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2 public transit

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11 administration
12 planning

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Contents

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Urban Intergovernmental Transportation Decision-Making Systems: Portland's Investment in Light Rail Transit

SHELDON M. EDNER

ABSTRACT

The research reported here places particular emphasis on the intergovernmental aspects of deciding on and financing the light rail transit (LRT) project in Portland. The significance of the case lies in its demonstration of the importance of intergovernmental collaboration in large-scale transportation investments. It also underscores the inherent fragility of such cooperative decision-making systems. In the context of metropolitan-wide investments, most often there is little institutionalized decision-making process or structure. Frequently, the structure for such decisions is an outgrowth of federal grant-in-aid requirements, which mandate the creation of a metropolitan decision-making framework. In the absence of any historical precedent for or stability in such systems, projects such as Portland's LRT founder on the rocks of political fragmentation and conflict. In this case, the metropolitan decision-making system worked and the lessons to be learned are of value to other urban areas embarking on similar efforts.

The February 16, 1984, Wall Street Journal observed that, "Despite the opposition of Reagan Administration budget officials and many independent planners, American cities are suddenly eager to build costly subways and other rail systems." In the same issue Michael Kemp of the Urban Institute suggested that "the pressure for rail starts typically has far more to do with civic pride, federal largesse and downtown development interests than it has with concerns about moving people efficiently." With an estimated $17 billion in pending new starts or extensions, rail system development is clearly a high-stakes arena. UMTA has struggled for years to establish a process framework to effectively support both the technical and political dimensions of decision making. Until recently, this framework has been the categorical grant program established under Section 3 of the Urban Mass Transportation Act. Despite great efforts to develop the technical quality of this approach, the decisions have often been reached in the congressional arena, through either earmarking or pressure on the UMTA Administrator and the Secretary of Transportation. Clearly, the increasing pressure for new rail systems will even further test the ability of UMTA to effectively handle the fiscal and political choices that must be made. The problem, however, is not just that of UMTA but extends to the basic intergovernmental framework within which such decisions are made.

Decision makers at all levels of government face three basic questions about transportation investments:

- Can the rational, sequential character of the technical process mesh with the iterative, value-laden framework of the political arena?
- What factors support effective decision making, particularly regarding policy continuity, regulatory flexibility, institutional procedure, and financial flexibility, in the intergovernmental system?
- What is the most effective way to structure the noninstitutionalized character of intergovernmental decision making, particularly the inclusion of relevant actors and the handling of unanticipated events?

In the absence of effective decision-making procedures and structures, investment decisions about rail systems are more likely to be governed by traditional "pork barrel" politics than by socially and technically desirable applications of decision criteria.

CASE SETTING AND RESEARCH APPROACH

The Portland, Oregon, metropolitan area is populated by slightly more than 1 million people. Governmentally, the metropolitan area is served by more than 40 jurisdictions, including some on the Washington side of the Columbia River and an elected regional government in the tri-county region surrounding the city of Portland. Transportation is a major concern not because of failing infrastructure but because of new development and economic potential. In 1973 metropolitan officials took the first steps toward identifying a new approach to meeting the region's mass transit needs. Ten years later, the construction of a 15.1-mile light rail transit (LRT) system and 4.3 miles of Interstate freeway widening and relocation began. Costing approximately $311 million (1982 dollars), the entire project will take just over 3.5 years to complete and will provide service for an estimated 44,000 transit users daily at opening (spring 1986).

Financed primarily with federal Interstate substitution money, the project is intended to serve a multiple set of objectives for the region:

- Reduce automobile congestion and improve eastside transit access to the Portland central business district (CBD),
- Enhance and maintain the vitality of the Portland and Gresham CBDs,
- Shape land use patterns to improve densities and mold residential and business location decisions, and
- Enhance and maintain the overall image of the region as progressive and vital.

Based initially on negative public reaction to a proposed eastside Interstate freeway, project scope evolved during a 5-year period before taking final shape in 1978. Thus, the project represents not the success of a single idea but, rather, the commitment of public officials to a viable decision with enduring value to the region. It also demonstrates the ability of these officials to work with an untried federal financing program and make it work effectively.

The data for this study were drawn from a number of sources. Interviews were held with more than 20 local political and technical officials during the summer of 1982. Documentary sources maintained by federal, state, and local agencies were consulted. Funding for the research was provided by the San Diego Association of Governments as part of a larger study comparing the experience of the Portland project with the San Diego LRT system. The time period covered is 1973-1983.

FREEWAYS AND ALTERNATIVES

Within metropolitan areas, Interstate segments have generated increasing controversy since the late 1960s. The "freeway revolt," predicated on environmental and social impacts, has produced significant local political opposition within urban areas. Court suits and the unwillingness or inability of state and metropolitan officials to program construction of these segments have produced considerable frustration.

In 1968, sensing a need to overcome this obstacle, Congress passed the first of a series of highway act amendments to avoid continued delays (1). This amendment (Pub. L. 90-238) permitted states to relocate troublesome Interstate segments. [The Interstate Highway Trade-In Process (1) contains a complete discussion of the history of the substitution program.] This proved insufficient in some cases, however, because it simply moved the controversy.

The 1973 (Pub. L. 93-87) amendments permitted the substitution of an alternative form of transportation. With approval of the state governor and agreement among the principal metropolitan officials, a segment could be withdrawn and replaced by a transit improvement project. The decision to withdraw rested with the U.S. Secretary of Transportation and was to be based on a determination that the withdrawn segment would not impair a unified and connected Interstate system. Further, the substitute project had to meet the same general intent as those funded under the Urban Mass Transportation Act (Title 49, U.S.C. 1601) Section 3 capital funding program. This option clearly contradicted the highway transportation philosophy of the Interstate program but opened new avenues for affected metropolitan areas.

The overall effect of the broadening of the withdrawal program was to introduce a new set of metropolitan-state-federal relationships. Consequently, the following options were made possible:

- A stronger role for metropolitan officials in the determination of freeway location and design;
- A broadening of the transportation philosophy in metropolitan areas, with particular emphasis on the development of transit;
- Support for the development of a multimodal approach to urban transportation planning rather than the categorical, single-mode approach of UMTA and FHWA; and
- A source of general fund monies for transit capital improvements other than UMTA Section 3 funds.

FHWA instituted a continuous, comprehensive, and coordinated transportation planning process for metropolitan areas in 1962. This highway-oriented process, however, has always emphasized state dominance, particularly because grant funds go directly to the states. In 1973 the infant UMTA capital program provided very little leverage for transit improvements. Metropolitan officials confronted with increasing resistance to highways and searching for transit improvement funds had few options. They had a planning role for highways but lacked significant transit, financial, technical, or political clout. If they had a role, it was in creating pressure on state transportation agencies to acknowledge urban needs. The substitution program created the potential for altering this arrangement and reflected the growing political clout that cities have in the nation's capital. This potential failed to flower until later in the decade after additional amendments (1976) and metropolitan experience with withdrawal efforts created a process for successful implementation.

PORTLAND AND THE FREEWAY REVOLT

The 1973 withdrawal amendments provided the context for Portland's LRT decision-making process. The LRT concept had surfaced in 1972 but lacked local credibility. In 1972 transportation planning for Portland was highway oriented, but the cost of additional freeways and the impact of their construction on neighborhoods were generating a negative public reaction. Despite a functioning bus system, there was no real commitment to transit.

In 1973 the matter came to a head over the proposed Mt. Hood Interstate segment. The segment had been planned for more than 10 years as a means of linking downtown Portland with another proposed outerbelt freeway on Portland's east side. The project was to have been funded with Interstate monies and would have provided improved automobile access to the Portland CBD for suburban residents. The project was to be built almost entirely within the Portland City boundaries and was a major intraurban rather than intercity freeway. As such, it barely met the federal eligibility requirements for Interstate funding and was accepted only after significant local political pressure was brought to bear on FHWA.

The freeway was planned during an era of heavy reliance on the automobile and reached the final stages of environmental review just as Portland began to develop its version of a "freeway revolt." The draft environmental impact statement (DEIS) clearly demonstrated that the primary beneficiaries of the freeway would be suburban commuters. The social and environmental costs would be borne by Portland residents. More than 1 percent of Portland's housing stock would be eliminated, substantial traffic would be diverted to neighborhood streets, and little improved mobility would be achieved for city residents. Realizing the costs to the city and seeking an alternative, a local citizens' group successfully challenged the procedural validity of the DEIS in court and won an injunction to halt the process. Portland's newly elected mayor, Neil Goldschmidt, who had actively campaigned for better regional transit service, took up the cause.

INITIAL STAGES OF THE METROPOLITAN DECISION-MAKING PROCESS

Because of the freeway controversy and as a means of resolving it, then Governor Tom McCall, at Goldschmidt's request, appointed a Governor's Task Force

(GTF), chaired by Goldschmidt, to review metropolitan transportation needs. The GTF began work in 1973 and functioned as a subcommittee of the metropolitan council of governments, the Columbia Region Association of Governments (CRAG). Its major products were a technical report justifying transit improvements for the metropolitan region and a recommendation to upgrade the staff and resource capabilities of CRAG.

Upgrading CRAG's technical capability was important for its contribution to the regional planning process. In 1973 only the city of Portland had the staff resources necessary for an effective transit planning effort. Tri-Met, the regional bus agency, had existed for only 4 years and was preoccupied with running its bus fleet. It had little technical planning ability. Multnomah County, within which Portland is located, had an interest in transit but insufficient staff to mount a regional planning program. The Oregon Department of Transportation (ODOT) had the ability to deal with the region as a whole but was firmly wedded to freeways. Despite its formal designation as the metropolitan planning organization (MPO), CRAG lacked resources, political clout, and technical ability.

Portland's capabilities stemmed from a 1972 commitment by Goldschmidt to an improved regional transit system to support a revitalized CBD and preserve the integrity of city neighborhoods. Several key individuals were hired in the city's Planning Bureau, among them a planner familiar with the Interstate substitution process. Further, this individual had the personal support of Goldschmidt, which enhanced Portland's early leadership of the decision-making process because it effectively linked the political and technical aspects of decision making.

POLITICAL PRECURSORS TO THE MT. HOOD WITHDRAWAL

The GTF provided the technical and political justification for a withdrawal effort. Two other steps were necessary before the effort proceeded. Early in 1974, at the insistence of Goldschmidt, Governor McCall replaced the entire governing board of Tri-Met. The justification was the necessity of having a transit agency with more than a bus operations philosophy. The second action was to convince the governor to support the withdrawal. With the exception of four cities, all in the east, no urban area had traded in an Interstate segment for a substitute project. The first four cities to successfully trade in Interstate segments were Boston; Hartford, Connecticut; Philadelphia; and Washington, D.C. Because these cities did so only a year before Portland began the withdrawal process, their experience provided little certainty about the financial or other benefits that could be expected. This created uneasiness about funding for a project and about potential political pressure over lost construction jobs. Because no specific project had been identified for Portland, McCall risked substantial political embarrassment if a guaranteed highway entitlement was exchanged for an empty transit promise. Moreover, ODOT clearly supported the Mt. Hood project. Glenn Jackson, Chairman of the Oregon Transportation Commission, wanted an east-west connector between suburban Multnomah County and downtown Portland. Because he was a major political figure in the state and "father" of the state's highway system, Jackson's support would stave off a state-metropolitan fight over the issue.

Jackson's support, and hence the governor's, depended on his inherent political pragmatism and the construction of another outerbelt freeway (I-205). Goldschmidt was able to convince the county commissioners to withdraw their opposition to the I-205 project. In return, the state agreed to include an alignment for a busway or rail system in the I-205 alignment and relocate an existing decrepit county jail with FHWA highway money. The county agreed to rebuild an existing east-west freeway, the Banfield, to Interstate standards. Subsequently, McCall agreed to support the withdrawal.

MT. HOOD WITHDRAWAL

McCall announced his support for the withdrawal in October 1974 but left office in January 1975. The new governor, Robert Straub, had not been party to the initial negotiations. However, Goldschmidt, a close personal friend of Straub; Gerry Drummond, the new Board Chairman of Tri-Met; and Jackson were able to persuade Straub to support the withdrawal.

Federal requirements mandate that the state governor formally request a withdrawal from the U.S. Secretary of Transportation. Given the relative infancy of Straub's administration, the responsibility for developing a technical justification fell to the city of Portland Planning Bureau. Working with the governor's office, the bureau drafted a withdrawal letter. Signed by Straub in June 1975 and backed by CRAG, the letter was sent to the Secretary of Transportation. Approval was granted in June 1976 establishing the right of the state and metropolitan area to use the Mt. Hood funds (approximately $191 million) for alternative transit and highway projects.

The lapse of a year between the request and its approval was partly the region's fault. At the time the request was made, major legislative changes were pending that would make the withdrawal process more beneficial to the metropolitan area. Portland, Multnomah County, and Gresham had committed themselves to a withdrawal but not to a substitute project. To generate a regional consensus on an alternative to the Mt. Hood project, a more flexible substitution process was necessary.

In 1976 Portland hired a congressional lobbyist to seek a series of amendments to the Federal Aid Highway Act. Supported by other metropolitan areas interested in such flexibility, the amendments were passed in June 1976. The principal changes were

- Escalation of project authorizations with the latest estimate to complete the Interstate system,
- Elimination of a June 1981 deadline for initiating construction, and
- Extension of eligibility to highway projects of a more localized nature.

These provisions greatly enhanced the flexibility of withdrawal funds. Extending the time frame allowed urban areas without specific projects to identify them. Escalating funding with Interstate completion costs created a growing metropolitan bankroll for projects. Adding highway projects reduced the need for large-scale projects, provided substantial opportunity for relieving localized transportation problems, and provided incentives for local political cooperation.

The initial $191 million produced by the Mt. Hood withdrawal was allocated by CRAG to projects throughout the metropolitan region. The bulk of the funds went to three regional transit corridors. The remainder was promised to other jurisdictions for local highway and transit improvements. Altogether, a list of 140 projects was generated. This list provided financial and political inducements for regional transit planning without fear about where the money would come from.

PLANNING FOR TRANSIT ALTERNATIVES

From 1976 through 1978, the region completed a Banfield alternatives analysis. In August 1976 a regional commitment was made to the Banfield corridor as the number one regional priority and the potential site of a project to replace the Mt. Hood freeway. The commitment was based on several factors:

- The corridor was on the east side where the freeway had been withdrawn, and there was an inherent political commitment to build there first.
- Highway improvements were necessary in the Banfield corridor to coincide with the opening of the I-205 freeway and fulfill political commitments made to Jackson.
- There was political pressure to replace the jobs lost from the Mt. Hood withdrawal.
- ODOT had the lead-agency role on the corridor (Tri-Met on the other two corridors) and a proven construction track record.
- The initial technical work on the other two corridors indicated that they would take longer to complete.

At the same time, Portland was having technical troubles with FHWA and UMTA concerning the planning process. Having created a flexible decision-making environment, the metropolitan area was confronted with two federal agencies operating on a categorical grant basis with different planning requirements. Because the Banfield corridor was evolving into a joint highway-transit project, both agencies had to be involved. Never having shared responsibility for a project before, they insisted on applying their own separate approaches to a project that the region perceived as a single effort.

The region was caught between the two agencies and had to integrate the two sets of planning requirements. The FHWA process was better suited to the need for progress because it was shorter and permitted funding for preliminary engineering before final federal project approval. However, the transit aspects of the emerging project would require a close working relationship with UMTA. Furthermore, Tri-Met would have responsibility for constructing the transit element. Tri-Met did not want to deal with the highway-oriented FHWA or ODOT--Tri-Met wanted a natural ally. Finally, despite the availability of the withdrawal funds, the region did not want to sink all of its monies into the Banfield corridor. There was a clear preference for supplementing them with an additional grant from UMTA, adding to financial flexibility. Ultimately, a compromise was struck that permitted the region to proceed under a modified FHWA process but with concurrent final approval from UMTA.

ARRIVING AT A FINAL DECISION

The planning process was completed in December 1978 with the approval of the preferred LRT alternative by Tri-Met, Gresham, Multnomah County, Portland, CRAG, and the state. However, before UMTA would grant permission to prepare a final environmental impact statement (FEIS), it forced Tri-Met to retrace a number of the technical estimates in the DEIS, particularly ridership estimates. UMTA questioned the choice of the LRT on the basis that the Banfield corridor was located to the north of the most logical pathway for express transit service--the Powell Boulevard corridor in southeast Portland. This corridor was downgraded in the technical analysis because it was the site of the Mt. Hood freeway. It made little sense to regional officials to undertake a major construction project in the corridor that had produced the political conflict surrounding the proposed Interstate segment. The Banfield corridor, as an existing freeway corridor, was less likely to generate controversy. UMTA felt that the LRT was unlikely to generate the ridership and, hence, operating cost savings that were claimed in the DEIS for the Banfield alignment. Consequently, UMTA sought adequate justification of the project. Because of this dispute, it took several months to gain permission to proceed with the FEIS: permission was finally granted in August 1979.

FINANCING THE LRT

As the decision-making process played out, local efforts shifted to the financing of the LRT. Little attention had been focused on this issue because of the Interstate bankroll. The LRT cost estimates, however, had risen to $161 million by the time of recommendation. Approximately $70 million was available from the Mt. Hood monies. The remainder was to come from an UMTA capital grant and local matching funds. Tri-Met, which was to build the LRT portion of the project, lacked the resources to provide the matching funds. ODOT could tap state gasoline tax revenues for its highway matching money.

In the fall of 1978 Goldschmidt proposed the withdrawal of another Interstate freeway segment. This freeway, I-505, was contained solely within the boundaries of Portland and was intended to serve the city's northwestern industrial district. City planners determined that a replacement project could be developed at far less cost. Hence, the mayor proposed to the state that I-505 be withdrawn and the funds be distributed to regional projects including a portion to the LRT. Because the project affected only the city and because Goldschmidt chaired CRAG, it was relatively easy to obtain regional approval. Simultaneously, the mayor proposed that the state provide the Banfield transit matching funds. In return, the metropolitan area would forego other federal highway funds that would have come to the region. Approximately $76 million over an 8-year period would thus be available for projects outside the metropolitan area.

