costs by increasing fuel consumption and wear and tear.

The Ordinance of 1785 also established that a portion of one section of each township should be reserved for the school system. Slowly, over the years, the rural one-room school system was developed. Then, as education became more complex, the rural school consolidation movement began.

The yellow school bus became a standard fixture on the rural scene. Today, the school bus fleet is perhaps the largest mass transportation system in the world. For example, an unpublished report by the Michigan Department of State Highways and Transportation, noted that the state's primary and secondary school districts operated a fleet of some 12 000 vehicles in 1974. These buses traveled more than 800 000 km (500 000 miles) daily; most of the distance traveled was on the rural road system.

In counties that have a low population density, school buses must travel long distances between stops for pupils. In Michigan's southern counties, which have a higher density of pupils, buses are operated for less than 20 cents/pupil trip. In northern areas, which are less densely populated but have the same road-network density, the cost is more than 32 cents/pupil trip.

Public utilities, such as electric power and telephone companies, are also influenced by the 1.6-km (1-mile) grid. Local electric and telephone lines usually follow the road network. Because of the scattered distribution of rural dwelling units, utility lines must be constructed over long stretches of land and maintained to serve a rural area.

The Ordinance of 1785 established the 256-hm^2 (640-acre) section as the basic unit of land. Although other survey standards were contemplated, the 1.6-km (1-mile) grid met the needs of 200 years ago. The farmer's primary concern was feeding his family and providing some extra agricultural products to buy or barter for those few commodities he did not produce. The amount of land tilled was usually 16 or 32 hm^2 (40 or 80 acres).

In contrast, farm size and productivity have increased until today's farmer is producing enough to feed 50 nonfarm families. However, the road network is still predominantly based on the 1.6-km (1-mile) grid. Thus, the question is, Will the existing network serve tomorrow's needs? Current trends in farm and farm equipment size are briefly examined here in response to this concern.

Recently, a dramatic change has occurred in the size of Michigan farms. Farms in the range of 20 to 200 hm^2 (50 to 500 acres), which were adequate for full-time farming not too many years ago, have decreased between 18 and 20 percent in the last 6 years. What is happening is that many of these farms are being divided into very

small, less than 4-hm^2 (10-acre) plots occupied by a nonfarm family. These small parcels have increased by 25 percent. At the opposite end of the spectrum, the full-time farmer has been trying to accumulate more land. This is demonstrated by the increase in the number of farms in excess of 200 hm^2 (500 acres). These larger farms have increased between 27 and 74 percent. As farm size has increased, so has equipment size.

The change in the size of farm equipment is highlighted by the sale of farm tractors from 1969 to 1975 (4, 5). Sales of all tractors under 74.6 kW (100 hp) have decreased, while those of tractors having more than 74.6 kW have dramatically increased. Sales of the larger tractors have increased more than 200 percent in the United States and more than 300 percent in Michigan.

There are indications that these trends in farm and equipment size will continue. If the productivity of the farmer is increased, the trends should be encouraged. One impediment to the continuation of this trend is the high degree of accessibility and division of the countryside by the 1.6-km (1-mile) grid of roads. The density of the road network that served the farmer of yesterday so well is an impediment today.

What alternatives to the 1.6-km (1-mile) road grid are available? Because most county road networks follow this pattern, the alternatives would be combinations of 1.6-km (1-mile) spacing. A 3.2×3.2-km (2×2-mile) grid would result in the closing of every other road, theoretically reducing by 50 percent the total distance covered by county roads. A road-free area of 1000 hm^2 (2500 acres) would be created compared to the 256 hm^2 (640 acres) in the 1.6×1.6-km (1×1-mile) grid. Also, some of the land now used for roads could be returned to agricultural use. For a county the size of Clinton County, this would total more than 1800 hm^2 (4500 acres).
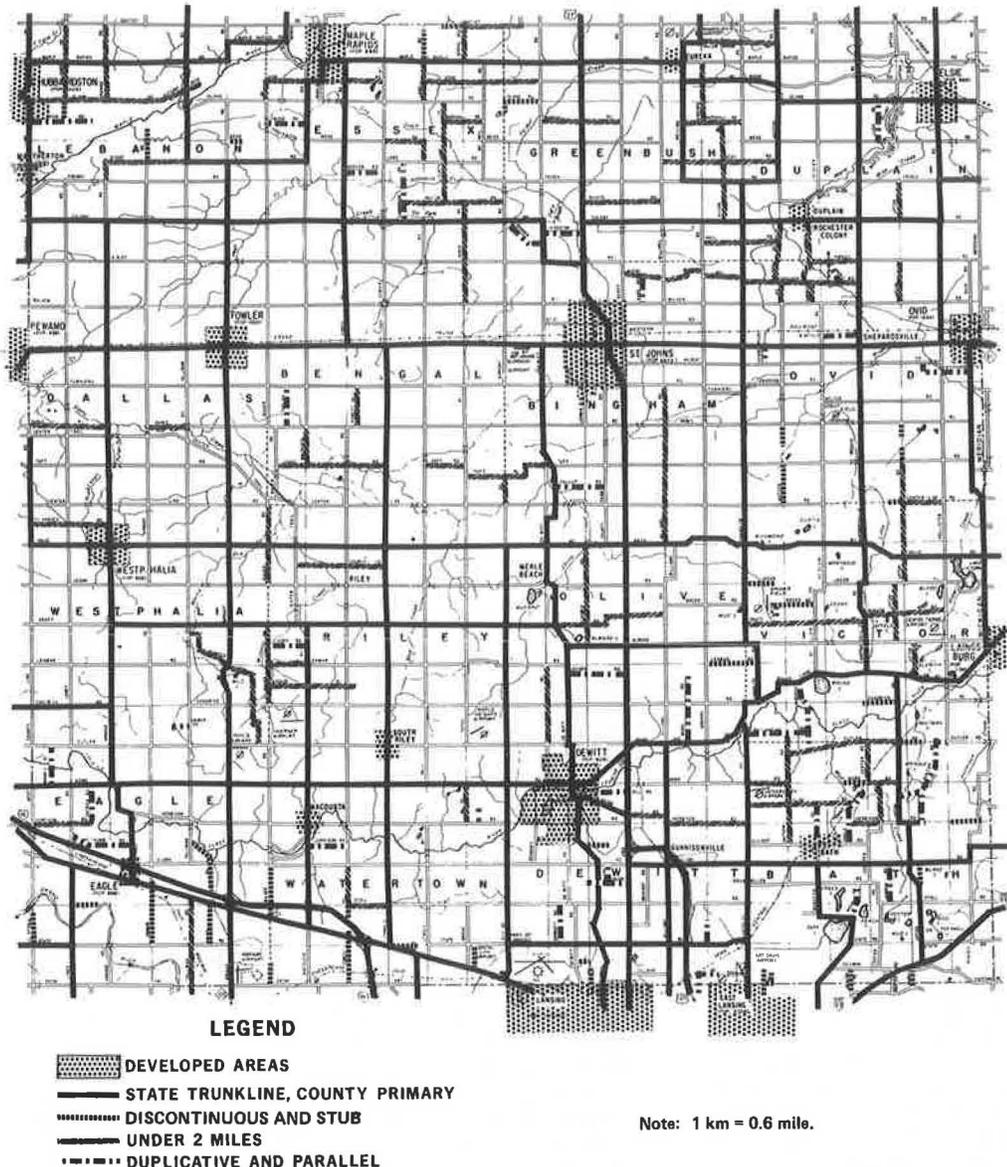
Another alternative would be the 4.8×4.8-km (3×3-mile) grid. This would result in the closing of two out of every three roads and in reducing the total county roadway figure by 66 percent. It would result in a road-free area of over 2000 hm^2 (5000 acres)—a ninefold increase over the 256-hm^2 (640-acre) section used today. Thus, more than 2400 hm^2 (6000 acres) of land used for road rights-of-way could now be used for other purposes.