The legislature was asked to provide $16 million and in return other cities in the state would share the $76 million. However, there were two major stumbling blocks. First, Straub had lost a reelection bid to his Republican opponent, Victor Atiyeh. Atiyeh, who assumed office in January 1979, was a fiscal conservative and a previous supporter of the Mt. Hood freeway. With the assistance of Jackson, a major Republican supporter, Atiyeh was convinced to accept the proposal on the strength of the local political consensus and the financial windfall to the rest of the state. Atiyeh persuaded the legislature to accept the proposal with the understanding that any additional local matching funds would come from metropolitan sources.

The second obstacle was Oregon Congressman Robert Duncan. As Chairman of the House Appropriations Subcommittee on Transportation, Duncan believed that the matching funds should come from local sources to guarantee commitment to the successful completion of the project. He was troubled further by the precedent it might set for other states. He was finally persuaded to accept the arrangement when new cost estimates indicated that the $16 million would be insufficient to meet matching needs. Tri-Met agreed to provide another $10 million, which sealed Duncan's approval.

FEDERAL APPROVAL

When the local match had been arranged and Duncan pacified, the metropolitan area turned to obtaining final federal project authorization. The FEIS was begun in September 1979 and completed in June 1980. The FEIS was approved by U.S. DOT in July 1980, and final project authorization was issued by Goldschmidt, newly appointed U.S. Secretary of Transportation, in August 1980. All that remained was federal approval of an UMTA capital grant for $85.7 million and appropriation of necessary Interstate transfer monies by Congress. Goldschmidt, despite his position, was hamstrung by a lack of sufficient DOT budgetary authority. As a result of the assistance of Oregon Representatives Duncan and AuCoin in the House and Senators Packwood and Hatfield, legislative authorization to provide funds for the project was obtained.

A letter of intent was announced by Goldschmidt in the early fall of 1980, one of his last acts as Secretary. Ronald Reagan assumed office 2 months after the announcement and placed a ban on new rail starts. Because of a lack of administration and congressional support, the Portland project was effectively at a standstill. UMTA simply refused to honor the commitment of the previous administration. The metropolitan area, however, was not about to give up. Another legislative resource surfaced: Senator Mark Hatfield, new Chairman of the Senate Appropriations Committee.

Hatfield had not played a leading role in the early phases of the Banfield project, but he was familiar with it. His support for funding was pivotal, but he was caught in a squeeze. Oregon needed his support. The White House also needed his support for its budgetary proposals. The White House could not afford a direct capitulation to a Portland request, nor could Hatfield afford to make the request without jeopardizing his relations with the executive branch.

To circumvent this impasse, Tri-Met proposed that the project be funded completely with Interstate transfer funds on a cash flow basis. The attractiveness of this scheme was twofold: (a) no grants would be made from UMTA funds and (b) the budget demands would be spread over a 4-year construction period. Hatfield took this concept to the White House and gained support for a legislative authorization that was finally approved in September 1981.

Portland won a double victory. In suggesting the funding scheme, the region had promised to move Mt. Hood funds previously promised to the west-side Sunset corridor to the Banfield corridor. In return, UMTA promised $76 million in nonrail capital improvements to the Sunset corridor. Because the region had not identified a project for the west side, it reaped a guaranteed windfall of monies that would otherwise have had to come from annual congressional appropriations and the UMTA administrative approval process.

In March 1982, 6 months after legislative approval of the funding scheme, UMTA Administrator Arthur Teele brought a full funding agreement to the groundbreaking ceremonies for the LRT maintenance facility.

ASSESSING THE CASE

The development of the transit option for Portland provided a direction for the rethinking of the region's transportation planning and decision-making process. Given the initial absence of particular project-level objectives and the ambiguity about how transit could supplement, replace, or support highways, the ensuing decision-making process had to be diffuse and fluid. Without the pressure to provide an alternative project to the Mt. Hood one to ensure capture of federal monies, the subsequent events might not have occurred at the same pace or with the same certainty. Facilitated by the absence of clear-cut cleavages between competing project objectives, decision making was framed around options rather than alternatives. As the alternatives emerged, the respective participants were in a position of opportunity rather than opposition. The flexibility of the funding process minimized costs to the respective jurisdictions, and the only potential losers were the supporters of the Mt. Hood proposal who were politically hamstrung by public opposition to the freeway. In the vacuum created by the withdrawal, new directions were possible that might not have been at any other time. That they came to fruition was a product of the leadership provided by a number of individuals, the political pragmatism they demonstrated, and the willingness to exploit opportunities as they presented themselves. However, it is also clear that, although many individuals contributed, no one had a grand game plan that led the process from start to finish. Instead, a slow aggregation of support and consensus building, which coopted where necessary and fed divergent interests, produced an outcome that had not been a foregone conclusion.

The Banfield corridor transportation planning process reflected the inherent federal interest in promoting effective regional cooperation, but it did not do so through specified regulatory channels. Moreover, it facilitated local accommodation of political and administrative agencies without undue red tape and paperwork. Implicitly, the federal categorical grant process provides a structure for grantee development and choice of alternatives. However, the grant process is usually imposed on a situation of drawn local battle lines or predetermined choices. The Portland case was unique not in the fact that its political and technical officials were any better than those of other urban areas but in that they were able to enter the federal process before a project commitment was made, make use of the process for the purpose of identifying a workable approach, develop the necessary decision-making consensus, modify it where necessary, and consequently develop a workable project.

Clearly, the integration of the technical and political process underlying the Banfield decision was important. Perhaps not fully justifiable from either perspective, it was acceptable and understood by the institutional participants. Moreover, the time invested in building this linkage resulted in a solid base of support for the project.

The Banfield corridor project has contributed to the development and enhancement of two of the region's major organizations, Tri-Met and METRO. METRO became an improved regional forum for decision making. Without this forum, a far more cumbersome and complex approach would have been necessary. Used or abused by the participants, the MPO has become a common meeting ground for the resolution of policy and program differences. There is sufficient justification to question whether without METRO and its technical capability the process would have found the necessary mechanisms for integrating diverse interests.

For Tri-Met, the result has been its emergence as the sole transit advocate for the region. Its participation as a passive observer in the early phases of the transportation planning process may not have served transit interests well. But, as Gerry Drummond, Tri-Met's Board Chairman, has observed, now that the commitment to transit is established, a major project underway, and the original leadership dispersed, Tri-Met is the metropolitan leader in the transportation development process. The building of the organization's administrative capacity, the rethinking of its mission, and the upgrading of its public image have made the agency a recognized leader in the national transit industry.

Organizational change also led to a greater state role in metropolitan transportation issues. ODOT is still a traditional state highway agency in many respects, but its involvement in the transportation planning process for Portland affected and accelerated its evolution toward a broader transportation philosophy. This has not resolved all of the tensions between Tri-Met and ODOT but it has tempered and hastened the recognition that the two agencies share a future of common interest. A deeply seated, antagonistic relationship between them would have impeded both regional decision making and the achievement of the respective goals of the two agencies.

MULTIPLE FORMS OF POLITICAL LEADERSHIP

Goldschmidt played an early, central role, but he alone did not drive the decision-making process. Many local and state officials contributed to the development of the local political consensus. Further, there was a mutual interest, either for pragmatic or philosophical reasons, in seeing the process move forward productively. Because of this, the project was not identified solely with any one interest or perspective. It became a truly regional product.

From the inception of the analytic process, the commitment to build an east-west freeway improvement was a key ingredient in ODOT's political and technical support. This support was not without its costs, however. The county's insistence on the LRT option and ODOT's commitment to freeway improvements meant that these alternatives took on an independent existence and could not be ruled out simply for technical reasons. Portland's commitment to its CBD also became an obstacle to a smooth technical process. Despite their linkage to transit, these options limited the evaluation of alternatives. Accommodation of these interests and resolution of conflict were critically important to the ultimate success of the project and maintenance of the local political consensus.

There were other less troublesome issues but none were more important. The resolution of these "squeak points" was possible because of the commonly felt need to get some project agreed to, the commitment to tap the Interstate transfer monies, and the flexibility of the funding scheme. Perhaps most important, however, was the recognition that all of the participating jurisdictions stood to lose if an agreement on a project was not reached. Without deeply seated commitments to specific contending projects, the participants could work constructively toward a project that was ultimately acceptable to all involved. The absence of a preferred project until relatively late in the process also meant that the participants were generally working toward an ambiguously specified goal. Such efforts take time.

DECISION-MAKING DELAYS

The problem of federal regulations must be approached on two levels: (a) in what areas should the federal government regulate and (b) what improvements can be made in the federal regulatory approach in order to fine tune the administrative process and thus alleviate unnecessary paperwork and expedite decision making? Ultimately, the answers to both questions rest on a fundamental problem of multiple publics and accountability to them. None of the local respondents interviewed questioned the need for federal regulations. Federal requirements, and those of state and other jurisdictions, become troublesome, however, for the following reasons:

- Critical time problems inherent in an individual project,
- Conflict with the inherent substantive interests and program objectives of individual or multiple participants,
- Consumption of time with no ascertainable payoff or benefit, and
- Arbitrary and capricious application.

The regulated party may not always clearly articulate its objection to regulation on any of these grounds. Indeed, it may confuse them, complain vociferously on one ground for the purpose of circumventing a requirement founded on another, or engage in an activity that simply falls between the cracks of existing regulations. Particularly in the latter situation, new and different projects and processes raise issues and problems that confound the intent or prior knowledge of even the wisest of regulation drafters. The problem of regulation is not just a matter of an undesirable regulation. The perceptual and practical context of a regulation's application determines its acceptability to affected parties.

In the Banfield corridor case, the major local problem with federal regulations was more with their application than with their content. Most respondents felt that there was far too much capriciousness in the application of regulations and technical requirements. However, local officials were just as willing to delay or bend rules when it suited their needs or time requirements.

The uniqueness of the Banfield funding process and the nature of the project left it between the cracks of two federal funding programs. Both UMTA and FHWA were dealing with a project that did not quite fit their respective guidelines. Consequently, they often had to redesign or custom fit federal regulations to the conditions presented by the Portland approach. This made the application of federal requirements less predictable.

Further, decision making takes time. Administrative agencies, policies, regulations, and people change. This critically affected the outcome of the federal-local relationship. Local officials believe that the constantly changing organizational structure and personnel of federal agencies have led to mixed and inconsistent interpretations and applications of regulations. Changes in the federal bureaucracy made it difficult to plan, often occurred at critical points, and sometimes created incomprehensible Catch-22s.

INTERGOVERNMENTAL CONTEXT

Large-scale projects require a flexible decision-making process. Flexibility, however, is often difficult to achieve in a constructive fashion because of potential impacts and consequences. Major rail and highway projects inevitably pose problems arising from unique on-site conditions, changing contexts, and potential opportunities. Flexibility in the Banfield case often had to be forced, in the perception of local officials, on the federal government. The "rightness" of this local effort notwithstanding, this meant custom tailoring federal requirements to local circumstances. The degree to which this is possible for the federal government is problematic, particularly with regard to issues of accountability and precedential claims by other grantees.

The federal government can make an effort to accommodate local initiatives. Although local officials believe that their proposals merit such attention, it is important to recognize that they may be pushing their federal counterparts to the limits of discretionary authority or exposing them to policy consequences that may prove counterproductive from a national perspective. Couple this with local efforts to change federal policy requirements and a situation is created that goes beyond a matter of mere regulatory discretion and flexibility.

PROJECT FOCUS

Illustrative of this problem are the federal transportation planning requirements. Although couched in terms of a continuous, comprehensive, and coordinated process covering three distinct time frames (short-, medium-, and long-range), the requirements really emphasize a project focus. Hence, if a metropolitan area has established a working consensus and process for local decision making, which produces the expected products, there is a substantial likelihood that a cooperative federal-local relationship will exist. This consensus, however, may only be "skin deep," developed solely to take advantage of federal funding, and without significant commitments to a long-term working relationship focused on mutually acceptable goals. The novelty of the Portland case illustrates still another problem: when there is not a project or product focus, it is difficult for federal agencies to work with metropolitan areas involved in a major reorientation of policy goals and decision-making processes. From a local perspective, dragging the federal actors into the process may be done in the name of cooperation but without recognition that these agents lack the ability to resolve local conflict or wish to avoid the often zero-sum character of local decision making.

Unlike traditional categorical grants for highways and mass transit projects, the withdrawal funds were used for a wide variety of projects. This laid an important groundwork for an effective local political consensus not only for the Banfield project but for transportation improvements and goals throughout the metropolitan area. The flexibility also enabled the region to respond effectively to administration prohibition of new rail starts by internally reallocating funds to construct the project. Thus, the flexibility of the process provided options and forced local rethinking of priorities without extending the decision making ad infinitum. It also demonstrated the ability of a less restrictive funding format to promote creative problem solving and mesh disparate objectives. This is the kind of outcome hoped for within a broadly construed set of federal priorities.

CONCLUSIONS

The Banfield experience illustrates the desirability of making known jurisdictional objectives and of developing both an effective local consensus and communications capability and an effective problem-solving process. In the absence of a definitive set of federal decision criteria and locally derived priorities, this may be the most desirable outcome. The pseudo-block grant mechanism developed through the Interstate withdrawal program puts a premium on several attitudinal and programmatic approaches to transportation decision making in an intergovernmental system.

First it requires a broad frame of reference within which the respective agencies must establish and share their objectives and goals. It minimizes the need to examine in minute detail each action by the respective parties, relying instead on a commitment to a constructive process of mutual agreement and problem solving. By establishing broad parameters for optional courses of action, it allows the respective parties to adjust to the realities of given situations and negotiate workable solutions. It forces recognition of individual policy and program limitations without interjecting or forcing accommodation to the programmatic and regulatory requirements of another entity.

Within the financial resources available, this approach permits exploration of attainable options without precluding opportunities and innovation. Achievement of these ends, however, requires a good-faith attitude, a recognition of legitimate policy mandates and regulatory requirements, and communication that promotes learning and understanding.

Too much cooperation, however, also poses a danger to effective decision making. The political and technical marriage of the Banfield project produced a project that met political tests and technical procedures. The technicians and politicians honestly and sincerely believe that the project will work, be cost-effective, and be the centerpiece of Portland's transit future. In retrospect, however, the decision took place in an evolving technological context. The expectations of the 1970s concerning transit's ability to solve land use, environmental, and energy problems were very high. These expectations have been tempered by greater recognition that such results have not always been achieved. Similarly, the basic models for transit demand forecasting during the decade were not as sophisticated as are those of today. Thus, to some extent, there was an element of faith in the ultimate selection and effectiveness of LRT.

Within this context, several broader implications emerge. Categorical grants have contributed to the creation of structured decision-making processes for metropolitan areas, particularly where none previously existed. The minimization of federal grant requirements through a switch to block grants reduces this structuring capability and, thus, forces local decision makers to rely more heavily on their own ability to create effective intergovernmental decision-making systems. Viewed from national and metropolitan perspectives, this may generate greater ambiguity in decision-making processes and outcomes.

Where large-scale transportation investments are concerned, time is always important because its passage adds to costs. However, with potentially less rigid decision systems, more effective decisions may be sacrificed for less costly projects. The national, social, and political costs of a faster, more localized decision-making approach are simply not clear.

Changing national and state policies has always posed a dilemma for local decision makers. Reliance on more flexible decision-making systems may temper the impact of such changes. However, as the Banfield project experience suggests, flexible decision-making systems are not immune to the consequences of policy changes. Although it would be naive to expect a guarantee of policy continuity, there is still some need for predictability in the policy framework. The minimization of programmatic and policy structures may tend to reduce predictability. The relationship of crosscutting policies (e.g., Davis-Bacon, Buy America, civil rights) and the principal policy focuses of transportation may become even more ambiguous than in the past. Moreover, there may be even greater latitude for intergovernmental participants to mutually tamper with one another's legislative, policy, and programmatic goals.

The current stresses facing MPOs suggest a troubled future for the institutionalization of intergovernmental decision-making systems. Although flexibility may be enhanced, just as likely perhaps is the possibility of local stalemates. Metropolitan areas have often demonstrated an inability to produce workable commitments and to maintain them. Divergent local political factions have often thwarted effective decision making. However, the need for successful and effective political leadership in transportation investments is clear. As important, local policy continuity is also required. In the absence of metropolitan political leadership and policy continuity, other intervening factors (e.g., the national economy, political opportunism) may drive the decision-making process.

The ability to deal with intervening factors requires some stability in the intergovernmental decision-making arena. Changing technological, economic, and political factors demand institutional stability and strength. These characteristics take time and nurturing to develop. There is some doubt that the necessary institutional muscle of metropolitan intergovernmental decision-making systems exists at the present time.

These observations are not intended to bury the concept of block grants or more flexibility in intergovernmental decision-making systems. They are rather cautions that have been overlooked in the rush to decategorize transportation investments and federal grant programs. As decision rules and federal programs become less structured, more politically acceptable decisions can probably be expected locally, but outcomes will be more ambiguous. The metropolitan decision-making systems created under the federal programs of the last 20 years may still lack the institutional character demanded of them in the case of very costly transportation investments. This is an issue that is worth continued monitoring and attention.

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The opinions expressed herein are those of the author and not the San Diego Association of Governments, UMTA, or Tri-Met. A more comprehensive report on the Portland decision-making process will be printed by the U.S. Department of Transportation in late 1984.

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Microcomputer Applications in a Metropolitan Transportation Planning Agency

JOEL MARKOWITZ

ABSTRACT

The explosion in microcomputer applications in transportation has largely been in the planning and engineering areas. Another area where microcomputers show great promise is improving the ability of a metropolitan transportation planning agency (MPO) to organize and analyze the large amount of information it needs to manage the complex financial planning of the region's transportation investment program. The initial experience of the San Francisco Bay Area's MPO with microcomputers is described and the most important areas for further development are explored.

The objective of this paper is to serve as a two-dimensional case study about developing microcomputer applications in regional transportation planning. The first dimension is the process by which needs were analyzed and choices made, resulting in the acquisition of a microcomputer system. Others might benefit from both positive and negative experiences. The second dimension is the actual development of new tools to aid in the management of an increasingly complex transit financing environment. Although such development is relatively recent, a surprising number of successful applications have been found in a production-oriented setting.