Conversion to one of these alternatives would, of course, have many serious repercussions. But, before dismissing the idea entirely, some of its benefits and advantages should be considered as they affect the farmer, the nonfarm resident, the county road commission, and providers of public services.

For the farmer, a reduction in the amount of roadway could reduce the potential for nonfarm land uses. For example, the 4.8×4.8-km (3×3-mile) grid would have only 18.2 km (12 miles) of road frontage for development compared to 54.6 km (36 miles) in the 1.6-km (1-mile) grid. If nonfarm development is reduced, land value should stabilize. This, in turn, will help stabilize the assessed valuation. A stabilization of the assessed valuation would slow down the current upward spiral of property tax increases. Also, right-of-way areas used for roads could be returned to agricultural production. With a larger road-free area, larger contiguous fields could be assembled without being crossed by a road. This would mean that the farmer would not have to transport equipment over long stretches of poorly maintained county roads.

On the other hand, some disadvantages to this approach exist. Some farm homesteads would have to be relocated. Because accessibility is decreased, some trip lengths would be increased. Any increase in distance traveled between farm and market would affect the farmer's profitability. The greater the travel that is re-

Figure 1. Roads in Clinton County, Michigan, selected for possible closure.

LEGEND

▨ DEVELOPED AREAS
▬ STATE TRUNKLINE, COUNTY PRIMARY
⋯ DISCONTINUOUS AND STUB
▬ UNDER 2 MILES
·—·—· DUPLICATIVE AND PARALLEL

Note: 1 km = 0.6 mile.

quired, the lower are the farmer's profits. Closing many kilometers of roads would also disrupt the social interface of the farm community.

The rural nonfarm resident could realize some benefits. If the roads that remained were improved and paved, travel for work and other trip purposes would be easier. If fewer kilometers are driven, vehicle operating costs are lowered. The cost of public services may also be lower. However, the rural nonfarm resident may have to relocate his home. Depending on where he lived, he may have to travel farther to get to work. The residential density of an area would increase. Because many rural nonfarm families locate in a rural area to enjoy a low residential density, they would find this undesirable.

The county road commission would also be affected by a change in the road network. There would be fewer kilometers of roads to maintain and many substandard roads could be eliminated. In 1975, more than 46 400 km (29 000 miles), or almost 48 percent, of the county local roads in Michigan were inadequate (6). A decrease in the amount of roadway would enable the county road

commission to increase maintenance on the remaining roads and to bring them up to a higher standard. In Michigan, over $7.7 million is spent annually on snow and ice control. Some of this money could be saved if the county road network were reduced. Road closures would result in a more efficient use of roadway capacity. Because providing road capacity is a discrete function, the density of today's rural roads provides more capacity than traffic volumes warrant.

Benefits would be realized by the providers of public services. Some utility lines could be eliminated, and the savings in maintaining those lines could be passed to the customers. Also, as the residential density along the remaining roads increased, there would be an increase in revenue per line kilometer. The potential for line breaks, due to an ice or wind storm, would be reduced because there are fewer kilometers of exposed lines. Reinstitution of service after a storm could be quicker and at a reduced cost because fewer lines would have to be repaired. The per pupil cost of school bus service would be reduced, as would the time students spend riding the bus. Fewer kilometers would be trav-

eled by school buses and these would be on better-maintained roads, thus reducing school bus costs.

There would, of course, be some disadvantages to the public service providers. As future urbanization is reduced, there would be fewer future customers. It also would be very difficult for an area to diversify its tax base as less land would be available for nonfarm uses.

If the benefits of an alternative road grid outweighed the disadvantages, then a planning program to implement the selected alternative is needed. Planning is preparing for change. However, most physical planning focuses on change that requires more streets, buildings, and physical facilities. What is suggested here is a planning program that requires fewer roads. A program of converting to an alternative road grid would be politically and financially impossible to accomplish in a short time frame. Therefore, a two-phased program is envisioned: a short-range program to identify which roads, if closed, would cause a minimum of disruption and a long-range program, which would perhaps establish the desired road network over a 20-, 30-, or 40-year period.

The long-range planning program should be viewed as a policy plan. The objective is to determine the long-range direction that development should take. It should deal with generalized areas and alternative land development patterns. Once a development pattern is selected, then a road network that complements the pattern should be selected. If the long-range goal is to preserve and enhance an area for agricultural production, then an alternative to the 1.6-km (1-mile) road grid should be considered and selected for implementation.

Once a long-range goal is developed, then a short-range program is needed. The short-range program should develop a step-by-step implementation of the long-range goal. During the short-range process, procedures for closing roads should be established. Issues that have to be addressed are funding of relocation expenses, notification of public hearings, and a specific timetable for closing the roads. The short-range program should also identify those roads that have the most potential for closure.

Using Clinton County as an example, a four-step procedure was developed for identifying roads having closure potential. The first step identified all of the densely developed areas, state trunk lines, and county primary roads. These roads would not be considered for closure and would form the network for statewide and countywide travel.

The next step located the stub or discontinuous roads. These roads do not form any system. Included were roads with the lowest surface types, such as soil surface, graded and drained, or unimproved. In general, these roads are less than 1.6 km (1 mile) long. About 41.6 km (26 miles) of roads were in this category.

The next step located all roads less than 3.2 km (2 miles) long. These roads are not vital to the system for countywide travel. Of the 144 county roads, 40 were

in this category. Essentially these roads provide a high degree of accessibility and encourage rural nonfarm development.

The next step identified longer road segments that are discontinuous. The service they provide is duplicated by nearby parallel roads. Many of these roads are just 3.2 km (2 miles) long. There were 208 km (130 miles) of roads in this category.

These last three steps identified almost 320 km (200 miles) of county roads with closure potential. Very few of these roads were longer than 3.2 km (2 miles). They obviously are not being used for any significant trip making (Figure 1).

These roads exist because at one time there was a policy to construct all section line roads. It is time to reconsider that policy. Should we continue to develop those section line roads or are changing conditions in the rural area demanding a different direction and a different policy? For example, in Clinton County almost 50 percent of the local roads are inadequate. The nearly 320 km (200 miles) of roads identified would reduce the amount of roadway by 25 percent.

A recent editorial in the Des Moines (Iowa) Register stated: "County roads that served dozens of farms 40 years ago may be serving two or three farms today. Many roads that were once vital to a county's well-being have become in effect private roads, although the county is responsible for their upkeep. Such roads no longer belong in a county road system." The concept of closing little-used, poorly maintained rural roads has enough merit to warrant more detailed examination. Perhaps it is time to evaluate the 200-year-old objective of opening up the country and to develop an objective that serves the needs of the future.

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Abridgment

New Location Patterns and
U.S. Transportation Policy

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During the next 20 years, geographic shifts of jobs and residences from the central cities to the suburbs, from larger to smaller metropolitan areas, and from the Northeast to the sunbelt cities of the West and South are expected to continue. Potentially, these changes might aggravate or mitigate particular U.S. transportation problems and thus influence the policies designed to solve them. Furthermore, U.S. transportation policies might be called on to arrest or slow the central-city-to-suburb and regional shifts in population that are viewed by many analysts as having undesirable consequences.

Neither of these potential impacts are likely to be realized. The impact of expected location changes on transportation problems in the near future is likely to be relatively modest, so that the response of transportation policy should be correspondingly small. Future transportation policy will be molded principally in reaction to other developments, such as rising per capita incomes. Moreover, transportation policy should not be used to control or arrest these new trends. Whether such control is socially desirable is questionable. However, transportation policy would be ineffective because it has only very limited leverage over the residential and business location decisions that underlie the migration of population.

IMPACT OF EXPECTED
LOCATION PATTERNS

Public policy toward transportation is usually formulated in reaction to important underlying trends in traveler or shipper behavior. Consequently, the expected new location patterns will be important in shaping policy only if they have a major impact on trends in urban passenger, intercity freight, or intercity passenger transportation markets.

Urban Passenger Transportation

Two important travel trends have influenced postwar urban transportation policy: (a) the rise in automobile ownership and use and (b) the decline in patronage on public transit systems. The two key factors that will continue to encourage the growth of automobile travel over that of any form of mass transit are rising real incomes and shifts in the locations of residences and employment. The steady increase in real incomes during the postwar period is thought to be the single most important explanation of the decline of transit and the rise of automobiles. During the period from 1947 to 1975, real incomes per household grew by a remarkable 88 percent. As incomes grow, people are willing and able to pay for those amenities more commonly associated with the automobile than public transportation. Especially important are the door-to-door convenience, instant availability, and faster speeds that conserve traveler time. Moreover, rising incomes affect public transportation operators adversely by increasing the wages necessary to attract drivers and other qualified personnel. Public transportation costs are more sensitive to wage increases than are the costs of automobile use, because public transportation drivers must be paid and most automobile drivers do not consider driving a burden.

The change in the location of residences and employment, and specifically the higher rates of population and employment growth in the suburbs than in the central cities and in the South and Southwest than in the Northeast, is a less important cause of the shift from transit to automobiles. These shifts are caused by a variety of complex factors, including growth in real income (which encouraged the purchase of larger and newer homes—most commonly and more cheaply found in the suburbs) and changes in production technology (such as the one-story plant) and in transportation systems (the development of the truck and the postwar construction of highways). Whatever the causes, the movement of residences and jobs from the central cities to the suburbs has contributed to the shift from public transportation to the automobile because conventional mass transit is not well suited for serving people who live and work in dispersed locations. Also, the suburbs, smaller metropolitan areas, and sunbelt cities generally have newer and more extensive highway systems with lower levels of congestion that further encourage automobile use.

Intercity Freight Transportation

Postwar intercity freight policy has been preoccupied in large measure by the poor financial performance of the railroad industry. During the postwar period the rate of return on capital earned by the railroad industry has been lower than that of most other industries. In recent years, the industry's return has been below 3 percent, less than one-third the average for all of private industry.

Rising per capita income has been, and probably will continue to be, the major reason for both the modest growth in intercity freight and freight carried by railroads. Freight grows more slowly than the gross national product (GNP) because, as per capita incomes rise, a declining share of total income goes to pay for goods with high raw materials and durable manufactured goods. Instead, an increasing proportion of the GNP is used for services that require few material inputs. Moreover, the weight and raw material inputs per dollar value of manufactured goods decline because rising per capita incomes generate improvements in the quality, design, and variety, but generally not weight, of these products.

Rising per capita incomes and the resulting changes in the types of commodities produced and shipped play key roles in the decline in the railroads' share of the intercity freight market. Railroads are at a disadvantage in competing with trucks for highly manufactured traffic because the shippers of such high-valued goods generally require frequent, fast, and reliable service that is more commonly associated with trucks. Moreover, the railroads have had a difficult time competing for bulk commodities; the major growth in bulk commodity movements in the postwar

period has been petroleum shipments, for which pipelines are often better suited.

The movement of manufacturing and other plants from central city to suburban locations is only a secondary reason for the railroads' declining share of the traffic. The shift to the suburbs by employers is caused by a variety of factors, including increasing wage rates (which makes the substitution of floor space for labor more attractive), shift of residences from the central city to the suburbs, and highway construction (which makes suburban locations accessible to trucks). But whatever the causes, suburban plants tend to use trucks rather than railroads because suburban highways are less congested and the plants are usually far from major railroad yards, which tend to be located in the inner city.