BAY AREA SETTING

The Metropolitan Transportation Commission (MTC) was established by California law in 1970 to oversee the coordinated development of the transportation system in the nine-county San Francisco Bay Area. Since then, MTC has taken on a variety of functions that relate to the direct allocation or review of millions of dollars in operating and capital aid for public transit each year. In the year ending June 30, 1982, MTC allocated $166 million in operating assistance and $53 million in capital assistance, much of the latter serving to match the more than $140 million in federal transit capital grant requests MTC approved (1). The magnitude of these figures reflects the intensity of transit investment in the region.

The Bay Area encompasses 7,000 square miles and 93 cities. Its 5.2 million residents are served by one of the most varied public transit systems imaginable. In addition to large bus and rail operations, two dozen smaller public transit agencies and three dozen paratransit providers complete the picture of Bay Area transit. Taken as a whole, Bay Area operators account for more than $500 million in annual operating expenses, $160 million in fares collected, and 100 million revenue vehicle-miles provided with 3,600 vehicles serving more than 1 million rides each weekday (2).

Were there just one large operator, MTC's tasks would be much more simple. However, with so many transit service providers in the same geographic area, MTC must continually make choices about which system should receive how much of each of the many transit funding sources available. Although some of the fund sources are tied by law to specific geographic areas or purposes, MTC has great discretion under state law over five types of funds:

- Transportation Development Act (TDA),
- State Transit Assistance (STA),
- One-quarter of the BART sales tax (AB1107/842),
- Net revenues from bridge tolls, and
- State guideway funds (Article XIX).

In addition, MTC is the designated recipient for the new federal formula funds under Section 9 of the 1982 Surface Transportation Assistance Act. As the designated metropolitan planning organization (MPO) for the Bay Area, MTC must annually submit the transportation improvement program update to federal agencies to serve as the basis for all federal grant requests.

THE PROBLEM

With this complexity and diversity come the same problems any individual transit operator has with its own annual planning and budgeting, only greatly magnified: How much money will it cost to keep the system running and to expand and improve it? How much money can be expected from each of the revenue sources? What about the impact of legislative changes? What if state or federal appropriations fall short? How can an annual program be adopted on time in the face of this uncertainty? How can one keep up to the minute with changes in budget actions and assumptions at all levels?

MTC staff coped with these problems by investing tremendous amounts of overtime during the peak funding cycle, April through June, as did each of the operators' own staffs. The information overload was processed exclusively by hand, with individual MTC staff analysts left to their own devices. Most used desktop adding machines or hand-held calculators as their tools to analyze large, hand-written spreadsheets. The situation seemed ripe for computerization, but there appeared to be no ready-made solutions available.

The U.S. Department of Transportation's Transportation Systems Center had begun investigating the potential use of microcomputers in transit financial planning in 1982 (3-6). A great deal of interesting information was assembled and some potentially valuable tools are still under development. Unfortunately for MTC, the focus was exclusively at the detailed level of an individual transit operator, and the tools were not directly applicable to the more aggregate level of regional analysis.

The continuing efforts of the federal agencies to facilitate the use of microcomputers in transit and transportation planning have also been at the level of project or agency-wide analysis. The March 1983 issue of UMTA/FHWA's Microcomputers in Transportation: Software and Source Book lists 88 software packages in five major categories, but only one of those is at the level of overall program management (7). The user group newsletters spawned by the federal effort in microcomputers have yet to report any regional-scale transit financial management projects (8,9). The special sessions devoted to microcomputer applications at the 62nd Annual Meeting of the Transportation Research Board similarly seemed to reflect the initial focus of efforts on operational and planning problems at the individual agency level (10-13).

Even those applications that did deal with transit financing issues tended to focus on budgeting and revenue forecasting rather than capital programming and financial management. It may well be true that other MPOs like MTC have been dealing successfully with these problems, but there is no direct evidence in the literature. The conclusion was that MTC was, at least for the time being, on its own.

INSTITUTIONALIZING MICROCOMPUTERS

Planting the Seeds

Although MTC had years of experience with large computers and was regularly upgrading its word-processing equipment, it had no experience with small computers. Furthermore, use of large computers was limited to typical MPO data processing tasks: travel modeling, census processing, survey data analysis. Only two other regular types of files were maintained on large computers, a file of potential consultants and a special file of minority business enterprises, both used to develop mailing lists for MTC's and other public agencies' frequent requests for proposals. In all cases, all computer work was done by remote job entry (RJE) to off-site mainframe computer services, and therefore was done by a small number of staff persons who were either in the data processing department or were very familiar with computers and programming. The idea of introducing microcomputers into ongoing work tasks had never been broached.

When the author returned from the Massachusetts Institute of Technology's week-long 1982 summer course on microcomputer applications in transportation, he was convinced of their usefulness. The appeal of microcomputers was great; at last, there was a tool that made real computing power easily accessible and was responsive and adaptive to personal problem-solving styles. Potential applications seemed to be everywhere at MTC, but the missionary's role is lonely. It took about 3 months to gain enough support to make a serious effort to define microcomputer needs.

The first step was to hold two 2-hour seminars to share with staff the basic information from the MIT course. About 15 staff members attended each session, and about a dozen potential applications of microcomputers in on-going MTC activities were identified by the group. Because of that expression of interest, a formal proposal to management to form a study group to develop specific recommendations was prepared. The proposal was approved, and a committee representing the three main functional divisions of the agency plus data processing staff was formed by early October 1982.

That first proposal said, in part:

> While it is easy, and deadly, to overstudy the feasibility of acquiring and using a microcomputer, I think a small committee (perhaps one person from each section) can develop a plan of action in a week. For the short term, I think the committee should make a recommendation on a single hardware/software package in the $5,000-10,000 range. This would get us going, developing specific applications and seeing how many people would actually make use of the equipment, and would give us a chance to work out training, maintenance and access questions. If the experience with this investment pays off, then the committee can consider longer-term options for multi-user systems, tie-ins to mainframe computers or the Wang system, and a strategy for placement of microcomputers or terminals in the new building (unpublished MTC internal communication).

That seemingly simple proposal to purchase a microcomputer soon turned into an elaborate, 4-month process.

Evaluation of Applications and Systems

MTC tried to follow what has become the standard advice in approaching microcomputers: (a) decide what needs to be done, (b) locate software (programs) that accomplishes those tasks, and (c) look for hardware (microcomputers) to run the needed software. This way of proceeding was not very helpful because MTC needs were so generally defined that many hardware-software combinations seemed feasible.

Applications

As the first step, the staff committee developed a list of 19 potential applications, which ranged from financial planning to automating the annual transit operator reporting system and keeping track of materials charged out from the office library. A variety of alternative schemes for ranking the relative importance of these applications was discussed, but the committee was unable to reach a consensus. Six criteria were considered.

The first possible criterion was potential labor savings, but the time saved would not result in cost savings. Instead, it would allow more time for analysis, improving the final product, and avoiding the rush of a production schedule. The thrust of several project proposals was in this direction--doing existing tasks better, faster, and less painfully. Unfortunately, it was difficult to estimate either the base data on time previously spent or the potential time savings for specific projects.

Another more self-serving criterion was the selection of projects that had high potential for early, positive results. This would help establish a good foundation for more elaborate, and risky, undertakings.

A third criterion was to increase the sophistication of analyses and allow individuals to do the kind of work they wanted to do before, but could not because their tools (calculators and adding machines) just were not up to the task. MTC had no intermediate tools between calculators and mainframe computers. If the former were inadequate, the latter were inaccessible to nonprogrammers.

Another proposed criterion was to make the microcomputer applications test a wide range of functions: administrative, personnel, budgeting, analysis, and data management.

A similar experimental criterion was to mix "safe" projects that had no serious scheduling constraint with those that were on a critical path in the annual grant review and allocation cycle.

The last criterion considered was that specific individuals be identified with these proposed projects and that those individuals make personal time commitments to carry out the tasks. This was in keeping with the overall proposition that microcomputers were tools to be used by individuals to enhance their abilities to perform their jobs. There was a strong sentiment against turning everyone on staff into a "computer jockey," or of simply compounding the work load of the current data processing staff.

The two clear directions from management when they saw the criteria were, first, that no time-critical projects be undertaken and, second, that projects be tied to specific individual commitments.

Individual staff members who expressed interest were assigned responsibility for writing a project description that included (a) a clear project title, (b) a description of the current practice, (c) the proposed microcomputer application and its benefits, (d) the name of the lead staff person who would actually develop the application, and (e) a schedule for the activity.

The following list of proposed projects was selected after rankings by each of the section managers of the projects proposed by their staff:

1. Pavement management data system,
2. Bicycle project and grant inventory system,
3. Transit capital priorities analysis,
4. Transit capital grant monitoring system,
5. Tax revenue forecasting,
6. Fare revenue projections,
7. Reporting system for summary tables on transit data,
8. Time and cost charts for annual work program,
9. Library circulation system, and
10. Work force and affirmative action report generation.

Software

The second step of the process was to match software to these tasks. The three types of programs that could accomplish these tasks are electronic spreadsheets, data base managers, and graphics programs. A number of commercially available programs of these types were found to be suitable and were ranked according to the ratings they received, or number of desirable features they possessed, as reported in a variety of industry periodicals. Magazine reviews turned out to be the primary source of specific product information and comparative ratings. Graphics were later dropped from consideration as a requirement in a "starter" system because they could be added later as use and demand warranted.

A number of spreadsheet and data base programs were considered on the basis of readily available comparative information. Because none of the initial tasks appeared to have special requirements, all the leading microcomputer products were deemed contenders. Weight was given to how long the product had been on the market and the reputation of the manufacturer, in addition to magazine review ratings, if available. General features thought desirable for both types of programs were

- Twelve-digit accuracy to handle all financial uses,
- Ability to display percentages and dollar and cents formats,
- Flexibility to format and label tables, and
- Ability to sort by more than one variable.

Integrated programs that combined spreadsheet and other functions were new on the market at the time this evaluation was made, and therefore rated low on the "proven product" scale.

Word processing was not a major consideration because the assumption was that the existing agency word-processing system would be the principal way to produce final text. There was consideration of including a simple word-processing program so that staff could draft memoranda or reports, but it was considered an extra feature.

Hardware

The collection of information about hardware proceeded in parallel with the evaluation of potential tasks and software. The basic desire was to find a workable system that could perform the identified tasks, stay as far under the $10,000 ceiling as possible, and have some capabilities for future expansion. There was nothing magic about the $10,000 limit. Management simply wanted a realistic trial system before committing itself to any large-scale capital investment.

As good planners, MTC tried to lay out all of the options. First was the possibility of accessing spreadsheet and data base programs through the existing remote systems, at the cost of a few terminals and on-line charges. Second was the possibility that either the word-processing systems (a Wang System 30) or the remote-job-entry station (a Harris minicomputer) could be enhanced. Third were the new acquisition possibilities. These were arranged in seven options:

1. Use remote time-sharing on other systems with the desired features,
2. Upgrade the existing word-processing system to accommodate the desired features,
3. Upgrade the existing minicomputer (used exclusively for remote job entry to off-site mainframes),
4. Obtain one or more portable microcomputers,
5. Obtain one or more single-user fixed microcomputers,
6. Obtain a two- to four-user multiuser microcomputer system, or
7. Obtain a four- to eight-user multiuser microcomputer system with remote-job-entry capability.

The last option was a latecomer to the list but would prove to be the critical one. The first option was dropped after only one system was found that offered a spreadsheet, and its access costs were quite high. The second option was dropped after it was found that the Wang system would have to be upgraded to a more costly configuration and that Wang's proprietary system precluded simple communications with other manufacturers' programs or equipment. The third option was eliminated because the manufacturer had announced, but not yet released, a microcomputer add-on board for its terminals. That still left four options.

Again the major source of information was magazine reviews. In addition, the Bay Area has frequent computer trade shows, and these were a further source of information during the evaluation period, as were visits to local computer stores.

Because the options were all-inclusive, the criteria were quite general. The fact that applications and software needs had been identified was of little help in the hardware area because so many systems could satisfy the minimum requirements. Hardware considerations included the following:

- Was the microcomputer (chip) well established?
- Was the operating system widespread?
- Were disk drives of adequate capacity?
- Was the internal memory (random access) at least 64,000 characters?
- Was the display of high resolution quality?
- Was the keyboard standard and comfortable to use?
- Was a large amount of business software available?
- Was the system expandable to accommodate high-capacity hard disk drives, communications with other computers, additional users, more internal memory?
- Was maintenance easily available?
- Were high-level languages available?
- What were the manufacturer's experience and reputation?

Most of these questions could be easily answered from published data and resulted in simple high-medium-low ratings, although some judgments were subjective.

Nearly 30 systems were identified as currently on the market, meeting several of the criteria, and staying within the price range for a total system (hardware and software). The line could easily have been drawn at 50 or 100, given the rapidly expanding industry, but those identified appeared to cover the market choices available at the time. MTC was well aware that there would be more and better products on the market in another few months, but all those that could be considered proven in business use were on the list already.

Decision

After all the work, two other circumstances dictated the final choice. The lease on the existing minicomputer remote-job-entry equipment was coming up for renewal and the data processing staff were considering going to another system. The monthly lease and maintenance costs amounted to more than $30,000 annually, so the option of purchasing a system seemed attractive. Data processing staff found that some multiuser "super" microcomputers were coming on the market with software that served the remote-job-entry function. It was feasible to take the funds already budgeted for lease payments and purchase a system that could do double duty as both a remote-job-entry system and a self-contained microcomputer for performing the desired spreadsheet and data base functions.

An additional development was the desire of the major transit operators to develop an on-line data base for tracking their elderly and handicapped discount rider identification registrations. Each operator wanted a terminal from which new applicants could be logged into the system so that issuance of multiple cards could be avoided and summary data on registrations could be extracted. A system with this capability could also be included, at additional cost, and would allow some enhancements to the overall system in terms of expandability.

The apparent free lunch was too attractive to pass up. The data processing department would get the improved equipment it needed, the transit operators would get their data base, and MTC analytic staff would have access to the system's spreadsheet and data management software, at virtually no net additional cost, when the minicomputer system was hauled away.

The criteria for software and hardware developed by the committee were still used in developing the request for bids, but additional criteria for the remote-job-entry and transit operator data base functions became paramount. The bids came in in February 1983, a selection was made, and installation was scheduled for June.

The specifics of the MTC microcomputer system are as follows:

- Molecular Super Micro 32--a Z-80 based system running the N-star operating system, basically CP/M-80;
- Sixteen user terminals (Freedom 100's)--tilt screen, green 80 x 25 display, 10 function keys, numeric keypad, Selectric layout;
- Printronix high-speed line printer;
- Epson MX-80 dot-matrix printers for local printing;
- Sixty-megabyte hard disk with tape backup;
- Multiplan spreadsheet (Microsoft);
- DataFlex data base management (Data Access); and
- PeachText/Magic Wand word processor (Peachtree).

Each user terminal accesses its own Z-80 card with 64K bytes of on-board memory and shares the hard disk, which is managed by the operating system.

Implementation

Several months passed between the time the issue of microcomputers was first raised and the time a selection was made, and it was clear that a working system was still some months off. The author was responsible for several data-intensive tasks (among them those identified in the proposed applications) regarding MTC's annual fund distribution and capital priority-setting functions, yet it was clear that microcomputer help would not be at hand during the critical spring cycle. Serendipitously, it was discovered that funds in the current fiscal year's budget were available in the right category for computer expenses. Although the funds in the operating budget could not be converted for capital acquisition, they could be used to rent equipment. Now that the decision about MTC's main microcomputer hardware and software configuration had been made, it seemed reasonable to rent a single-user system with the identical spreadsheet software in order to test learning time and to develop a few applications in the most critical areas. This test period was very successful and is described in detail in the following section.

The installation proceeded in June and July 1983, with some bugs still being corrected in October. The new system is being used for only a few of the originally proposed applications at this time. One reason is that training on the spreadsheet program (the intended workhorse of the system) could not be organized until late July. Three 1-hour introductory sessions attended by about 40 staff members, with the goal of teaching them enough so that they could sign on to the system and manipulate basic spreadsheet commands, were conducted. Self-teaching by working through a tutorial in the spreadsheet manual or simply by trial and error is very effective because the particular program chosen (Multiplan by Microsoft) provides on-screen help and displays a command menu in simple English terms. This is of great assistance to the occasional user who would not be likely to remember terse command codes and multikey sequences.

So far, staff acceptance has been quite high. There are very few "technophobes" who freeze at the sight of a computer terminal, and only a few "envelophiles" who still prefer to do analysis on the backs of envelopes. The major new concern is whether there will be a sufficient number of terminals to accommodate the staff who are now interested in doing new work. MTC staff have had temporary use of the nine terminals destined for the transit operator data base project. When that project gets under way, only two to four terminals will be available. By early 1984 MTC is moving to new quarters, and some staff are already asking if access to the microcomputer will be easier. All this points to a repetition of experiences with microcomputers elsewhere: In a very short time, people become dependent on the increased power the microcomputer provides and cannot imagine doing without it.

Future Hardware Extensions

Additional hardware expansions are always possible. One that has the most far-reaching potential is the development of communications links with the Bay Area's major transit operators, all of which have computer (and some microcomputer) capabilities. The potential for electronically submitting reports, updating data files, and transmitting documents seems high, given the great amount of paper that passes between MTC and the operators. The incompatibilities of computer systems across agencies, however, may make achieving this goal dependent on improvement in "black boxes" that will allow the different computer systems to communicate.

Another area for experimentation is the acquisition of expansion circuit boards and operating systems to run software, developed on other types of systems, that might be applicable here. The previously mentioned microcomputer user groups supported by the federal government have established their intention to support a fairly limited number of the most popular computer systems and to provide some assistance in converting useful programs from one system to another. There are several approaches to this.

One approach is to wait for the computer manufacturer to come out with an appropriate circuit board to plug into the machine. For example, MTC is already acquiring a 16-bit processor unit that will be compatible with IBM's Personal Computer, although not with the IBM operating system. Another option is to acquire stand-alone, single-user systems of the most popular manufacturers (IBM, Apple, Radio Shack) and use them either exclusively for converting outside applications or for general development work as well.

A more attractive option may be to acquire a single-user multiprocessor microcomputer that can operate under the MTC microcomputer's operating system (CP/M), or on Apple's or IBM's. This capability is now possible through computers that already have dual processors or the ability to accept plug-in boards that emulate other systems. This would allow testing and adapting software developed on other operating systems, but would still present a problem of transferring programs to the MTC system.

A final potential hardware enhancement would be acquisition of one or more portable computers compatible with the fixed system. This would allow easy sharing of the equipment among staff, allow the possibility of working while traveling or at home, and introduce the possibility of using the computer at meetings. The latter turns out to be a controversial suggestion to the extent that control over information can be an important factor at critical stages of some discussions. Whether or not it is advantageous to have instant access to a data base and the ability to analyze and respond to complex proposals on the spot is a question of strategy with no simple, technical answers.

MTC's Selection in Retrospect

The most significant regret about the MTC purchase is that a more powerful microprocessor was not obtained at the outset. Large spreadsheets and large documents (like this paper) tax the 64K memory limitation. Just as 64K seemed like a lot before MTC began developing applications, it seems like an insufficient amount now. Although the system can accept plug-in expansion boards, these must be customized for the operating system and separate software must be acquired. It is probably a truism with microcomputers that one cannot fully anticipate what one needs because the capabilities of the machines encourage learning by doing. The more one uses the spreadsheet, for instance, the more one learns how to develop complex, interlinked files that eat up memory. The lesson is, therefore, to not just determine if expandability is possible but to plan for the expanded system at the outset.

The same holds true on the software side as well. As mentioned, the new breed of integrated data base, spreadsheet, and graphics programs was just coming to the market at the time MTC acquired its system, and therefore ranked low on the "proven product" criterion. Although it was blithely assumed graphics could be added to the system at a later time, it turns out that no single program on the market can graph data from both the spreadsheet and the data base programs without some significant effort by programming staff. If linking such applications is clearly intended at some future time, it should be explicitly accommodated in the initial system choices.

Computer documentation is inadequate. Training, therefore, becomes a critical task. Either the system vendor must include a substantial amount of hands-on, on-site training or the buyer must carry this load. The time it takes to develop training materials and conduct classes should not be underestimated. A number of firms offer on-screen tutorials for the most popular software packages. These should be considered to supplement more formal training, especially for staff who only use the system occasionally.

DEVELOPMENT OF FINANCIAL APPLICATIONS

Test Period

Despite the dictum that no time-critical projects be dependent on developing new microcomputer applications, the author was convinced that certain tasks could be accomplished more effectively with a microcomputer and with relatively little risk. The single-user rental system was obtained in mid-March (Apple IIe with 128K memory). Within a week, the author was able to learn the basic system operation, and within 2 weeks he developed a spreadsheet to test several policy options for distributing $30 million in transit operating assistance under the new federal Section 9 formula program. The basic issue was how the federal formula would work for distributing funds within the region. That spreadsheet (Figure 1) allowed varying the assumptions until an acceptable, equitable result was obtained. This enabled MTC to respond to operator concerns and adopt a final approach within the needed time frame.

	Population Factors	Revenue (Miles)	Vehicle-Mi (Percent)	50/50 (Percent)	Dollar Estimate
AC					
D1-ALA	23.6522%				
D1-CC	3.2630%				
D1 TOT	26.9152%	25,905,000	40.0723%	33.4937%	4,517,501
Union C.	0.9893%	378,932	0.5862%	0.7877%	106,246
D2	3.8132%	2,149,000	3.3243%	3.5687%	481,337
CCCTA	6.5073%	1,392,788	2.1545%	4.3309%	584,134
WCCTA	1.0179%	137,000	0.2119%	0.6149%	82,937
BART Bus	3.3568%	2,850,000	4.4086%	3.8827%	523,686
SF MUNI	36.3187%	15,125,190	23.3971%	29.8579%	4,027,111
GOLDEN GATE	4.4254%	8,517,152	13.1751%	8.8003%	1,186,944
SAMTRANS	14.1106%	7,638,028	11.8152%	12.9629%	1,748,385
VALLEJO	2.1441%	552,605	0.8548%	1.4995%	202,241
BENICIA	0.2895%			0.1448%	19,523
NAPA	0.1120%			0.0560%	7,553
SF-O URBAN	100.0000%	64,645,695	100.0000%	100.0000%	13,487,598

FIGURE 1 Estimates of FY 1983-1984 Section 9 operating funds (partial table).

The second test was simpler in concept and a demonstration of the display capabilities of the system. A spreadsheet to estimate potentially available funds for transit capital projects was prepared. Simple formulas displayed the consequences of varying assumptions about the region's possible share of federal discretionary transit capital funds (Section 3) and matching requirements over a 5-year planning period. The spreadsheet demonstrated the likely shortfall in ability to match potentially available federal funds.

The third test was an attempt to bring more staff into contact with the spreadsheet program. Staff responsible for reviewing transit operators' grant requests must amass a great deal of budget data and make certain comparisons. Although skill and experience are needed to properly interpret the data, the basic operation of summarizing the key data is mechanical and repetitive, and therefore ripe for automation. Figure 2 shows a table that staff could use in their transit operator budget analyses to display the basic last year-this year-next year comparison of budget data by line item, revenue source, and function, with dollar and percentage changes calculated. A second table (not shown) displayed key performance data and ratios. Had the author been more experienced with the program at the time, it would have been possible to link the two spreadsheets so that the budget data from the first table would be automatically passed through to the second, to reduce data entry.

All staff who might use the two templates were trained with a 15-20 minute demonstration, a short manual specific to the spreadsheets, and access to the system on an hourly sign-up basis. Almost all of the staff doing the operator budget analyses took advantage of the opportunity to do the work on the microcomputer, even though it was purely optional. The major problem was that some of the staff laid out all the data by hand first, then did some of the calculations manually to check on the spreadsheet results. This meant that they were entering data twice, once by hand, once on the screen. Some never got used to working directly from source documents to the screen, and the process appeared much slower to them as a result. A few objected that the spreadsheet made data clerks or technicians out of them. Most, however, found the templates real time-savers in keeping up with repeated changes in operator budget projections.

Because these tests were relatively successful, the commitment was made to pursue the most complicated remaining set of tasks in the annual cycle, the preparation of the annual update to the regional transit capital priorities.

Capital Priorities and Programming

The determination of an initial list of capital projects was made during January-March as each operator's proposed 5-year program was received. There

Operator:____________ TABLE A (Thousand Dollars)

Budget Analysis

Category	FY81-2 Act	Percent	FY82-3 Budg	Percent	$ Change	% Change	FY83-4 Prop	Percent	$ Change	% Change
FUNCTIONS										
Operations		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Veh.Maint.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Non-Veh.Maint.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Gen.Admin.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Other		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
TOTAL	0	#DIV/0!	0	#DIV/0!	0		0	#DIV/0!	0	
OBJECT CLASS										
Labor/Fringe		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Services		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Fuel/Lubr.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Purch.Trans.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Other		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
TOTAL	0	#DIV/0!	0	#DIV/0!	0		0	#DIV/0!	0	
REVENUE & ASST.										
Fare Rev.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Non-Fare Rev.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Local Asst.		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Reg'l. Asst.										
TDA		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
STA		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Sec. 5		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Sec. 8		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Sec. 9		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
Other		#DIV/0!		#DIV/0!	0			#DIV/0!	0	
TOTAL	0	#DIV/0!	0	#DIV/0!	0		0	#DIV/0!	0	
BALANCE	0		0		0		0		0	

FIGURE 2 Transit operator budget analysis.

was no opportunity to use the spreadsheet to arrive at actual priority rankings for the several hundred proposed projects during that period, so efforts began at the point the initial list was developed. The immediate tasks were to display the projects, sorted out by operator and fund source, for the immediate planning year (annual element) and for the remaining years in the 5-year program (phase II).

Figure 3 shows the initial spreadsheet with estimated local fund source matches for the Section 9 federal category; a similar sheet was developed for Section 3. The formulas allowed accommodating changes in project costs, shifting projects from one phase of the program or fund source to another, and varying the matching sources, while maintaining running totals by fund type to ensure keeping within revenue expectations. To summarize these detailed figures, additional summary spreadsheets were developed that read the component spreadsheets into the summary table.

The last major step in the capital programming process is the preparation of the transportation improvement program (TIP) for submission to the federal funding agencies. A new microcomputer-oriented format was developed for entering each project's details. It was not possible to link this back to the capital priorities and programming spreadsheets because of time constraints and the memory limitations of the rental equipment. These spreadsheets will be regularly updated throughout Fiscal Year 1983-1984 as project reviews are conducted and specific grant requests are received, eliminating the tedious retyping and hand corrections of past TIP amendments.

Annual Fund Estimates

By late fall, staff had become more experienced with the new equipment, and bolder. By December each year, MTC must develop estimates of funds available to more than 50 claimants under the state Transportation Development Act (TDA). After estimating unexpended funds from the prior year and new tax generations for each of the nine counties, the funds are divided into six different categories under different formulas and allocated accordingly. These preliminary estimates must be immediately superseded in January and February with updated data from the state and the counties, and the whole computation process must be repeated. This, like other tasks, had been done by hand in the past.

Automating this activity required the interlinking of 19 spreadsheets. Although time consuming and tedious to set up, this system of spreadsheets can now be easily updated in February and will form the basis for future annual computations.

Further Applications

Several projects were accomplished in the summer of 1983 on the newly installed multiuser microcomputer. A 5-year plan required by the state for funding certain types of transit projects, including fixed guideways, requires a table and summaries similar to

PHASE I ANNUAL ELEMENT (FY 1983-4)	Total Cost	Cumulative Total	Federal Share	Local Match Total	Sources: Tolls	STA	Art. III TP&D	Local
AC TRANSIT								
Div.2 Operating Fac.(II)	8,167		6,534	1,633	1,633			
Div. 4 Operating Fac.(II)	8,705		6,964	1,741	1,741			
Div. 6 Operating Fac.(II)	7,831		6,265	1,566	1,566			
Subtotal	24,703		19,762	4,941	4,941	0	0	0
		24,703	19,762	4,941	4,941	0	0	0
BART								
Retrofit 138 A-Cars with ATO	13,800		11,040	2,760	2,760			
Daly City Turnback Constr./ Turnback/Stor. Design	16,340		12,173	4,167		417	3,750	
Motor Rewind Upgrade	960		768	192		192		
Sta. Parking Improve.	3,786		3,029	757		76	681	
Syst.Perf. Stdy.	344		275	69				69
Subtotal	35,230		27,285	7,945	2,760	685	4,431	69
		59,933	47,047	12,886	7,701	685	4,431	69
CCCTA								
5 40ft. Buses	796		637	159	159			
Bus Stop Improvments	103		82	21	21			
Martinez Amtrak Station	185			185			166	19
Subtotal	1,084		719	365	180	0	166	19
		61,017	47,767	13,250	7,881	685	4,597	88
CALTRANS								
Station Acquisitions	500			500			500	
Station Improvements	2,560			2,560			2,560	
Standby Power-SFO	1,406		1,125	281			281	
Standby Power-SJ	1,725		1,380	345			345	
Prel. Eng.-Maint. Fac.-SFO	500		400	100			100	
Subtotal	6,691		2,905	3,786	0	0	3,786	0
		67,708	50,672	17,036	7,881	685	8,383	88
GGBHTD								
Third Boat Diesel Conver.	1,900		1,520	380		380		
Vessel Improv. and Rel.Equip	620		496	124		124		
Ferry Facility Improvements	798		638	160		160		
Fareboxes and Rel. Equip.	200		160	40		40		
Replace Service Vehicles	32		26	6		6		
Computer and Comm. Equip	295		236	59		59		
San Rafael Improvements	999		799	200		200		
Administrative Building	1,615		1,292	323		323		

FIGURE 3 FY 1984-1988 transit capital priorities, Section 9 projects (partial table, $000s).

those for the main capital priorities programming. These were completed before the required November schedule. Entering summary tables of transit operating and financial data (one of the originally proposed projects) was begun and will establish an important trend-line data base for general use, in addition to contributing to two specific summer projects: an annual summary of key data and base line information for an analysis of operating costs. The initial work on Section 9 formula allocations is being revised on the basis of final congressional appropriations and revised formula factors. These tasks are all within the area of the author's direct responsibilities, and he has made sure that his staff is trained to take advantage of the microcomputer. Use by other sections of staff for production work is still quite limited. One area being explored is the entry and checking of the periodic screenline travel counts in key corridors to speed turnaround of final reports. Another is the use of the word processor to draft memoranda and reports by some staff who prefer that medium to longhand or typewritten drafts.

Future Extensions

Many financial applications projects are waiting in the wings for staff time to pursue them:

1. Developing spreadsheets to link initial capital priorities lists to the programming, summary, and TIP sheets to more fully automate the process and reduce transcription errors;
2. Developing spreadsheets to link the operator budget and operating data into the budget analysis summary sheets;
3. Developing spreadsheets to link the TIP sheets to required documentation for the Section 9 Program of Projects;
4. Developing a system for tracking and summarizing progress in implementing the capital program;
5. Developing a spreadsheet for analyzing capital projects to arrive at initial priorities using scoring, weighting formulas, and sorting;
6. Developing spreadsheets for each operating assistance fund source to determine annual fund distributions; and
7. Developing spreadsheets to consolidate both capital and operating budgets and allocations as an overall management tool.

The goal in each case is to produce finished tables in a format that requires no additional manipulation or editing before inclusion in formal reports and resolutions.

Beyond financial applications are the other tasks originally identified as potential microcomputer applications. Only time will tell if the good intentions of those who volunteered bear fruit.

CONCLUSION

It is hard to talk about microcomputers without expressing two contrary regrets: first, that MTC waited so long to act when it could have been benefiting from the capabilities that the microcomputers of today offer and, second, that MTC acted too soon and should have waited for next month's newly announced and perfect product. This is both natural and unavoidable. Certainly, were MTC in the market now rather than a year ago, specific hardware and software choices would be different. At this early stage in "microcomputerization," MTC can report gratifying progress in developing useful applications that do not even begin to take advantage of the sophistication of even one of the software packages. It may be a while before MTC starts to outgrow its system, but MTC already finds that some spreadsheet applications stretch the limits of the machine's internal memory. This may be the first area for hardware expansion.

It should be noted that none of the applications proposed or developed break new ground analytically or reach the state of the art in sophistication. There may be a lesson in that. As attractive as high-powered modeling and statistical applications may be, MTC's first concern is doing more effectively what it already knows how to do. When control of the numbers is gained and the existing complexity is managed more easily, MTC will be free to explore those extensions in abilities that could result in some real breakthroughs. That microcomputers may hold out that hope is perhaps their greatest benefit.

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Transit Advisory Office: An Approach to Technical Assistance in a Decentralized Environment

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ABSTRACT

Historically, in Los Angeles County, transportation planning has taken place at the regional or subregional level. This situation was dramatically changed in July 1982 when the Los Angeles County Transportation Commission (LACTC) began allocating transit funds directly to cities as a result of a 1/2 cent increase in the county sales tax for public transit. Because responsibilities for transportation planning in the Los Angeles area had been centralized, there was little transportation planning expertise at the local level. To assist cities in transportation planning, the LACTC established the Transit Advisory Office. An approach to technical assistance developed by the LACTC during the first year of a 2-year grant funded by UMTA's Office of Service and Management Demonstrations is outlined. In the initial year of the program, the LACTC found that the highest demand was for the services of information provider and impartial mediator or facilitator. Major problems encountered included lack of communication between elected officials and city staff, a tendency toward overly ambitious projects, and a general apathy toward transit in some cities.

In July 1982 the Los Angeles County Transportation Commission (LACTC) began collection and distribution of a countywide 1/2 cent sales tax for transit. The LACTC returns 25 percent of the proceeds of this tax to the 83 cities and to county unincorporated areas for local transit improvements. The broad discretion that localities have in using these tax revenues has led to a shift in transit planning responsibilities from regional and subregional government to the local level. As a result of this shift, the LACTC perceived a need for increased technical assistance with transportation planning to local governments. An approach developed by the LACTC for providing technical assistance to local jurisdictions in this newly decentralized local planning environment is outlined. Although the LACTC approach has some similarities to technical assistance efforts developed by other regional planning agencies or metropolitan planning organizations (MPOs), the LACTC has developed a unique blend of elements that are believed to have particular relevance to increasingly decentralized and independent city environments.

LACTC AND THE LOS ANGELES ENVIRONMENT

LACTC

The LACTC was created by the California state legislature in 1976 as a centralized policy agency representing the exising political structure in the county. Before LACTC's existence, various local agencies held closely guarded pockets of authority and often competed against each other for state and federal financial support. The California state legislature sought to solve this problem by vesting the LACTC--a central agency with an appointed board of elected officials representing all areas in the county--with control of state and federal transportation funds for Los Angeles County.

Los Angeles Area

One of the key aspects of transportation planning for Los Angeles County is the diversity of the area. The Los Angeles area is composed of 83 cities interspersed with numerous pockets of county unincorporated areas. Populations in the 84 jurisdictions (the cities plus the County of Los Angeles) range from 3,071,120 in the city of Los Angeles down to a total population of 89 in the city of Vernon. More than 1 million people reside in the unincorporated areas. A wide variety of local geographic and demographic characteristics is represented in the county; communities are situated in hillside and coastal areas as well as in the low-density semi-desert northern and eastern areas of the county.

With the exception of the city of Los Angeles, which is governed by the council and mayor system, all Los Angeles County cities operate under the council and manager form of government. Eighteen of the cities are "contract" cities; that is, they contract out major city services such as police, fire, and public works to county agencies or private firms. Each city and unincorporated area in the county is--or is of the opinion that it is--unique. This perceived uniqueness is reflected in the transportation needs and problems of the local jurisdictions.

Sales Tax for Transit

Among other broad allocation authorities for public transportation, the LACTC's legislative mandate included authority to seek a local sales or gasoline tax increase to finance public transit projects. After more than 2 years of staff-level development, the LACTC placed a 1/2 percent sales tax, Proposition A, on the November 1980 general election ballot, where it obtained 54 percent voter approval. After legal challenges to the constitutionality of the tax were settled, collection of the sales tax began in July 1982.