Intercity Passenger Travel

The postwar trends in intercity passenger travel that have received the most attention from the federal transportation policymakers are the steady increase in the total volume of intercity travel and changes in the shares of passengers carried by the principal intercity modes. In the postwar period, total domestic intercity passenger kilometers grew at an average annual rate of 4.1 percent. Equally significant, the automobile continued to be the dominant intercity passenger mode (especially for shorter-length trips): Between 1950 and 1973, the automobile's share of intercity passenger kilometers remained reasonably steady (87 percent). Airlines have largely replaced railroads and, to a lesser extent, buses as carriers of the balance of intercity passenger traffic.

Many of the factors that caused the recent rapid growth in intercity passenger travel in general and automobile and air travel in particular are long standing and likely to continue. The single most important factor accounting for the rapid postwar growth in passenger travel has been the growth in per capita income. Households with higher incomes tend to make many more person trips. Population growth has also played an important, though secondary, role in past travel growth; it accounted for perhaps one-seventh of the total postwar increase in travel. Finally, travel growth was also encouraged by substantial reductions in intercity travel times and travel costs. These reductions were particularly large for airlines, automobiles, and buses and due primarily to postwar highway construction and technological developments in aircraft, such as the introduction of pressurized cabins and jets.

Rising per capita income is also probably the single most important factor in the automobile's continued dominance of intercity travel, because higher incomes make the automobile's door-to-door service and instant availability more valuable and affordable. Improvements in intercity highways during the postwar years also helped the automobile by increasing intercity speeds. Finally, the relatively rapid growth of suburban areas contributed to automobile use by ensuring that the origins and destinations of increasing numbers of intercity trips were distant from center-city train and bus stations.

The recent rapid growth in airline travel is also due in part to postwar increases in per capita income; this factor increased the value people placed on the higher speed and convenience offered by air service, especially for longer trips. Airline use was also significantly encouraged by major technological improvements to aircraft, which greatly improved travel speeds and reduced capital and operating expenses.

The recent location trends will not affect the growth in intercity travel and the dominance of automobile and air travel significantly. Moreover, any small effect they do have will be to reinforce the existing travel trends. The dispersal of population to smaller metropolitan areas may well require that persons make more intercity trips for business, shopping, and recreational purposes. Most of this new traffic would likely be carried by automobile or airlines rather than by the railroads. The population movement to the West and South might also decrease intercity travel somewhat in the Northeast Corridor and thus contribute to slight additional losses of railroad passenger traffic and to slower growth of airline traffic in Northeast airports, which tend to be more congested and more affected by noise problems.

TRANSPORTATION POLICY AND EFFECTS ON LOCATION TRENDS

In the past, transportation policy has been viewed largely as a means of solving problems within the transportation sector. Increasingly, however, policymakers have been tempted to use transportation policy to try to correct nontransportation problems, including some of the recent location trends. The particular location trends that are most often suggested as appropriate targets for transportation policy are the migration of people and jobs from larger to smaller metropolitan areas and, especially, from the central cities to the suburbs of the larger metropolitan areas.

Reorienting transportation policy in an attempt to encourage growth of large metropolitan areas and central cities is probably undesirable, if only because the current range of transportation policies appears to be relatively ineffective in determining the rates of actual city and suburban growth. Many policy analysts find this hard to believe because historically transportation changes are thought to have been the single most important factor in shaping the general patterns of metropolitan development and regional growth. It is important to keep in mind, however, that these past transportation developments, widely credited with shaping central-city and suburban growth, represented enormous changes in the transportation technologies, costs, and accessibility of their times. As a result, accessibility is extremely high in major metropolitan areas—one can travel between any two points in most metropolitan areas very rapidly, often within 20 or 30 min, even during rush hour. More significantly, the range of transportation policies currently being contemplated by U.S. policymakers would not change the general levels of accessibility and transportation costs nearly as much as past developments did. Many current transportation policies, such as the regulation of new-car emissions, fuel economy, and safety standards, change the out-of-pocket costs of travel only modestly and leave travel speeds virtually unaffected. Even public policies or projects that are widely regarded as having a major impact on accessibility, such as the construction of a new freeway or a new rail transit line, usually alter travel costs and times for only a fraction of the metropolitan population—those who live or work close to the facility and choose to use it. Because the range of transportation policies currently being considered does not have nearly the effect on accessibility as past transportation developments, the impact of current policies on the shape of metropolitan development should be proportionately less.

The impact of transportation policy in shaping central-city and suburban growth rates is further weakened by the importance of nontransportation considerations in determining household- and business-

location decisions. The effects of changes in these nontransportation factors may offset or swamp the effects of transportation policy. Factors other than transportation that are significant in residential location choices include levels of real per capita income, public services (especially education), crime rates, and the racial composition of neighborhoods. The steady post-war growth in real per capita income is thought to have played an especially significant role in encouraging residential suburbanization. As per capita incomes grow, households usually purchase more and better-quality housing services; this, in turn, encourages households to locate in the suburbs where lots (which are considered by many to be an important quality improvement) are cheaper because land prices are lower and where newer (and thus often higher-quality) housing tends to be located. Thus, the effects of a future transportation policy designed to discourage residential suburbanization would be offset in part, if not entirely, by the continued rise in real per capita incomes.

The nontransportation factors that influence business-

location decisions are probably more numerous (and more poorly understood) than those that influence residential changes. Rising wage rates and consequent changes in production technologies, for example, are thought to have been important factors in suburbanizing the location of businesses. As per capita income and wage rates increased, it became profitable for manufacturers to substitute capital for labor by using production lines and one-story plants; these new plants were space extensive, situated in suburban locations, built where land was cheap, and proved to be generally advantageous to employers and employees. Improvements in communication technologies may have also encouraged suburbanization of employment by making it more possible to locate central office, clerical, manufacturing, and other functions of a single firm on separate sites.

Development of Truck Trip-Generation Rates by Generalized Land-Use Categories

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One method of truck trip-generation analysis—that is, the relation between the number of truck trips produced in or attracted to an area and the characteristics of that area—is land-area trip-rate analysis. This technique develops truck trip rates, usually on a per acre or per square mile basis, for each of the various land-use types in a study area. This study reviews previous research on land-area truck trip rates and develops additional land-area truck trip rates for several case-study cities. Use of these rates may prove valuable in the analysis of the impact of major truck generating activities in localized sections of an urban area. An examination of the developed truck trip rates shows that, in general, commercial and industrial land uses are the largest generators of truck trips. Much variation is apparent, however; only residential land uses exhibit any consistency when the results of this research and previously reported truck trip rates are compared.

Trip-generation analysis techniques are usually grouped into one of three categories (1):

1. Multiple-regression analysis, the most widely used of the three procedures, relates zonal trip ends to various socioeconomic and demographic characteristics of a traffic analysis zone through a mathematical modeling procedure.
2. Cross-classification, or category analysis, stratifies independent variables into several distinct groups creating an n-dimensional matrix. For example, averages of the dependent variable and trips per dwelling unit are then computed for each cell of the matrix and forecasts are made by summing the trip ends for the forecast proportions of the independent variables.
3. Land-area trip-rate analysis attempts to develop trip-generation rates—for example, trips per acre—for the various land-use categories existing in the study

area. (Because data compiled for the four case-study cities discussed later in this paper were all in customary units, no SI equivalents are given either in the text or in the accompanying tables.)

The applications of each of these approaches to truck trip-generation analysis are varied but certain techniques have been more widely used than others. Cross-classification analysis, for instance, has had limited use as a truck trip-generation analysis procedure. Although some early work was reported in the Puget Sound Regional Transportation Study (2) and more recent federal guidelines have suggested a modified cross-classification approach for nonresidential trips (3), few specific applications have been made.

Multiple-regression analysis, in contrast, has had widespread use in truck trip-generation analysis. Typical examples of developed regression relations for urban truck trips are shown in Table 1 (4, 5). This table indicates that the earlier equations were often quite complex and involved a variety of independent variables, some with possible high intercorrelations. The Richmond example, however, reflects the continuing trend toward simplification through the use of only one equation for all internal trucks and a limited number of independent variables.

The third approach to truck trip-generation analysis has been the development of truck trip rates, usually truck trip ends per acre, for the general land-use types existing in an urban area. Application of these developed land-area truck trip rates rests not so much in long-range strategic planning on a regionwide, urban, or even networkwide basis, but rather in the short-run tactical

planning area. This approach has merit on a local level and may prove valuable in the analysis of the impact of major truck trip-generating activities in localized sections of an urban area.

The use of land-area trip-rate analyses, therefore, may be a valuable tool for evaluating transportation systems in general and the impact of truck movements in particular on an intermediate scale. The level of detail for this type of analysis would be more refined than that associated with the regression analysis techniques usually associated with large-scale areawide forecasting. Similarly, implementation time of the land-area trip-rate technique would be shorter than the long-term strategic planning generally associated with the regression analysis procedures, both because of the shorter time required for data collection and model development and the possibility of using "borrowed" rates previously developed for similar urban situations. Time requirements would be more in the tactical planning realm and results of analysis would be more readily available and easier to implement.

The scope and timing of the land-area trip-rate technique are less detailed and of longer range, respectively, than the use of truck trip-generation rates based at the business establishment level (6). The land-area trip-rate technique thus occupies a somewhat intermediate position in the array of options available for the analysis of urban truck travel demands. Use of truck trip rates by various land-use categories would enable local traffic engineers and planners to evaluate the truck traffic impact of a proposed industrial park, for example, even though the types of establishments that would eventually occupy the site could not be immediately determined.

The purpose of this research is the development of truck trip-generation rates by various stratified land-use categories. Previous applications of the land-area truck trip-rate approach are discussed and truck-trip origin-destination data from several case-study cities are analyzed by land-use type as well as by city size, economic base, and geographic location. Results of the study yield important information on local impact analyses relating to urban truck movements and may be valuable input to decisions at the sketch-planning level.

EARLY RESEARCH

Because of the short-term application of land-area trip-rate analysis and the traditional long-range orientation of the conventional transportation planning process, few applications of the land-area trip-rate approach have previously been made. Early research in the area has been summarized for several intermediate-sized urban areas by Smith (7). As expected, these studies showed that commercial land uses generated the greatest number of truck trips per acre; residential uses generated the fewest and also had the greatest stability across cities.

Another study (8) broke down land-area truck trip rates in Nashville by light and heavy truck vehicles. Again, the commercial land-use category had the highest rates, both overall as well as for each truck type. Industrial land uses also generated a significant number of heavy-truck trips; a large number of the residential truck trips were made by light truck vehicles.

A more recent example of the application of the land-area trip-rate approach is given in Table 2 in which Zavattero (9) summarizes truck trip-generation rates for the Chicago region. As might be expected, although commercial land uses represent only 3.5 percent of the developed land in the study area, they account for over 37 percent of the total truck trips. Manufacturing land uses account for another 12 percent of the truck trips and only an additional 4.4 percent of the developed land. Residential land uses account for almost 35 percent of the truck trips and use over 35 percent of the developed land; thus, they have a relatively small truck trip rate.

DATA AND CASE STUDIES

Truck-trip origin-destination data from four case-study cities (Flint, Michigan; Columbus, Ohio; Kenosha, Wisconsin; and Racine, Wisconsin) that included both destination land-use data and land area by land-use type on an areawide basis were used in the development of the land-area truck trip rates in this study. In addition to the trip-rate stratification by land-use type, the developed truck trip rates were also categorized by truck type. Thus, individual rates are available for light, medium, and heavy trucks, as well as for total trucks for each of the case-study cities. This breakdown by

Table 1. Typical truck trip-generation equations for zonal productions and attractions.

Study Area and Year	Regression Equation
Winston-Salem, North Carolina (1965)	Light trucks = 0.09 (population) + 0.24 (dwelling units) + 0.12 (employment, white collar) + 0.06 (employment, blue collar) - 0.24 (school enrollment) + 0.02 (retail sales, convenience) + 16.22 Heavy trucks = 0.04 (population) + 0.07 (dwelling units) - 0.16 (automobiles) + 0.19 (labor force, white collar) + 0.18 (employment, blue collar) - 0.08 (school enrollment) + 13.30 External trucks = 0.75 (automobiles) - 0.57 (labor force, blue collar) + 0.86 (employment, white collar) + 0.82 (employment, blue collar) - 0.18 (school enrollment) + 0.02 (retail sales, convenience) + 0.05 (retail sales, general) - 1.97
Richmond, Virginia (1974)	Truck productions or attractions = 43.84 + 0.180 (internal employment) + 0.370 (dwelling units)

Table 2. Truck trip-generation rates by land-use categories in the Chicago area.

Land Use	Land Area (acres)	Total Land (%)	Developed Land (%)	Total Truck Trips	Trips (%)	Truck Trips per Acre
Residential	335 307.1	11.3	35.8	428 941	34.8	1.28
Manufacturing	41 532.2	1.4	4.4	149 916	12.2	3.61
Commercial	32 449.6	1.1	3.5	462 380	37.6	14.25
Public buildings	78 933.7	2.7	8.6	31 545	2.6	0.40
Public open space	144 885.2	4.9	15.5	4 733	0.4	0.03
Transportation, communication, utilities	99 813.0	3.4	10.8	111 338	9.0	1.12
Highways-streets	181 174.3	6.1	19.4	26 076	2.1	0.14
Automobile parking	3 762.2	0.1	0.3	1 835	0.1	0.49
Total developed	939 017.4	(31.5)	100.0	1 216 757	(98.8)	1.30
Undeveloped	2 034 632.8	68.5		14 431	1.2	0.007
Total	2 973 650.2	100.0		1 231 188	100.0	0.41

truck type is particularly important in order to isolate the impact of the larger and heavier truck vehicles because they are often the critical units in terms of environmental considerations and roadway geometric constraints.