The tax has three basic components. There is a change in the funding mix for two of the components after 3 years.

1. Twenty-five percent of revenues ("local return") is returned to local jurisdictions as a permanent part of the program.
2. Operating subsidy, to reduce bus fares and cover bus system deficits, remains in effect for 3 years.

3. The rail program receives all remaining funds during the first 3 years. After the initial 3-year period, rail is guaranteed a minimum of 35 percent, and 40 percent of the fund becomes discretionary.

The relationship among these components is shown in Figure 1.

Local Institutional Structure

During the past 30 years, public transit planning and decision making in the Los Angeles area have become centered in a few large agencies. The major actors include

1. Southern California Rapid Transit District (SCRTD), the operator of 86 percent of the transit service in Los Angeles County, was created in 1965 to absorb many small private transit operators. The agency has been left relatively free to make its own service deployment decisions within the framework of available funding. Because of the regional nature of most SCRTD bus lines, city involvement in transit planning has been limited to sporadic review of SCRTD plans by city management.
2. Southern California Association of Governments (SCAG) is the officially designated metropolitan planning organization (MPO) in the Southern California area. The agency was created in 1965 for the purpose of undertaking comprehensive regional planning in the six-county region. SCAG has had regional responsibilities for transportation planning since 1971. The agency also maintains expertise in long-range transportation planning. Local involvement in transit planning has been minimal, even though most cities are members of SCAG. This is due, in large part, to the longer-range, regional planning perspective of the agency.
3. The State Department of Transportation (Caltrans) became an actor in public transit in 1971 with the creation of a state sales tax subsidy for public transit. The agency's exposure to cities has been limited to those cities receiving state subsidies for bus operations.
4. Eight of the 83 cities in Los Angeles County maintain municipal fixed-route transit services. Before the passage of Proposition A, these eight local jurisdictions were the only cities directly involved in transportation planning. When necessary, the remaining 75 cities generally allocated transportation planning responsibilities to a member of the city planning or traffic engineering staff.

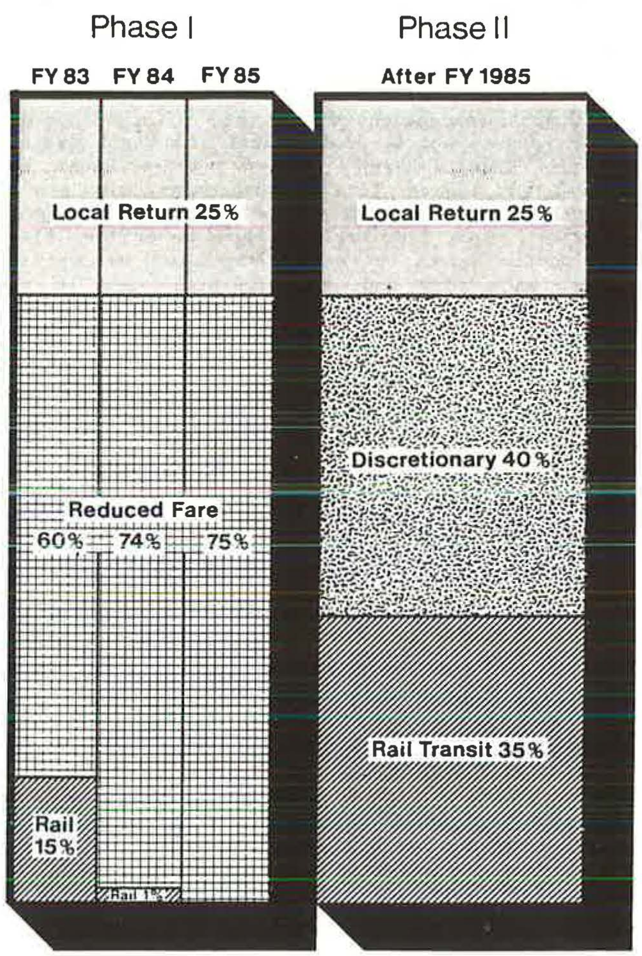

FIGURE 1 Proposition A transit development program.

Change in Planning Responsibilities

The passage of Proposition A shifted a considerable portion of planning responsibilities to the local level in Los Angeles County. Some of the precepts of "new federalism," prevail because money is returned directly to local governments. These local jurisdictions are then given broad discretion in local transportation decisions. However, as indicated earlier, transportation expertise in Los Angeles County has traditionally been centered in a few large agencies and in the eight cities with municipal transit systems. This indicated a need for transit assistance at the local level, although the form that technical assistance would take was, as yet, undetermined.

APPROACHES TO TECHNICAL ASSISTANCE

Existing Approaches

The LACTC recognized that the influx of new money combined with the lack of local transit expertise would result in a need for technical assistance. The question was what approach would be most effective. The technical assistance staff could

1. Provide tools (models, computer programs) that could be used by relatively expert groups of planners to analyze or evaluate a set of options. SCAG provides some of these functions in Los Angeles County.
2. Research available information on transit options and present it to clients in a concise, easily understandable format. This might also include some training in data collection and analysis.
3. Work alongside city staff on a temporary basis to provide a particular type of expertise or to absorb temporary work overflow. This might also include supplying project ideas to cities without the incentive or expertise to develop their own.
4. Act as an impartial third party, ironing out differences among city staff departments or between cities.

Each of these approaches has been implemented, to some degree, in other areas or agencies. SCAG, because of its role in regional long-term planning and research, frequently provides census information and transportation modeling expertise to local communities. The Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area (1) has implemented a rent-a-planner concept, providing planners at no charge to cities with a specific project to implement. Technical assistance at the federal level has, so far, focused on providing handbooks, training planners, and assisting in the development of demonstration projects.

Working with the UMTA Office of Service and Management Demonstrations, the LACTC developed an approach to technical assistance that incorporates a number of features that make it particularly responsive to the decentralized environment in Los Angeles. This approach included extensive use of the short-range planning guidelines developed for UMTA by the Urban Institute (2). These documents provide a ready source of transit options and innovations; they not only describe what projects other cities have undertaken but also identify a step-by-step planning process.

Development of the LACTC Technical Assistance Approach

In developing the approach for local technical assistance, the LACTC had to consider a number of factors including

1. A number of other agencies were gearing up to do technical assistance. SCAG has well-developed staff skills in transportation modeling and demand forecasting. These could be tapped as necessary. Similarly, SCRTD has extensive data on transit ridership by line segment. The agency offers sketch service assessments on a no-cost basis, and does detailed route analysis and needs studies on a fee-for-service basis. What would be the most efficient use of these regional resources that would allow other agencies to exercise their areas of expertise?
2. Private consultants viewed the LACTC technical assistance effort as potentially in conflict with their services. How could the perceived competition be avoided?
3. Only two planners were budgeted in the grant for technical assistance. How could they best be deployed to most efficiently meet the technical assistance needs of 83 cities and a large unincorporated area?

These issues are not unique to Los Angeles County but occur in most areas where there are many actors in decision making, an active consultant population, and limited resources for providing planning assistance. The LACTC technical assistance office case may, therefore, be instructive for other areas in terms of approach and experiences.

TYPES OF ASSISTANCE PROVIDED BY THE TRANSIT ADVISORY OFFICE

The tasks performed by the Transit Advisory Office were designed to be flexible and responsive to the demands of cities. As expected, during the first year, considerable time was devoted to orienting cities to transit and methods for transit needs assessment. Very little traditional "technical" transit work was performed for cities possibly because, as discussed earlier, the initial level of transit knowledge and experience among cities was so low. As detailed hereafter, primary tasks during the initial year of the program centered around orienting cities to transit in general, assisting city staffs with consultants, and providing information on alternatives analysis, capital procurement, and program evaluation.

City Orientation to Transit

The Transit Advisory Office initially embarked on a course of orientation, visiting all Los Angeles County jurisdictions to gain firsthand information from city managers and administrators, mayors, or the designated Proposition A staff person to ascertain the level of assistance needed. These meetings specifically included a discussion of the local return program, present and future uses of the monies, and the city's perception of the community's transit needs. Additionally, the planners explained why the office had been established and the services it could perform at no cost to the cities.

Newsletter

As part of the effort to keep cities informed about transit in the county, state, and nation, a newsletter, "Transit Tips" was begun that highlighted Proposition A projects, innovative transit concepts, and available resource material. In addition, condensations of case studies from the Urban Institute's planning handbook were featured (2). The newsletter evolved from the discovery that cities could benefit from receiving regular written material on program administration, project eligibility, and the experience of other cities.

Assistance with Requests for Proposal

With the influx of transportation monies to the cities due to the passage of Proposition A, cities for the first time have great control of the shaping of local transit services. However, because many cities historically were not oriented toward mass transportation, they were unsure about how to go about spending their Proposition A monies wisely.

The Transit Advisory Office was called on to develop requests for proposal (RFPs) for individual cities or groups of cities interested in ascertaining the unmet transit needs of residents. Office planners would tailor the RFP according to the needs of the city or cities involved. The RFP would note specific areas that had to be addressed by the consultant including intracommunity, intercommunity, and regional transportation needs as well as a complete financial analysis of each alternative recommendation.

Because most cities requesting this type of assistance had little or no knowledge of local needs, city councils used the study's final recommendations as justification for future action. Without the RFP as justification, the office found that councils were wary of implementing a program and thus spending money. Providing this assistance has afforded an excellent opportunity for the technical assistance staff to become involved at the local level.

Proposition A Information

Through the close initial contact the Transit Advisory Office staff had with each city, the planners became a source of administrative information on the Proposition A program including project eligibility, interpretation of guidelines, and project submittal procedures.

Incidental Assistance

Many tasks performed by the Transit Advisory Office could best be described as "incidental assistance." This includes providing such items as

- Inventories of paratransit operators for communities initiating paratransit service;
- Lists of vehicle manufacturers;
- List of bus shelter manufacturers (it is speculated that the popularity of this project arose from the local need to undertake a small, yet visible project);
- Service analysis of existing transit operations; and
- Operator evaluation checklist to be used by a city when reviewing the proposals of potential contract service providers.

EFFORTS TO ADDRESS THE LEVEL OF INFORMATION NEEDED

The Transit Advisory Office provides technical assistance with emphasis on assistance; the level of technicality is tailored to the city's specific need or to the specific project design. The need for this type of flexibility in the provision of technical assistance and information dissemination is documented in an analysis of the subject performed by the U.S. Department of Transportation (3).

The report identifies and defines three functional information user levels. The first of these user levels is the policy user group, including top-level administrators and elected officials. This policy-level information user group requires overview publications, introductory in nature, designed to aid in gaining basic familiarity with and understanding of the subject area. The second level is the planning and evaluations group whose work tasks are generally the responsibility of midlevel administrators. The planning and evaluations level needs publications that provide technical and related information to augment understanding and decision making. The third and final level of information user is the operations level, generally made up of program managers. The program manager level is most receptive to highly technical publications designed for authoritative reference by transportation technical specialists.

The Transit Advisory Office has been able to incorporate these identified user levels in the office's provision of technical assistance. In addition, the office has identified another dimension in user stratification: "city situation."

Reflecting on the Department of Transportation analysis (3), the Transit Advisory Office has identified four categories of potential assistance requirements that act as an additional dimension to the level of requirements for information dissemination identified in the Department of Transportation study. The city situations the Transit Advisory Office has encountered are given in Table 1.

RELATIONSHIP OF TRANSIT ADVISORY OFFICE TO OTHER TECHNICAL ASSISTANCE APPROACHES

In retrospect, the type of assistance provided by the Transit Advisory Office varies from other technical assistance efforts primarily in its situation adaptability.

Because this was a first-time effort, UMTA allowed great flexibility to the Transit Advisory Office. It was uncertain just what assistance the cities would request, how they would react to outsiders, and if there would be a demand for assistance.

The planners often act as information brokers, providing cities with a variety of literature on available transit options. It is believed that information on options is important because cities with little or no transit planning experience may tend to gravitate to well-known alternatives instead of pursuing less well-known or innovative options that may meet local needs. The substitute staff function accommodates the needs of the cities by working with them to provide expertise in a specific area.

The planners have acted as mediators and facilitators. This role has been actively pursued in an eight-city area in eastern Los Angeles County. Here the Transit Advisory Office has helped develop a request for a transit needs assessment study incorporating elements on an intracity, intercity, and

TABLE 1 City Situation and Identified Level of Need for Assistance

CITY SITUATION	POTENTIAL ASSISTANCE NEEDS	DOT-IDENTIFIED LEVEL INFORMATION NEEDS	EXTENT ENCOUNTERED BY THE TAO PLANNERS
1) Transit City - Municipal Transit Service - Full Transit Planning Staff	- County and Nationwide Project and Demonstration Updates - Information Broker - Coordination Efforts	Policy	Moderate
		Planning & Evaluations	Moderate
		Operations	Minimal
2) Small Operator City - Dial-A-Ride Small Circulator - Skeletal Transportation Planning Expertise	- Information Broker - Procurement Procedures - Costing/Evaluation Procedures - Resources Provider	Policy	Minimal
		Planning & Evaluations	Moderate
		Operations	Moderate
3) Transit Neophyte - New Transit Projects or Ideas for Projects - Little or No Transit Planning Expertise	- Advisement on Prop. A Project Eligibility - Project Design and Implementation - Procurement Procedures - Information Broker	Policy	Maximal
		Planning & Evaluations	Moderate
		Operations	Minimal
4) No Transit - No Documented or Preceived Transit Needs - No Ideas for Projects - No Transit Planning Expertise	- Alternatives Analysis Methodology - Advisement on Prop. A Project Eligibility - Project Design and Implementation - Advisement on Contracted Services	Policy	Variable
		Planning & Evaluations	Minimal
		Operations	Minimal

regional basis. Since first contacted by the group, the Transit Advisory Office has worked with the cities for more than 10 months in compiling the RFP, establishing an impartial consultant interview process, and advising on the proper Proposition A administrative procedures. In this effort the planners synthesized the interests of eight cities and a large county unincorporated area. Because some of the study participants assigned a low priority to carrying out the study, a principal future task of the office will be to attempt to keep the group together and avoid fragmentation while making sure the consultant considers the political and economic realities before recommending service alternatives.

RELATIONSHIPS WITH ELECTED OFFICIALS, CITY STAFF, AND THE CONSULTING COMMUNITY

City Staff and Elected Officials

The relationship of the Transit Advisory Office with elected officials and city staff has generally been good. Most of the working relationships have been with city staff, primarily city engineers, planners, and administrative aids. As a general rule, initial meetings have been held with the city manager, and the day-to-day contact with the office has then been delegated to city staff. There is little direct contact with elected officials. Often the planners will receive a call for assistance from city staff as a result of an elected official's request for information. When the office has had direct contact with local officials, such contact has usually been provided through a presentation to a city council (for example, when a new city council requested information for their recently elected members).

Consultants

Initially, the professional consulting community feared that the creation of the Transit Advisory Office would channel potential business away from them, although it was the consistently expressed intent of UMTA and LACTC not to compete with consultants.

When visiting cities, the planners make it clear that services of the office do not include services traditionally provided by consultants such as in-depth project analysis or design. The office will, however, on request from the city, work with the consultant in an effort to make sure the end product not only meets the needs of the community but also is implementable and likely to be approved by city councils.

WHY THE LACTC APPROACH SEEMS TO BE WORKING

Given that this is the first year of the program and the level of transit orientation among the cities before Proposition A was so low, it would be premature to make a definite statement about the overall success of the approach. However, 47 of the 84 local jurisdictions in Los Angeles County have made use of the services of the office. About 40 percent of these (19 cities) have asked for assistance that required significant time on the part of the planners in the office. A survey conducted in the summer of 1983 revealed that 85 percent of the 50 survey respondents were satisfied with the assistance provided by the office. There is speculation that the Transit Advisory Office seems to be working for a variety of reasons. Among them are

1. Addressing the perceived need for assistance: The LACTC perceived a need of local jurisdictions for an assistance office that could guide a city staff as they selected strategies for transit alternatives analysis and project implementation. The Transit Advisory Office has addressed this need by providing project ideas, assisting with program evaluation, and aiding the cities in securing consultant services if detailed service or alternatives analysis is deemed necessary or desirable.

   Using this knowledge and approach to structure the office, the planners have been able to offer a commodity that effectively addresses city requests and makes efficient use of the planners' time by delegating tasks for which the expertise is readily available elsewhere.

2. Flexibility of approach to assistance provision: The task structure of the Transit Advisory Office was left flexible during the formation of the office expressly to allow the planners to adapt to the kinds of assistance requested by the local jurisdictions. This concept of flexibility was found to be one of the most desirable elements of the office, in terms of making it attractive to cities, and has been retained.

3. Cooperative, not competitive, role with city staff: Another well-received approach has been the planners' ability to act as temporary additional city staff. The success of this role has depended on the ability to develop a team effort between the Transit Advisory Office and the city that blends the city's familiarity with local characteristics, demographics, and local political concerns with the Transit Advisory Office's expertise in transit planning, alternatives analysis, and local return program guidelines.

4. Availability of federal and local expertise: One of the most significant benefits for the Transit Advisory Office in providing technical assistance to the 83 cities in Los Angeles County has been the dual association the office has with UMTA and LACTC. UMTA and its contractor, the Urban Institute, can provide a broad range of information on transit options and demonstration projects. The assistance the Transit Advisory Office offers cities is attractive, in part, because of the office's familiarity with eligible Proposition A projects, which is pertinent because Proposition A is the source of most of the municipalities' transit funding. Concurrently, the Transit Advisory Office is a relatively separate and distinct entity, reducing the threat to the local jurisdictions that "inside information" may be used against them in the project approval process.

ISSUES AND PROBLEMS

A number of issues and problems have been encountered by the planners in meeting requests for assistance. As outlined hereafter, these have included (a) level of innovation, (b) diversion of retail sales, (c) unnecessarily elaborate projects, (d) lack of communication between city staff and elected officials, and (e) city attitude toward transit.

Innovation

The expectation that Proposition A would create a rash of innovative projects has led to impatience among some LACTC governing board members. However, in authorizing the local return aspect of Proposition A, the increasingly centralized nature of transportation planning and the concomitant atrophy of local transportation expertise were not considered. This meant that local city planners would be starting from nearly "ground zero" in terms of knowledge, and it would take considerable orientation and time to develop any projects, much less innovative ones.