The study first discusses the findings of the land-use truck trip-rate development in each of the four case-study cities. A general comparison of the rates is then made across the case-study cities analyzed in this research as well as with the land-area truck trip rates developed in earlier research. Because the land-area truck trip rates in each of the case-study cities were developed using areawide land-use totals, no estimate of the variance of each of the land-area truck trip rates among the study areas' analytical zones was possible. In order to make such an estimate, area size by land-use type and truck trip ends by land-use type would have to be available for each of the traffic zones in the area. Such was not the case, unfortunately, and only areawide rates are reported.

Flint

Truck trip rates by land use and truck type for the 405 367-acre Flint study area are given in Table 3 for the nine-category land-use breakdown coded on the Flint truck origin-destination records. An examination of the data in Table 3 reveals that wholesale land uses are the highest generators of truck trips, both overall and for each of the truck-type categories, with 30.02 total truck trip ends/acre and 19.05, 7.57, and 3.40 truck trip ends/acre for light, medium, and heavy trucks, respectively. Both retail and manufacturing land uses are also heavy-truck trip generators, although the retail category has relatively high trip rates for light and medium trucks (11.85 and 5.60 truck trip ends/retail acre, respectively) and the manufacturing land uses have high trip rates for the heavy truck vehicles (2.16 heavy-truck trip ends/manufacturing acre)—defined in this case as all combination (tractor-trailer) units. The relatively large trip rates for heavy vehicles in both the wholesale and manufacturing categories make sense because these land uses would be expected to produce or attract large shipments of either raw materials or finished products. It should be pointed out, however, that these land uses also generate a substantial number of light- and medium-truck vehicle trips, indicating the intensity of the overall truck use occurring on these particular sites.

In contrast to the large-truck trip rates for wholesale and manufacturing land uses in Flint, the retail, and to a lesser degree, the services land uses generate primarily smaller-truck vehicle trips. This, too, is logical because land uses of this type may be expected to contain comparatively smaller facilities with either service or delivery functions that are conducive to the operation of smaller truck vehicles. Land uses of this type may also have various access constraints, a central

Table 3. Truck trip rates by land use and truck type in Flint, 1966.

Land Use	Daily Truck Trip Ends per Acre[a]			
	Light Trucks[b]	Medium Trucks[c]	Heavy Trucks[d]	Total Trucks
Residential	1.68	0.20	0.09	1.97
Manufacturing	10.37	2.06	2.16	14.59
Transportation, communication, utilities	0.68	0.28	0.74	1.70
Wholesale	19.05	7.57	3.40	30.02
Retail	11.85	5.60	1.13	18.58
Services	4.92	1.19	0.18	6.29
Cultural, recreation, entertainment	0.31	0.10	0.01	0.42
Resource production and extraction[e]	0.04	0.01	-[f]	0.05
Undeveloped[g]	0.01	-	-	0.01

[a] Trip rates include both truck origins and destinations.
[b] Light trucks = all single-unit, single-rear-tire trucks.
[c] Medium trucks = all single-unit, dual-rear-tire and single-unit, three- and four-axle trucks.
[d] Heavy trucks = all combination units.
[e] Includes agricultural land.
[f] Less than 0.01.
[g] Vacant and water areas.

Table 4. Truck trip rates by land use and truck type in Columbus, 1964.

Land Use	Daily Truck Trip Ends per Acre[a]			
	Light Trucks[b]	Medium Trucks[c]	Heavy Trucks[d]	Total Trucks
Residential	0.48	0.38	0.11	0.97
Industrial	2.76	2.94	1.13	6.83
Communication, transportation, utilities	0.69	0.84	0.61	2.14
Commercial	11.93	8.58	1.28	21.79
Public facilities	0.52	0.49	0.13	1.14
Recreation, open space	0.30	0.23	0.03	0.56
Mining	-[e]	0.01	-	0.01
Agricultural and vacant	0.01	-	-	0.01
Water	0.28	0.20	0.05	0.53

[a] Trip rates include both truck origins and destinations.
[b] Light trucks = all panel and pickup trucks.
[c] Medium trucks = all other commercial trucks except combinations.
[d] Heavy trucks = all semi- and full-trailer combinations.
[e] Less than 0.01.

Table 5. Truck trip rates by land use and truck type in Kenosha, 1972.

Land Use	Daily Truck Trip Ends per Acre[a]			
	Light Trucks[b]	Medium Trucks[c]	Heavy Trucks[d]	Total Trucks
Residential	1.20	0.52	-[e]	1.72
Manufacturing-nondurable	0.56	3.40	0.10	4.06
Manufacturing-durable and extractive	18.49	16.70	8.85	44.04
Transportation and utilities	0.16	0.11	0.10	0.37
Commercial wholesale and storage	1.94	3.00	0.04	4.98
Commercial retail and services	16.93	22.17	0.55	39.65
Institutional and government service	1.35	0.34	-	1.69
Recreation	-	-	-	-
Agricultural and related	0.02	-	-	0.02
Open land and water areas	-	-	-	-

[a] Trip rates include both truck origins and destinations.
[b] Light truck = under 8000 lb, except farm (under 10 000 lb).
[c] Medium truck = 8000-50 000 lb.
[d] Heavy truck = over 50 000 lb.
[e] Less than 0.01.

Table 6. Truck trip rates by land use and truck type in Racine, 1972.

Land Use	Daily Truck Trip Ends per Acre[a]			
	Light Trucks[b]	Medium Trucks[c]	Heavy Trucks[d]	Total Trucks
Residential	0.93	0.36	-[e]	1.29
Manufacturing-nondurable	1.94	2.00	0.15	4.09
Manufacturing-durable and extractive	12.81	8.75	0.36	21.92
Transportation and utilities	0.27	0.19	0.02	0.48
Commercial wholesale and storage	2.69	3.39	0.13	6.21
Commercial retail and services	19.07	22.93	0.13	42.13
Institutional and government service	2.22	0.82	-	3.04
Recreation	0.03	0.02	-	0.05
Agricultural and related	0.01	-	-	0.01
Open land and water areas	0.03	0.16	-	0.19

[a] Trip rates include both truck origins and destinations.
[b] Light truck = under 8000 lb, except farm (under 10 000 lb).
[c] Medium truck = 8000-50 000 lb.
[d] Heavy truck = over 50 000 lb.
[e] Less than 0.01.

business district location, for example, and thus preclude the operation of larger truck vehicles.