Projects

Because the money is retained on a population share basis with few strings, development of highly visible, sometimes elaborate, and often unnecessary projects by local officials is a fairly regular occurrence. Where transit is concerned, there are factors, such as local ridership levels and trip patterns, that it is necessary to analyze in order to justify expensive or grandiose projects. In facing such an issue, the Transit Advisory Office has attempted to document any factors that might negate the project's potential use and suggest alternatives that perhaps would be better suited to the particular community. Examples of projects that have been diverted include

- A shopper shuttle to be provided with a London doubledeck bus in the sparsely commercial downtown of a small city,
- An electrified guideway system for minibuses in a low-density city, and
- The construction of a transit center on a suburban college campus served by one bus line operating on hourly headways.

Communication

Communication between local staff and elected officials is often lacking. It is common for a city council not to be notified of the availability of Transit Advisory Office assistance. Hence, a councilmember may meet with the transit planners and request the same information already relayed to city staff by the Transit Advisory Office. Conversely, a councilmember may meet with the transit planner and request the same specific information while staff conveys an entirely different need, presenting the Transit Advisory Office with a conflict to resolve.

No approach to these issues has been identified as completely right or wrong; however, the planners have been able to establish working relationships with the cities even on some of the most sensitive of issues through cooperation, suggestion, and mediation.

Technical Assistance as Justification for the Status Quo

When the Transit Advisory Office began assisting cities in developing requests for proposals, it found that it could categorize the cities requesting such assistance in two distinct groups: those with little knowledge of residents' transit needs and who intended to use the study as a basis for decision making, and those who hoped to reinforce preexisting opinions by means of the outcome of the study. Usually this latter group included (a) cities that thought that a finding of no pressing local transit needs would encourage the commission to liberalize the Proposition A guidelines and allow use of the funds for nontransit projects and (b) cities that thought that their present local transit service was adequate for the needs of local citizens and that a study might justify not participating in projects with adjoining cities. Reasons for the latter claim include the assumed loss of local control by cities involved in a joint system, past bad experience with a transit operator, and the belief that local people know what is best within their community. One of the goals of the Transit Advisory Office is to encourage cities to coordinate transit services, and obviously this feeling on the part of the cities presents serious and sometimes impassible roadblocks to joint ventures.

Attitude Toward Transit in Cities Not Using Transit Advisory Office Services

The Transit Advisory Office has encountered three general types of attitudes prevailing in nonactive Los Angeles County cities: (a) apathy or antipathy, (b) postponement, and (c) indefinite delay.

1. Apathy or antipathy to local return: These cities have no projects or project ideas primarily because they feel they have no unmet transit needs and are therefore uninterested in the local return program.
2. Postponement: These cities have postponed decisions primarily for the purpose of allowing an accumulation of funds for specific high-cost projects (e.g., a park-and-ride facility). These cities have generally deferred technical assistance.
3. Indefinite delay: This attitude can be generally attributed to the inability of the city to develop a transit needs assessment strategy or an alternatives analysis methodology. Transit is often a low priority politically in these cities, yet, in many cases, assistance in transit planning is desired by city staff.

As the Transit Advisory Office developed its approach to provision of technical assistance, these various city attitudes had to be discerned by the planners, and an assessment made to determine what minimal assistance could be offered to every city, regardless of disposition. The Transit Advisory Office has found that virtually every city is interested in the information broker service that the planners provide. Notably, the "apathy or antipathy" category cities have been most receptive to this type of assistance.

FUTURE ISSUES AND WORK

Entering its second year, the Transit Advisory Office faces a new and different set of tasks designed to enhance local awareness of key transportation issues as well as to provide feedback on specific issues of concern to the cities. Future issues to be addressed and to be undertaken by the office will include the following.

Transit Advisory Office and Fare Reduction

Because the Transit Advisory Office has been the primary LACTC contact with the cities, the planners will be an integral part of the city workshops that are designed to inform communities about the end of the fare reduction program in 1985. The office will not only attend the initial workshops but participate in follow-up exercises in an effort to make sure cities are prepared for potential fare increases and service cuts.

Facilitation of Increased Interaction Between Local Staff and Elected Officials

By increasing interaction between local staff and elected officials, the Transit Advisory Office will be able to minimize potential conflicts and maximize efforts to provide efficient use of Proposition A funds. It was determined that a workshop for local staff on how better to communicate transit-related issues to elected officials would be most useful.

Seminars

The transit planners will conduct a series of seminars on various transportation alternatives, planning, and problem areas identified through a survey mailed to all 84 jurisdictions in the county. By concentrating on these expressed needs of the cities, local staff will be better equipped to deal with elected officials.

Based on the survey results, the Transit Advisory Office will contact cities that requested assistance that might better be addressed in a one-on-one meeting instead of in a workshop setting.

SUMMARY

There are a number of approaches that may be taken in the provision of technical assistance to localities by the MPO or other regional agencies. As pressures for decentralized decision making ("new federalism") in transportation increase, the regional agency may have to reconsider its role in the provision of technical assistance.

In the approach developed by LACTC, mediation, facilitation, and project research have been in the highest demand. Traditional technical assistance, particularly that dealing with modeling and project development, has been deemphasized. The approach described here may be useful to other areas experiencing similar decentralization of decision making.

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Developing a Regional Strategy for Transportation System Development

BRAD WILLIAMS and JIM GOSNELL

ABSTRACT

The southern California region has historically been ineffective in obtaining capital money from federal agencies for transit system development. This has been the case in spite of the fact that the region contains more people than 46 other states and is still growing rapidly. Growth, in fact, is reaching a level that requires the region to become more effective in developing its entire transportation system in order to facilitate that growth. The history of transportation in the region is examined and the reasons why transportation development is slow are investigated. Overlapping agency responsibilities and the lack of regionwide consensus are cited as principal causes. The financial and talent resources of the region are substantial and could be used to develop a successful transportation program if properly managed. A strategy is proposed by which a successful program could be realized. The strategy involves a top-down approach that begins by asking, "What should the transportation system accomplish?" There follows a phased project development process that includes a series of decision points, each more specific than the last. The strategy also includes the assignment of specific decision-making responsibility to specific agencies at each decision point.

The southern California region comprises six counties surrounding the city of Los Angeles. The region's population of 11.5 million people would rank the region as the fifth largest state in America. As the premier Sun Belt area, southern California has experienced phenomenal growth over the last several decades--growth that even now shows no signs of abating.

Continuous growth has changed the complexion of the region in many ways. Orange County, once covered by orchards and farms, is now a dynamic economic growth area. One major outcome of the recent development is an overtaxed transportation infrastructure characterized by massive congestion even on weekends. San Bernardino and Riverside counties, once known for their rural environments, are also rapidly learning about the transportation problems associated with higher density development. Los Angeles County is learning that even a massive freeway system has its limits as demand continues to increase.

The region's planning community realizes that major improvements to the transportation infrastructure will be needed if the region is to continue to grow. For the first time, a regional transportation plan is being developed that quantifies anticipated deficiencies in the transportation system and seeks to take action focusing on the most crucial areas. New financial strategies are being pursued in earnest.

Los Angeles County has recently reached a major milestone through the ratification of Proposition A. For the first time, a guaranteed local source of funds has been earmarked for the development of public transportation facilities. The half-cent sales tax will generate approximately $1 billion in the first 10 years to develop a rail rapid transit system in the county. A countywide rail transit implementation program is being developed by the major transportation planning agencies, spearheaded by the Los Angeles County Transportation Commission. Orange County will soon find a similar tax referendum on its ballot.

In developing programs for transportation development, the agencies must consider a wide range of issues such as population and land use in major travel corridors, alternative technologies and alignments, and system financing. Addressing these and many other issues will help the planning agencies develop a program that can provide the greatest public benefits for the investment.

ISSUES

Although the planning agencies are facing some new questions in developing a rail transit system in Los Angeles County, the basic underlying issues that must be addressed have been around for a long time. Rail transit, after all, is but one element of a very large urban transportation system that currently services a populace of more than 7 million within Los Angeles County plus millions more in the rest of the region.

The existing transportation system is both praised for the number of people that it carries and maligned for not being able to carry more. The most recent growth projections indicate that the system will be required to carry many more people in the years ahead.

Evolution of the Transportation System

The transportation system serving the region is the product of a long evolutionary process. Planning studies were performed at least as far back as 1906. Since that time the key element, or backbone, of the transportation system has changed a number of times.

Electric Railway

In 1906, the backbone of the southern California transportation system was the electric railway (today it would be called a light rail system). The system expanded rapidly until its peak in 1925 when it extended more than 1,100 miles and reached nearly every developed area in the county.

Even at its peak, however, the transportation system based on the electric railway was proving to have some drawbacks. In 1924 and 1925 the city and county of Los Angeles prepared the Major Traffic Street Plan and the Comprehensive Rapid Transit Plan (1). Both of these plans addressed traffic congestion and the role of transportation in the development of the metropolis. The City Club of Los Angeles in 1926 cited "relief of congestion" as the most important issue in transportation planning and advocated a decentralized urban form consisting of "local centers and garden cities" that would minimize the demand for long trips.

The Rapid Transit Plan led to a bonding initiative in 1926 to begin grade separating the highest density portions of the system. This was soundly defeated whereas, on the same ballot, a proposal to build a unified intercity passenger rail station, Union Station, was passed. (The bonding initiative was jointly sponsored by the Pacific Electric; Southern Pacific; Union Pacific; and Atchison, Topeka and Santa Fe railroads and included a partial sharing of rail and stations. The Union Station ballot measure was one step in the city's plan to build a union station that started in 1915 and ended with the station opening in 1939. The railroads fought the project until 1931 when the U.S. Supreme Court ruled in favor of the station.)

Highways

A few years after the bonding issue was defeated, the electric railway began to decline until 1963 when it ceased to exist. The faster and more convenient automobile took over and a network of arterial highways became the new backbone of the transportation system. It soon became apparent, however, that the network of arterials would not be adequate and the concept of freeways was introduced.

A report by the Automobile Club of Southern California in 1937 stated, "the streets and highways of the Los Angeles area are daily becoming more difficult and hazardous to travel," and proposed exclusive motor vehicle facilities. This was reinforced in 1939 by the City of Los Angeles Transportation Engineering Board. Both reports referred to the growth of the region, the latter specifically mentioning the "decentralizing trends" of urban development (1).

Freeways

The region's first freeway, the Arroyo Seco Parkway, was completed in 1940, but large-scale growth in the freeway system did not begin until about 1950. In the 1960s the freeways clearly become the backbone of the transportation system. More than 500 miles of freeway had been constructed by 1970, and today more than 1,500 miles of freeway are operating in the region.

Transportation and Urban Form

The symbiotic relationship between the transportation system and urban form has long been recognized in Los Angeles. By the 1920s the multiple-centers form of development was already appearing in local plans. The impact that the transportation system would have on development was addressed in the 1925 Rapid Transit Plan: "a clear cut recognition of the fundamental relationship of transportation to the growth of a city is essential to the determination of a sound development policy."

Each time the transportation system went through a transition, congestion was the catalyst. This indicates that the county had outgrown its existing transportation system and was looking for a new solution. New solutions, when found, became the backbone of a larger, more efficient transportation system. In each case, the inconvenience and danger of congestion--created by population growth and increased personal mobility--gave way to a faster more convenient way of travel.

FACING THE PROBLEM AGAIN

In 1983 the fact that the growth of the region is exceeding the capacity of the transportation system must again be faced. Already serious congestion plagues many miles of freeway as well as localized centers such as downtown Los Angeles and the area around Los Angeles International Airport.

The recently adopted Regional Development Guide, the region's long-range projection of population, employment, and land use, promotes multiple centers and subregional job and housing balance--objectives of the metropolitan area for more than 50 years. The transportation system is to be designed to serve centers and promote subregional travel, and it is to be sized according to growth trends.

The existing transportation system has reached capacity in many areas and will be inadequate to meet the mobility needs of the future. By the year 2000, 454 miles of the region's 1,500 miles of freeway will be inadequate to meet the projected travel demand. Even the new Century Freeway, when built, will be seriously overcrowded.

New Freeways Unlikely

The opportunity to build new freeways is almost gone in many areas of the region. This is partly due to the completion of the federal Interstate system and the termination of FAI funding and partly due to the fact that increased densities have nearly eliminated the potential for acquiring new rights-of-way or widening existing freeways. It is unlikely that improving the freeways will in itself provide a transportation system that is adequate for the future.

Communities Concerned About Growth

The impacts of growth are being felt more and more by local communities. Several have adopted no-growth policies to try to limit the future demands on their local infrastructures. Local highway congestion has reached the critical state in many areas and is continually worsening. Some cities are actively pursuing ways to reduce congestion or to ensure that large-scale growth of arterial traffic does not occur.

The actions being used include evaluating transportation system management (TSM) strategies and requiring developers to provide their own roads when building major projects. Concerns about the impact of major transportation and other projects on local streets and arterials are being expressed more and more.

In some areas, greatly increasing the capacity of arterials is being studied as a short-term solution to the congestion problem. However, the impact of this solution is relatively small in some high-density areas. Other communities do not wish their arterials to be heavily used for regional travel, and therefore do not support this strategy. Improving arterials, then, will not provide all of the needed capacity in the long term.

A New Backbone Is Needed

If freeways and arterials will not be able to meet all of the region's mobility needs in the future, a new solution must be found. A new backbone for the transportation system--the key element of future improvements--must be found if the transportation system is to keep up with urban development. Important objectives of this new solution include

- Increasing total system capacity;
- Inducing people to stop traveling in single-occupancy automobiles (reducing congestion);
- Reducing travel times, especially during the morning and evening peaks; and
- Reinforcing the Development Guide and local development plans.

Several strategies to develop the needed transportation capacity have been examined. They include rapid transit, bus and high-occupancy vehicle guideways, light rail, mixed-flow bus, and commuter rail. Projects growing out of these solutions are in the development stage. One of these line-haul strategies, or perhaps all of them in combination, may be the source for providing a new backbone for the transportation system.

DEVELOPING THE TRANSPORTATION SYSTEM

One thing that Proposition A accomplished in Los Angeles County was to indicate a desire on the part of the general public for rail rapid transit. Planning agencies in the county now have a direction to pursue but do not yet have all of the answers.

It is up to the planning agencies to develop the total transportation system for the county. The issues to be addressed in developing that system have been addressed before, but they now must be looked at from a new perspective. Rail rapid transit must be an integral part of that system. In fact, it may be the backbone of the system in the future, as it is now in several areas of the United States.

THE NEED FOR A STRATEGY

During the past several years, the existing program for implementing transportation projects has yielded only disappointment and frustration. There is concern that this trend may continue and that the agencies involved may not be able to develop projects, which meet the mobility needs of the county as well as of the region as a whole, in a timely manner.

In this section, the institutional problems in the existing process are identified as are the tremendous opportunities that lie ahead. The existing situation including potential revenues, the tremendous need for projects, and the current institutional environment is described in some detail.

EXISTING CONDITIONS

Currently, Los Angeles has the largest all-bus system in the country, yet the percentage of trips that use transit rather than automobiles is very low relative to other major U.S. cities. One reason for this is that there is only one high-capacity transit facility in the entire region. This is the case in spite of the fact that many other major cities are operating or are in the construction phase on high-speed, high-capacity rail systems. Why is it that southern California has been unable to tap its resources to build such a system until now?

Available Revenues

A frequently offered explanation of why there is not more rapid transit in southern California is the lack of capital resources. Financial feasibility, in fact, is a major item in every work program concerned with project development. Perhaps this is a pessimistic outlook because the actual projections of transit capital revenues do not look dismal at all.

The Southern California Association of Governments (SCAG) analysis indicates that (assuming no change to existing state and federal programs and policies) total capital resources for the region from federal, state, and local sources (including Proposition A) for the next decade will total $5.1 billion. If federal funding for the Wilshire Starter Line is approved, this amount will increase to $7.3 billion. Total estimated capital revenues for the next 20 years are expected to reach $11 billion (2).

Another potential source of capital revenue is the increase in residual land value due to transit development. High-quality transit projects in the central business district (CBD) and regional core areas alone could result in an increase in residual land values of from $600 million to $1.26 billion per decade. A logical percentage of this increased value that might be captured by such value-capture techniques as joint development and benefit assessment is about 50 percent. It may, therefore, be possible to capture an additional $1.26 billion over two decades from increases in land values.

These and other potential capital revenues may yield up to $15.5 billion over the next 20 years if aggressive and innovative financing strategies are used. As an order of magnitude estimate, this is roughly five times the escalated cost of the Wilshire Metro Line.

The effectiveness of these revenues can be enhanced as well through some cost savings both in capital and operating expenditures. These savings include joint vehicle purchases such as the purchase of light rail cars by Miami and Baltimore, safe harbor leasing, and fare reform that reduces subsidy requirements.

Realizing this potential will require more than aggressive and innovative strategies. Favorable legislation at the state and federal level and local governmental actions will be needed. This means that a strong support base for transit projects will have to be developed. A well-established mechanism for obtaining value-capture revenues will also be required.

Needs

The recently approved development forecast, SCAG-82, recognizes there will be about 1 million more people and 800,000 more jobs in Los Angeles County alone by 2000. This is going to place increasing pressure on the region's transportation network. SCAG's analysis shows that increasing congestion and inconvenience will occur unless significant improvements are made or mobility habits (e.g., travel patterns, trip making, land use, or other behavior) change.

The adopted air quality management plan (AQMP) shows that the air basin will not achieve air quality standards by the year 2000 without rather sweeping long-range measures. Among them are substantial shifts in population to outlying deserts, substantial substitution of telecommunications for automobile travel, the introduction of high-speed trains, and changing the basin to a nonpetroleum-based economy. It also supports the urban form development patterns promoted in the Development Guide Policies. Finally, sufficient transportation infrastructure is needed so that the freeway network can maintain peak hour speeds of about 30 mph.

Project Development

Although the region has long believed that money was an extremely limiting factor in making transit investment decisions, it is becoming clear that this is not the case and, in fact, there could be more money than will be needed. The region has also believed that its population would always continue to enjoy the ability to move about and have the quality of life that most southern Californians have come to take for granted. This too may no longer be the case.

Long-Range Plan

Although a documented regional transportation plan (RTP) does exist for southern California, it is being revised to reflect changing conditions and forecasts of the future. The projects that made up the 1980 Regional Transit Development Program, for example, are in various states of completion, or confusion, indicating a distinct move away from the plan in just 2 years. Even though specific projects are clearly recommended in the RTP, local support has not always been maintained to enable the projects to be implemented.

The indication, then, is that the RTP is not being used by the state and the region as the sole long-range plan even though legislation and a multiagency memorandum of understanding clearly state its intended function. As a result, broad-based support for the plan and for specific projects is lacking, which makes nonlocal support very difficult to arrange.

Tie to Development Patterns

An essential linkage that the long-range plan must provide is to the development patterns that the region envisions. The recent adoption of SCAG-82 shows the magnitude of the increase in population in southern California and illustrates the form in which development is occurring. The form is one of subregions developing with a variety of centers throughout the region.

More important, SCAG-82 contains key policy statements about project planning and project decisions. The essence of these policies is to ensure that all infrastructure is phased, sized, and located according to the pattern and magnitude of growth shown in SCAG-82. This pattern would tend to emphasize the kinds of infrastructure improvements that serve short trips within subregions. SCAG-82 policies also give priority to transportation development, which serves centers, and recommend that land use decisions should encourage growth around transit stations and in identified growth centers.

County Agencies

There are numerous agencies in the region involved in transportation development. These include the county transportation commissions, transit districts, some of the larger cities, SCAG, and Caltrans. Each agency has different and similar responsibilities. Each has distinct technical expertise and talented staffs. All have varying relationships with one another and with other state and federal funding sources. The resources of these agencies give the region an excellent professional staff with which to develop a successful transportation program.

Overlapping Responsibilities

This complex institutional environment and the idea that "if you want something done you have to do it yourself" have led to overlapping activities among all these agencies. There seems to be suspicion of, or lack of respect for, other agencies' abilities or responsibilities. This unclear assignment of responsibility has led to competition among agencies, which results in apparent competition between projects. It divides political and technical support for projects both geographically and institutionally. Perhaps more important, the apparent competition leads to confusion and apparent lack of direction in the "signals" and communication to local, state, and federal agencies and the private sector.

Project Development

This lack of clarity has also led to inefficient project development. Public agencies seem to be falling over one another leading to redundant, parallel, or illogical work activities. For example, the Los Angeles-Long Beach Light Rail Project first had a feasibility study done by Caltrans; then one was done by the Los Angeles County Transportation Committee (LACTC).

The Santa Monica Boulevard Light Rail Feasibility Study was done by Caltrans, but for what purpose? Los Angeles City has begun an alternatives analysis for the same area. In the recent past parallel studies have been performed or proposed such as the Southern California Rapid Transit District (SCRTD) Starter Line Extension Analysis, SCAG's Line-Haul Study, and the LACTC Tier II Strategy. All of the studies have similar objectives but were or will be done by different agencies. Another example of inefficient project development is the selection of projects. Projects have been selected before corridor refinement studies have been completed (e.g., Harbor and Santa Ana Freeway HOV lanes).

Even the private sector has initiated transit studies out of either true community spirit or desperation. The El Segundo Employers Association South Bay Trolley Feasibility Study and the Central City Association Study of Los Angeles CBD Alternatives are two of the most prominent examples.

Lack of Overseer

Project development is a complex, detailed process that needs management. The region cannot afford to just let it happen. Project development needs orchestration, scheduling, resource allocating, assignment of responsibility, and accountability. What appears to be missing from the existing transit program is a manager or overseer of this process: an agency to marshall the resources necessary to do the job, apply those resources, and ensure that the project development process is producing the sorely needed projects in an efficient and effective manner. This process should produce flexibility for project scheduling in order to take advantage of available resources, to meet needs, and to respond to changing conditions.

PROJECT DELIVERY SYSTEM

An implied element in the guideway transit program is a process through which projects are eventually implemented, a project delivery system. To improve the current project delivery system the important characteristics need to be defined, the talents and responsibilities available need to be capitalized on, and identified gaps need to be filled with existing or new institutions.

There are several characteristics that are essential to an effective project delivery system. First, there needs to be an effective long-range plan that links transportation system evolution with other components of the environment (e.g., land use, air quality, economic base) and provides the direction to be taken. Second, there must be a manager of the delivery system who identifies milestones and marshalls the resources to accomplish the job. Next, there needs to be a clear assignment of work to each agency that has a responsibility and expertise to contribute. All responsible agencies with a role must be directly involved in this process. This is essential if the last characteristic, consensus of support of the project being developed, is to be obtained.

Long-Range Plan

Figure 1 shows how the long-range transportation plan should function in the planning process. SCAG is currently revising the regional transportation plan, which is the long-range planning document for southern California. This should provide the context and set the direction for project development work for each county of the region. It will provide the linkage to SCAG-82 and the AQMP both in a quantitative and in a policy manner. The modeling and analysis used in the plan's development will tie transport networks to land use and development patterns and should lead to the development of high-productivity transportation projects. It will quantify needs in subregions and corridors and recommend modes for refinement studies that are consistent with SCAG-82 and the AQMP. It will include mode-split objectives by subarea and corridor, some of which will require high-capacity transit projects.

Milestone Management

Milestone management is the next essential characteristic of a successful project delivery system. An overseer of the project delivery system, who is the final decision maker on guideway transit, is the first requirement. The overseer programs resources, identifies priorities, sets milestones, coordinates the process, and ensures that each activity is being carried out efficiently and effectively. The overseer also coordinates with the private sector through value-capture strategies and ensures that costs are minimized by coordinating cost-reducing strategies such as joint purchase agreements. In effect, the overseer controls the financial game plan for guideway transit development.

The overseer should ensure that an orderly set of decision points is charted--one flowing from the other and each leading to specific project choices. The manager also has to tap all available resources, not only construction and operating resources but institutional resources as well. The overseer has to manage the entire system.

Clear Assignments

Roles and responsibilities of each agency have to be understood, clearly anticipated, and accepted by every agency. The job is too large and the task too crucial to not bring to bear all the expertise that is available. The planner, the manager, the designer, the builder, and the operator roles and responsibilities must be delineated and given to various agencies if the project is going to be successful. It is essential that all agencies clearly understand their responsibilities throughout the process.

Consensus in Support of Projects

Perhaps the most essential ingredient for a successful project delivery system is a broad support base. The region must speak with a single voice to Sacramento and to the federal government in order to make that voice heard.

As a case in point, an elected official from one county spoke out against the Downtown People Mover Project and shortly afterwards UMTA dropped its support. What would have happened if several elected officials together with the major agencies in the county had collectively spoken out in support of the project? As it was, no single agency or individual had enough confidence in the support of others to

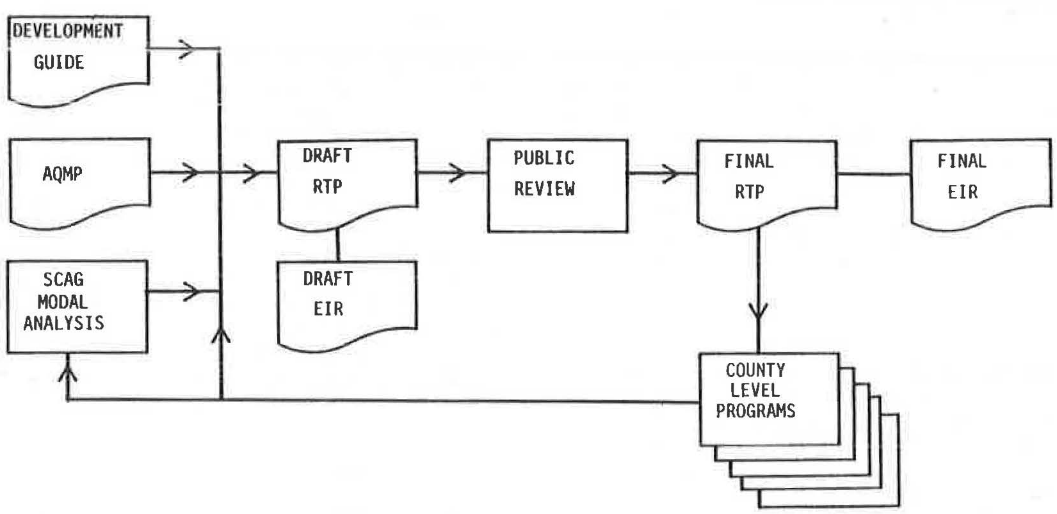

FIGURE 1 Regional transportation plan process.

make the first move and consequently no one spoke out to defend the project.

This lack of commitment is interpreted by state and federal officials as a lack of consensus in Los Angeles. Until federal agencies are convinced that a consensus does exist and that there is a commitment, federal capital funding will continue to flow elsewhere.

The size and complexity of the southern California region are major impediments to developing consensus. The approach to transportation infrastructure development, which has been approved in the Development Guide, breaks the region into subregions of about 1 to 1.5 million people each. It calls for a long-range plan to provide mobility within those subregions and to connect the major centers. Projects and strategies to meet the needs of each subregion and corridor must be pursued. Successful implementation of this type of approach requires strong commitment of all agencies to the plan even if it calls for a project outside of the influence of a particular agency or jurisdiction.

Commitment does not come into being spontaneously. The process by which project-level decisions are made must be designed to generate consensus as a natural by-product. This will require the active participation of all interested entities. Such participation cannot be superficial; it must include specific analytic and decision-making responsibilities. Only if it is involved in the decision-making process can an agency be expected to commit itself to the decisions being made.

Technical justification is also required for building consensus. Here again, an agency cannot be expected to support a decision unless convincing technical arguments can be made that the decision is appropriate.

One final necessary ingredient in building consensus on projects is the support of elected officials. This requires active discussion of projects by the elected officials in a regional forum. Adoption of projects by the policy body of the metropolitan planning organization, SCAG, is a step in this direction.

STRATEGY

The process of planning, developing, and implementing the regional transportation system is a complex arrangement of policy and technical decisions. Not only are the issues closely interdependent, they must transcend the local level and withstand the scrutiny of regional, state, and federal decision makers.

The key policy issues must be resolved in a series of consecutive decisions beginning with the most general, basic questions and leading to very specific decisions. The issues can be categorized in three basic groups indicating generally when they should be addressed. No order of priority or importance is to be implied in the categorization, simply chronological order. The three categories can be characterized by the following questions:

- Question 1: What should the transportation system accomplish?
- Question 2: What should be built, and where?
- Question 3: How can the system be financed?

Each of these questions entails a number of policy issues. Addressing the issues one category at a time provides an efficient process through which very specific decisions will ultimately be made. Resolution of the first two questions must be documented so that subsequent decisions will be based on precise language. Reaching resolution on the first question will make the second question issues much easier to address. In fact, the resolution of the first question will set the parameters for the second question, and resolution of the second question will set the parameters for the third. Without a resolution to questions 1 and 2 it will be very difficult, if not impossible, to reach any resolu- tion on question 3.

Question 1: What Should the Transportation System Accomplish?

This question is generic and refers to the transportation sytem as a whole rather than, for example, just the rail rapid transit element. The question speaks to the fundamental long-range goals of providing transportation infrastructure for the region and thereby sets the framework on which all subsequent decisions are based. It must be asked first so that the subsequent questions can be put into perspective.

Without a documented decision on this question, specific questions become much more difficult to resolve. As a case in point, suppose two rail projects have been proposed in the same corridor. One project will cost $100 million and carry 10,000 people per day, and the other will cost $1 billion and carry 100,000 people per day. Which project should be built?

A transportation analyst, attempting to determine the public benefit per dollar expended, calculates the cost per rider of both projects. It is found that the two projects have identical cost-effectiveness measures. One project will maximize patronage but is very expensive. The other project is much less expensive but carries a small number of riders. How does one decide which project is the wisest investment of public funds?

With a clear statement of long-range goals and objectives, the transportation analyst in this example would have little trouble choosing which project should be built. Without such a clear statement, the analyst has no uniform basis on which this, and many similar decisions, could be made. This would lead to a development program that was haphazard and inconsistent.

Question 2: What Should Be Built, and Where?

After the issues relating to the first question are resolved, the second question must be addressed. Again, this question speaks to the entire transportation system, although separate programs for developing various elements would be appropriate.

The focus of this question is to structure a program or group of programs that provide for a well-organized decision flow leading project implementation. The challenge is to conceive the best approach for achieving the long-range goals and objectives.

There are a number of transportation programs, such as aviation and ports, that must be dealt with at the regional level. These programs involve a small number of facilities with large regional significance. In ground transportation, however, so much is being developed and so much more is still needed, that several county-level programs are necessary to perform all of the planning and development work. Within each county, long-range planning is performed on a corridor-by-corridor basis. Short-range planning is performed on a subregional basis or on small subareas within subregions.

The organizational structure should enable the key agencies to provide input in the areas of their unique responsibilities and expertise. For example, SCAG has a responsibility to provide the linkage between urban development and transportation system planning. SCAG is also responsible for long-range transportation planning including defining and assessing needs and ranking transportation corridors in the entire region in priority order.

Similarly, Caltrans and SCRTD have both demonstrated expertise and responsibility in designing guideway transit projects. Caltrans has already built one project and has initiated construction on a second. SCRTD similarly is well into preliminary engineering on a high-capacity rail project. These two agencies should be relied on for project development and construction.

Before a project reaches implementation, it must pass through a number of key decision points. If each decision made along the way receives broad-based support from the region, the viability of the project is enhanced. Lack of regional support of any key decision point can jeopardize the entire project.

The following key decision points define the transportation planning process. This process is specifically designed to cover the development of major capital highway and transit projects. It is, however, an appropriate process to follow in planning for other types of projects as well.

- Adopt a regional transportation plan (system planning),
- Initiate corridor and area planning,
- Initiate project planning, and
- Add projects to the regional transportation plan.

These key decisions can be made by a number of different agencies in the region. The necessary ingredients for the decisions to be supported by the region are (a) agreement about which agency is responsible for any specific decision, (b) sufficient technical analysis and compliance with state and federal regulations, and (c) opportunity for all affected agencies and jurisdictions to participate in and influence the analytic work and concurrent policy discussions leading to the decision.

Following the transportation planning process are project development and operations. These activities include

- Preliminary engineering,
- Final design and construction, and
- Operations.

Question 3: How Can the System Be Financed?

Although question 3 is asked after question 2, it cannot wait until after the entire process described is completed. It must be asked at each funding decision point throughout the process. For some potential projects, such as the Harbor Freeway Transitway, this question must be resolved very early.

Funds available for transportation investment are limited for the region and come from a variety of sources. Depending on the fundamental long-range transportation goal of the region, current estimates of available funds may or may not be adequate to construct all that is needed. If they are not, perhaps a reevaluation of the Development Guide and its growth projections is needed. Another strategy is to aggressively seek additional funds from existing or new sources so that the fundamental goal can be accomplished. A third approach would be to reconsider the criteria for evaluation, which aid in determining the fundamental goal, and to change their priorities. Two of these strategies represent policy changes that would then be reflected in subsequent revisions of the Development Guide or the RTP.

Another strategy to improve the financing picture is to reduce total demand on the transportation system. This can be done through demand management techniques. Higher parking costs and increased fuel taxes are two examples of techniques to shift people out of single-occupancy automobiles to ridesharing or transit. These techniques can generate additional revenues for transportation. Another possibility is to rely more heavily on telecommunications to allow people to work at home, reducing peak-hour demand.

These strategies have the potential to improve travel in the region, yet they carry with them some significant social impacts. The region needs to examine these social impacts and determine the extent to which the techniques are justified.

CONCLUSIONS

Answers to the three questions described previously will help to streamline transportation planning in the region.

The answer to the question, "What should the transportation system accomplish?" is a set of goals and specific objectives. If possible, the goals should identify the first-priority consideration in transportation planning.

The answer to the question, "What should be built, and where?" is not a map but a well-defined transportation planning process or project delivery system. This process must include specific policies and criteria for making decisions.

The answer to the question, "How can the system be financed?" can be found in policy actions taken by elected officials representing the metropolitan planning organization. These policy actions include decisions on tax increases, demand management, and other strategies that affect both revenues and overall travel.

SCAG is currently revising its regional transportation plan to incorporate the recommendations presented in this paper. When the plan is adopted, more specific information on goals, objectives, and policies will be available. The authors hope to discuss these issues further in other papers after adoption of the regional transportation plan.

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Effects of Competition from the Private Sector on the Efficiency of Mass Transit: A Case Study

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ABSTRACT

This study explores the implications of private transit firms competing in markets traditionally served only by a government monopoly. Focusing on the emergence of privately operated subscription buses in an important Chicago rail corridor, the study explores how a shift in riders and resources from the public to the private sector is likely to affect the operating efficiency of transit. Quantitative tools are used to assess the ramifications of competition between public and private transit operators; the findings are used to recommend socially desirable legislation and regulatory change. The divestiture process of the public carrier is modeled using Interstate Commerce Commission cost data and an industry cost-allocation technique. Labor laws, capital replacement policies, and other constraints on divestiture are taken into consideration in estimating the potential long-run savings from public carrier service cutbacks resulting from ridership shifts to the private sector. These estimates are used to demonstrate how a shift in market share from the public to the private sector is likely to affect long-run operating efficiency--measured in terms of average cost per passenger-mile--of transit services in the corridor. The findings have important implications for assessing the future role of the private sector in the urban transit industry.

Until recently mass transit was considered exclusively a responsibility of the public sector. A painful half century of private sector abandonments and bankruptcies had made the idea of competition between government and private operators seem relevant only to the historian. However, with the emergence of privately operated commuter buses in Chicago, Los Angeles, New York, and Washington and the start-up of jitney services in dozens of other cities, there is a growing belief that the private sector may play a significant role in the future of mass transit.

One of the most striking examples of the return of the private sector can be seen in Chicago. A group of subscription bus operators has initiated no-frills transit services between the central city and the suburbs, carrying nearly 5,000 passengers each day. Offering monthly subscriptions at less than half the price of public rail service, the privately operated services have quickly established themselves as an important transportation alternative to dozens of suburban communities.