With perhaps the exception of residential land, which has some movement of light trucks (1.68 light-truck trip ends/residential acre), none of the other land uses in the Flint area generate truck movements of significant magnitude.

Columbus

Table 4 shows land-area truck trip rates by truck type developed for the Columbus study area of 344 111 acres. Commercial land uses, including both wholesale and retail categories, have the highest truck trip rates, both overall (21.79 total truck trip ends/commercial acre) and for each individual truck type (11.93, 8.58 and 1.28 truck trip ends/commercial acre for light, medium, and heavy trucks, respectively). Industrial land uses are the second highest generator of truck trips with 6.83 total truck trip ends/industrial acre and once again contain a high percentage of heavy-vehicle trips.

None of the other land-use types in Columbus have truck trip rates approaching the intensity of the commercial and industrial uses, although communication, transportation, and utilities (2.14 total truck trip ends/ acre) and public facilities (1.14 total truck trip ends/ acre) land uses have considerably higher rates than the others. Residential uses have a quite low truck trip rate of only 0.97 total truck trip ends/acre; the total rate, moreover, is somewhat spread across all three truck types with an unexpected nondominance of light-truck trips. This low rate may perhaps be due to the residential definition or, more likely, to the inclusion of personal business-type truck trips with the home-interview survey and their subsequent deletion from the truck survey (on which the truck trip rates are based).

Kenosha

The land area truck trip rates for Kenosha, a city with a 1972 population of 99 664 and a total area of approximately 86 miles², were developed from truck movement data from the Southeast Wisconsin Regional Planning Commission (SEWRPC) 1972 origin-destination study. Results of the Kenosha analyses are given in Table 5. Once again, manufacturing (in this case durable manufacturing) and commercial (retail and services) are the dominant land uses in terms of truck trip generations with total truck trip ends/acre of 44.04 and 39.65, respectively. Durable manufacturing has the highest truck trip-generation rate overall and is the only category with a significant number of heavy-truck trip generations (8.85 heavy-truck trip ends per durable manufacturing acre). Commercial retail and services has a high overall rate that is composed primarily of light (16.93 truck trip ends/acre) and medium (22.17 trip ends/acre) truck trips.

The other land-use categories with fairly high truck trip rates are commercial wholesale and storage, with a total truck trip rate of 4.98 trip ends/acre consisting primarily of medium-truck trips and containing an unexpectedly low rate for heavy-truck trip generations, and nondurable manufacturing, with a total rate of 4.06 truck trip ends/acre primarily composed of medium-truck trip ends (3.40 trip ends/acre). Residential land uses have a total rate of 1.72 truck trip ends/residential acre and are composed of mostly light-truck trip ends (1.20 light-truck trip ends/acre).

Part of the apparent difference in trip rates by land-use type between Kenosha and those for Flint and Columbus may be due to the definitions of light, medium, and heavy trucks. The Flint and Columbus origin-destination

studies, for example, coded truck vehicles by vehicle type, i.e., panel and pickup trucks, other single-unit vehicles, and all combination units. The SEWRPC coding by comparison was according to vehicle weight—i.e., light trucks under 8000 lb, medium trucks of 8000-50 000 lb, and heavy trucks more than 50 000 lb. It is thus possible, although not very likely, for some single-unit trucks to have a gross weight of more than 50 000 lb and, conversely, for some combination units to weigh less than 50 000 lb. Tennessee's weight restrictions by vehicle type, for example, show a maximum allowable gross weight of 48 000 lb for a small truck-tractor semitrailer combination, the "pup" vehicle being used more frequently in city deliveries (10).

Racine

Truck trip rates have also been developed for Racine, another city in the SEWRPC study area, with a 1972 population of 136 952 and an area of 100 miles². These rates are shown in Table 6. Commercial retail and services are the dominant land uses for the generation of truck trips in Racine with a total of 42.13 truck trip ends/acre. The retail and services rate, moreover, is almost exclusively composed of light (19.07 truck trip ends/acre) and medium (22.93 truck trip ends/acre) truck trips.

Heavy-truck trips, in fact, do not appear significant in any of the land-use truck trip rates in Racine. Even durable manufacturing, which has the second highest truck trip rate (21.92 truck trip ends/acre) in Racine and which generates a considerable number of heavy-truck trips in Kenosha, has a very small heavy-truck trip rate (0.36 heavy-truck trip ends/durable manufacturing acre). The low values for heavy-truck trips could be due to the economic makeup of the city that may preclude the need for the types of deliveries usually made by heavy trucks. Another explanation could be a large amount of total acreage in durable manufacturing use that would result in a low heavy-truck rate. If this were true, however, the rates for all truck types would also be much less; this does not seem to be the case.

Other land-use truck trip rates of significance in Racine include a commercial wholesale and storage rate of 6.21 total truck trips/acre and a residential rate of 1.29 total truck trips/acre. These seem comparable with the rates for the same categories in Kenosha.

COMPARING LAND-USE TRUCK TRIP RATES

In order to generalize about the use of land-area truck trip rates for truck travel forecasting, it is necessary to have an indication of the variability of these rates across a variety of urban areas from which such information is available. Unfortunately, land-area trip rates for truck movements are available from only a few sources in the literature on truck travel-demand forecasting; these have been summarized and reported on previously. In addition to the lack of previously published material on land-area truck trip-generation rates, financial constraints and time strictures limited the present analysis to the four previously described urban areas for which data were available.

The results of the comparison of land-area truck trip rates for total truck trips are shown in Table 7 for both the previously reported research and the research performed by this project. In order to make meaningful comparisons possible, it was necessary to double the rates reported by Smith (i.e., for Nashville, Richmond, Baton Rouge, Little Rock, Columbia, and Monroe) and those developed by Zavattero (Chicago) because they re-

Table 7. Comparison of land-use truck trip rates from selected urban areas.

Land Use	Truck Trip Ends per Acre												
	Chicago, IL	Columbus, OH	Nashville, TN	Flint, MI	Richmond, VA	Baton Rouge, LA	Little Rock, AK	Columbia, SC	Racine, WI	Kenosha, WI	Monroe, LA	Avg	SD
Residential	2.6	1.0	1.8	2.0	2.8	4.0	2.0	2.4	1.3	1.7	3.4	2.27	0.89
Industrial		6.8	5.0									5.90	1.27
Manufacturing	7.2			14.6	5.2	2.6	0.8	3.0			11.8	6.46	5.10
Nondurable manufacturing									4.1	4.1		4.10	0.00
Durable manufacturing and extractive									21.9	44.0		32.95	15.63
Commercial	28.5	21.8	29.6									26.63	4.22
Retail-wholesale trade					20.6	67.2	32.0	40.6			70.0	46.08	21.77
Wholesale				30.0								30.00^a	
Commercial wholesale and storage									6.2	5.0		5.60	0.85
Retail				18.6								18.60^a	
Commercial retail and services									42.1	39.7		40.90	1.70
Transportation, communication and utilities	2.2	2.1	1.9	1.7								1.98	0.22
Transportation and utilities									0.5	0.4		0.45	0.07
Transportation-warehouse					1.8	8.0		4.6			5.0	4.85	2.54
Service				6.3								6.3^a	
Services, schools, government					8.0	5.2		6.4			10.4	7.50	2.25
Institutional and government service									3.0	1.7		2.35	0.92
Public buildings	0.8											0.8^a	
Public land and buildings			1.0									1.0^a	
Public facilities		1.1										1.1^a	
Cultural, recreation, entertainment				0.4								0.4^a	
Recreation									0.05	-^b		0.05^a	
Public open space	0.06											0.06^a	
Recreation open space		0.6										0.6^a	
Resource production and extraction				0.05								0.05^a	
Mining		0.01										0.01^a	
Highways and streets	0.3											0.3^a	
Automobile parking	1.0											1.0^a	
Agricultural and vacant		0.01										0.01^a	
Agricultural and related									0.01	0.02		0.02	0.01
Open land and water		0.5							0.2	-		0.02	0.01
Other			0.06									0.06^a	
Undeveloped	0.01			0.01								0.01	0.00

^a Only one observation.   ^b Less than 0.01.

ported on either truck trip destinations or truck trips, not on total truck trip ends.

Interpretation of the stability of the trip rates across urban areas is difficult because of the wide variety of land-use categories employed. Residential land use is the only common category over all 11 cities. Industrial or manufacturing uses, on the other hand, are sometimes coded as "industrial," "manufacturing," or sometimes broken down into durable and nondurable components. The same is true for the commercial uses, which are reported in as many as six different categories, and most of the other uses as well.

In order to minimize this problem and to make some comparisons as meaningful as possible, the land uses in Table 7 have been grouped into somewhat similar categories. Residential land-use truck trip rates are thus seen to have some stability across all 11 cities, averaging a little more than two total truck trip ends/acre of residential land. Industrial-related land uses, on the other hand, are seen to have no consistent pattern, ranging from 0.8 truck trip ends/manufacturing acre in Little Rock to 44.0 truck trip ends/durable manufacturing and extractive acre in Kenosha. Part of this vast difference in industrial rates may be explained by the exact types of trips included in the two different categories; additional differences may be due to the economic makeup, geographic location, and size of the cities being compared. One general conclusion, however, is that, unlike trip rates for passenger travel, truck trip rates exhibit little similarity between urban areas.

It is possible, nevertheless, to draw some general conclusions from the available truck trip rates. Commercial uses, for the most part, exhibit the highest land-use truck trip rates, averaging as much as 46 truck trip ends/acre for some retail uses. Industrial-type land uses are the second highest land-area truck trip generators, followed by service, transportation, communication and utilities, and residential. All types of trip rates, however, with the possible exception of the residential category, show tremendous variability.

SUMMARY

An examination of the developed truck trip rates shows that commercial and industrial land uses are the greatest generators of truck trips. Much variation is apparent, however, with only residential land uses exhibiting any consistency when a comparison across the results of this research and previously reported truck trip rates is made.

Part of the difficulty in comparing land-area truck trip rates across several urban areas and part of the reason for the tremendous variation in the land-use truck trip rates is the differing land-use categories used in the various study areas. Industrial land uses, for example, may be coded as industrial in one area and as manufacturing or durable manufacturing and nondurable manufacturing in another area. Similarly, commercial land uses may be classified into any number of commercial, retail, and wholesale categories. Such a lack of

precise definition could be resolved by reliance on one land-use coding scheme for all urban areas, such as the one proposed in the Standard Land Use Coding Manual (11).

An additional problem in definition arises when analyzing the effects of light-, medium-, and heavy-truck vehicles. Comparisons are likewise not possible in this regard because some studies have defined light, medium, and heavy according to vehicle weight; others have used vehicle type as the classifying variable. Here again a standard definition is needed.

Perhaps the most significant recommendation to result from the research is the need for the development of truck trip rates by land use and truck type for additional urban areas from which data may be available. This work would permit the development of an adequate data base for land-area truck trip rates and would perhaps enable some generalities to be stated for land-area truck trip rates over urban areas of comparable size, economic structure, and so forth. Results comparable to those already available for passenger trip generation by land use may be realized (12, 13).

CONCLUSIONS AND RECOMMENDATIONS

Major conclusions and recommendations of this research are listed below:

1. In the short-range tactical planning area, the use of land-area trip-rate analysis, which uses simple truck trip rates per acre or per square mile of a generalized land-use category, is appropriate in evaluating the truck-traffic impact of land-use decisions when specific establishment functions are not yet known.

It is recommended that land-area truck trip analysis techniques be used when time and resources necessary for large-scale costly procedures are not available. Also, the use of land-area trip-rate techniques in the solution of localized, as opposed to areawide, planning problems should be considered when establishment-level truck trip data are not available or appropriate. The evaluation of the truck-traffic impact of a proposed industrial park where the nature of the specific establishments occupying the site may be somewhat uncertain is an example.

2. Because of the great variation in land-area truck trip rates among the different urban areas studied, the use of "borrowed" rates, at least for the present time, seems rather risky.

Until data on land-area truck trip rates from additional urban areas allow the development of rates with widespread applicability, land-area truck trip rates developed for one's own particular area should be relied on. This development is easily accomplished if origin-destination data for the area transportation study has coded destination land use on its truck trip records.

3. An additional drawback to the use of average land-area truck trip rates is their variability within the generalized land-use categories. Commercial land uses, for example, include both wholesale and retail categories that may vary tremendously in their truck trip-generating ability due to specific function, location, size, and a range of other factors.

A finer level of analysis may be necessary, using individual business establishments, when the land-use trip-rate technique appears too gross for particular localized planning issues relating to urban truck traffic.

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