To the policy analyst the significance of the Chicago subscription buses lies in their ability to help understand the long-range implications of allowing private firms to compete with public transit operators in providing transit service.

In contrast with privately operated services in other cities, appealing primarily to markets served poorly or not at all by public carriers, Chicago's subscription buses have entered into direct competition with a heavily subsidized rail carrier. The controversial new service mode, concentrated almost exclusively in the dense Illinois Central Gulf (ICG) Railroad corridor, operates parallel to rail services subsidized by the regional transportation authority (RTA) and is patronized almost entirely by former commuter railroad passengers.

This study explores some of the implications of private transportation firms competing in markets traditionally served only by a government monopoly. Conclusions are drawn about how increased private sector participation may affect the efficiency of transit systems by focusing on the competitive situation in Chicago's ICG rail corridor. This study is among the first to use quantitative tools to assess the ramifications of this competition for both suppliers and users of transit service, and the findings are used to identify socially desirable legislation and regulatory change (1).

The need for research is exemplified by the controversy created by the subscription bus industry in Chicago. The public sector, which has traditionally exhibited a clear preference for government monopolies to free market competition in urban transit systems, has made frequent accusations against its private sector competitors. It has accused private operators of "skimming the cream" by offering service only at the height of the peak period and being unfair by using nonunion labor or not providing certain amenities and station facilities. Some Chicago public agencies have claimed that the growth of private transit services is only a temporary phenomenon fueled by consumer outrage over 100 percent commuter rail fare increases in 1981. It has been argued that these private services benefit only a few yet make it increasingly difficult for the public sector to provide cost-effective transit service.

The need for research is made clear by past studies that effectively support the market potential of the private sector and enthusiastically call for the deregulation of the transit industry, but do not consider the long-range economic implications of allowing private firms to enter into competition with public operators (2,3).

In situations where the public sector can quickly divest itself of service that becomes unneeded due to advances by the private sector, the prescriptions of these studies are well founded. In such cases, there is not much doubt that increased private sector participation in transit is a socially beneficial trend. But when the public sector has invested heavily in a fixed-guideway transit system, and when divestiture is slowed by policy or law, the desirability of allowing private sector firms to operate service on parallel routes is more difficult to assess.

In such a case, there are a number of important economic considerations that make it necessary to reserve judgment until the issues can be analyzed in more detail. The first of these considerations is that public transportation systems--particularly fixed-guideway systems--are thought to enjoy powerful economies of density that can best be exploited through monopolistic protection. This suggests, for example, that a 5 percent ridership loss to private operators will increase the per passenger cost of handling the remaining 95 percent even if appropriate service cuts are implemented.

Another consideration is the diseconomies of peaking: highly concentrated demand during peak periods results in higher costs of providing service. This phenomenon is characteristic of transit ridership in Chicago's ICG corridor--more than 80 percent of the trips occur during peak periods from 6:40 to 0:00 a.m. and from 4:30 to 5:40 p.m. Because the private sector can serve to reduce peaking, its presence conceivably can, at least in the long run, reduce the average cost of providing public transit service.

Finally, the issue must be analyzed quantitatively because it cannot be assumed, even in the long run, that public carriers will be able to eliminate the excess capacity that results from ridership losses to the private sector. Railroad service can only be efficiently adjusted in train-size increments (simply shortening trains saves little); management is often unable to respond effectively to small, less-than-train-size losses in ridership. This argument against Chicago's private sector operators has often been cited by commuter rail officials.

Studies of private sector involvement in transit that do not consider these fundamental issues overlook the complexity of the divestiture process for public carriers and blindly welcome the flow of resources to the private sector. Because transit is almost universally regarded as a public utility relied on by an important percentage of the population, a special effort is necessary to avoid such assumptions and to reserve judgment until the effects of competition on efficiency can be thoroughly evaluated.

An appropriate measure for assessing changes in transit efficiency is average cost per passenger-mile, or the mean value of the resources necessary to move one passenger one mile. From an economic perspective, the problem can be defined as follows: Only if the average cost per passenger-mile of a transit system is lower under competition than under a public sector monopoly can it be concluded that competition has a desirable effect on efficiency. In determining this, it is useful to begin by assessing the impacts that competition is likely to have on the publicly operated transit carrier.

In the sections that follow, these issues are examined in the context of the ICG corridor running south from the Chicago Loop. Analyses were conducted under the assumption that the only change occurring, and being evaluated, was the introduction of subscription bus service. Secular trends in ridership, and changes in services of other modes, have been ignored. Thus, the interpretations may not be directly applicable to current policy and operating conditions in this corridor. They should, however, contribute to a ceteris paribus evaluation of private sector services in such a situation.

EFFECTS OF COMPETITION ON THE EFFICIENCY OF THE PUBLIC CARRIER

As more passengers are attracted from public to private transit services, fewer resources will be needed to support the public services. Trains can be eliminated, equipment retired or sold, labor furloughed, and administrative expenses trimmed. Ultimately, the question to be answered is whether this shift in resources from public to private control is in the best interest of the public--if it will lead to a more efficient transit system. This will depend heavily on the ability and willingness of the public carrier to divest itself of unneeded service. In this section a conceptual but realistic divestiture process for regional transportation authority (RTA) services in Chicago's ICG corridor is examined to determine how ridership losses to the private sector could affect RTA operating efficiency.

If, through the divestiture of labor and capital, costs on the public mode cannot be reduced in direct proportion to the shifts to the private sector, then the efficiency of the public carrier will deteriorate. If, on the other hand, costs can be reduced in greater proportion to lost ridership, then efficiency stands to be increased and private competition can be concluded to have a desirable effect on public carrier efficiency.

Because private sector commuter services in Chicago (and most other large cities) are limited to the peak period, their impacts on RTA ridership and costs will be similarly limited. This necessitates estimating RTA commuter rail peak-period costs. For this purpose, the Simpson and Curtin peak-base cost allocation model (private communication from Walter Cherwony, 1982) was used. This model requires data readily available in the 1982 ICG R-1 Annual Report to the Interstate Commerce Commission.

The Simpson and Curtin model allocates costs between peak and base periods based on four parameters: track-miles; peak-period car requirements (or peak car needs); car-miles; and total system revenues. Each of the 73 expenses listed in the R-1 Report is expressed as some linear function of these four parameters. Expenses that are almost entirely fixed, such as "maintenance of highway crossings," are allocated to track-miles--a parameter independent of level of service. Variable expenses, such as "electric power for train operation," are allocated to car-miles, a parameter measuring the level of service in the corridor. Other expenses, such as "equipment maintenance and cleaning," are allocated to peak car needs. A large number of the expenses are allocated to some linear combination of the four parameters.

This model assumes that the size of each expense item will vary in direct proportion to the parameter or parameters to which it is allocated. For example, "maintenance of highway crossings" costs will be incurred in direct proportion to the number of track-miles on the system. Similarly, the cost of "electric power for train operation" will vary directly with the number of car-miles operated on the system.

Using the Simpson and Curtin model, for example, the elimination of one ICG peak period train would enable car-miles to be reduced 6 percent and peak car needs 8.8 percent. In the long run, after disinvestment is complete and all appropriate changes in capital, labor, and administration take place, each expense item allocated to these parameters can be expected to be reduced by an equal percentage.

The public carrier cannot reasonably expect to realize the full amount of the savings projected in this way because there are practical constraints that stand in the way of change. Public transit disinvestment is a complex process: regulatory, institutional, and technical barriers will prevent or delay full recovery of the predictable savings. Labor laws, federal regulation, indivisibilities in assets, and the nonmarketability of capital are common examples of economic factors that stand in the way of efficient divestiture.

To avoid biased estimates of the magnitude of cost reductions from disinvestment, such constraining factors must be recognized and included in the analysis. This was accomplished by investigating relevant labor law and capital replacement policies, and by discussing the issues involved with public transit officials. Savings in labor-related expenses, for example, are constrained for 6 years because of severance pay arrangements established under the Railway Labor Act. Because of asset depreciation guidelines under the Internal Revenue Service tax code, savings in capital expenses are typically constrained for nearly a decade. Savings in administrative expenses are impossible in many areas because of institutional constraints.

With the Simpson and Curtin model and an understanding of the various constraints on divestiture for each major expense category, it was possible to estimate the potential savings from service reductions. To account for the lengthy lags in realizing many of the reductions in cost (e.g., labor), it was useful to annualize these potential reductions in cost. A 20-year planning horizon and an 8 percent discount rate were assumed to accomplish this (4).

By aggregating the individual expense categories, the following estimates were developed (1):

- Reductions in car-miles will enable long-run expenses to be reduced by $1.27 per car-mile,
- Reductions in peak car needs will enable long-run expenses to be reduced by $89,900 per peak car, and
- Reductions in system revenue brought on from private competition will enable long-run expenses to be reduced by 13.874 cents per dollar lost.

These estimates, along with estimates of the reductions in car-miles, peak car needs, and system revenue brought about by ridership shifts to the private sector can be used to estimate the potential reductions in cost on the public mode.

To reflect uncertainties in the ability and willingness of the public carrier to eliminate unneeded service, three scenarios were considered. The first, "complete excess capacity elimination," assumes the public carrier is willing and able to reduce service in direct proportion to ridership losses to the private sector. The second scenario, "partial excess capacity elimination," assumes the public carrier can eliminate service only at half the rate at which ridership is lost to private competitors. In the third scenario it was assumed that no excess capacity is eliminated by the public carrier. Using these three scenarios, conclusions were drawn regarding the effects of ridership shifts to the private sector and related public sector service cutbacks on the efficiency of the public carrier.

For example, consider the case in which 3,600 passengers leave RTA public rail services to use private buses each peak period. Also suppose that the distribution of ridership loss during the peak period along the rail line enables the carrier to eliminate capacity exactly equal to that required to move the lost passengers (scenario 1). In this situation, the RTA could reduce peak car requirements by 34 cars and car-miles by 595,000 per year, and system revenue would fall $4,212,000 annually. The net expected savings from these reductions can be calculated as follows:

34 peak cars reduced x $89,000 (annualized savings/ peak car reduced) = $3,056,600/year,
595,000 car-miles reduced/year x $1.27(annualized savings/car-mile reduced) = $755,650/year,
$4,212,000(revenue loss/year) x ($0.139 savings/$1 revenue loss) = $585,468/year, and
Total annualized cost savings = $4,397,718/year.

The private sector, in this case, has made it possible to reduce long-run expenses by $4,397,718 per year. The annual cost of services in the ICG corridor will drop from approximately $38,384,000 per year to $33,986,000.

How is efficiency affected? Before the emergence of private competition, 16 million passengers rode ICG trains annually, with an average trip length of 20.0 miles. Average cost per passenger-mile was, therefore,

(average cost/passenger-mile) = ($38,484,000/ 16,000,000 passengers x 20.0 miles per passenger) = 11.995¢.

If 3,600 passengers leave the system in favor of subscription bus service each day, ridership will drop to 14,200,000 annually. This ridership shift will reduce the average length of ride to 19.2 miles per trip (1,p.59). The new postcompetition average cost per passenger-mile is

(average cost/passenger-mile) = ($33,986,282/ 14,200,000 passengers x 19.2 miles per passenger) = 12.465¢.

It can be concluded that, in this hypothetical situation, private competition has an adverse effect on the efficiency of the public carrier, increasing total costs by 0.470 cents per passenger-mile.

Figure 1 shows the effects of competition on the efficiency and deficits of RTA rail operations in the corridor. Note that the effects of competition depend on the ability of the public carrier to divest unneeded service.

A significant and surprising finding is that, even under the most optimistic scenario, private competition has an adverse effect on the efficiency of the public carrier. Even if management is able to divest its services in direct proportion to lost demand, average cost per passenger will still rise by slightly more than 0.12 cents per mile for every 1,000 daily riders lost to the private sector. If capacity cannot be perfectly adjusted, the effects are more dramatic. When, for example, only half of excess capacity is eliminated, the average cost per passenger-mile will rise by as much as 0.23 cents for every 1,000 riders lost. If the discount rate is changed from 8 to 12 percent, the general implications, though less profound, were found not to change (1,p.79).

The effects of these ridership shifts on long-term operating deficits are slightly more encouraging. Currently, subscription buses are costing the public carrier approximately $2,100,000 per year in revenue. If the carrier completely eliminates excess capacity, long-run costs could be reduced by approximately $2,500,000 per year. Hence, annual deficits could be trimmed by $400,000 (2 percent). However, if only half the excess capacity is eliminated (scenario 2), deficits will rise by approximately 5 percent ($850,000 per year).

Chicago's RTA has, thus far, not eliminated excess capacity in the corridor in response to subscription bus competition. In the long run, if no service is reduced, the average cost per passenger-mile will rise from 11.995 cents to 12.82 cents. This loss in revenue will increase deficits approximately $2,100,000 per year in the long run and has important ramifications for the agency's ability to service the public.

This should not be interpreted as proof that competition from the private sector is undesirable. It merely confirms the fact that public railroad systems enjoy powerful economies of density, a factor

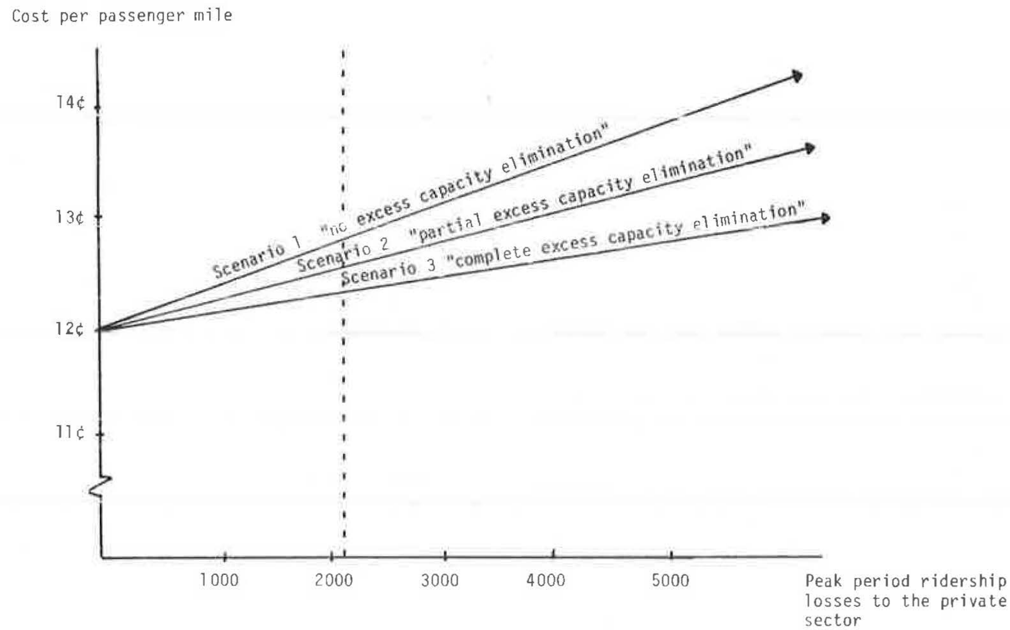

FIGURE 1 Adverse effect of private sector competition on efficiency of RTA rail services.

that must be taken into consideration when evaluating the potential role of the private sector. Like that of other public utilities, the efficiency of RTA services appears to be greatest in the absence of competition.

IMPACT OF COMPETITION ON THE EFFICIENCY OF THE TRANSIT SYSTEM AS A WHOLE

Thus far, attention has been focused exclusively on how private competition affects the efficiency of the public carrier. It must also be recognized that, because private carriers typically operate at lower costs than their public counterparts, a shift in resources to the private sector, although apparently detrimental to the public carrier, can still have a positive effect on systemwide efficiency. Simply stated, the gains in efficiency to the passenger from expansion of the private sector may offset the losses in efficiency in the public sector.

Chicago's subscription buses operate in an industrious, progressive environment; labor operates on split shifts to minimize costs; off-peak charter work is aggressively marketed; and most firms are large enough to permit maintenance and equipment refurbishment to be done internally (5). Firms appear to enjoy constant returns to scale, enabling them to expand or contract without affecting average cost (1). Analysis of the industry's cost structure shows that, even as the replacement of capital becomes necessary, the cost of providing the bus service will remain as low as 4.7 cents per passenger-mile, a full 7.3 cents lower than the cost of comparable public rail service (1,p.40).

There are, however, significant differences in service quality between the modes. The difference in cost to the passenger may not be due only to a difference in operator efficiency but may also be attributable to the reduced quality of service in terms of speed, frequency, and comfort. To avoid bias that might result from these less tangible factors, a simple nonlinear regression was performed to determine the extent to which consumers perceive the differences in quality between the modes.

By regressing the difference in fare between the modes on the number of passengers using subscription buses, using data from several points in time, an estimate of the average fare differential necessary to attract consumers from the higher quality rail mode to the lower quality bus mode can be calculated. This average fare differential can be interpreted as the additional nonpecuniary costs borne by the passengers of the lower quality subscription bus mode in the corridor (1,p.66).

With changing rail fares, subscription bus fares, and inflation, the constant dollar fare differential between the public and private services has substantially changed at least five times since 1981. This information, along with subscription bus ridership figures collected by the Chicago Area Transportation Study, provided a workable data base for the regression analysis.

This analysis indicates, at the January 1983 difference in fares of 4.3 cents per mile, that consumers perceive no less than 44 percent of their out-of-pocket savings from subscription buses to be attributable to the lower quality of service they receive (1,p.20). This roughly equates to 1.8 cents per passenger-mile at the current level of subscription bus ridership. To avoid bias, therefore, it is necessary to include these less tangible costs to the consumer in the estimate of the operating efficiency of the subscription bus. That is, these service-quality differentials, interpreted in monetary terms, were added to the costs paid by subscription riders.

When this is done, it is possible to estimate empirically how the overall efficiency of transit in the corridor (both modes combined) will change as resources shift from public to private ownership. Taking both the perceived differences in quality between modes and the potential savings from divestiture of public rail services into account, Figure 2 shows how the average cost per passenger-mile changes as consumers shift from public services to private services. The dotted line depicts the current loss in ridership to the private sector.

The results show that the gains in efficiency from increased use of lower cost private sector service can offset the losses in efficiency to the public sector, if the public sector is able to eliminate unneeded service.

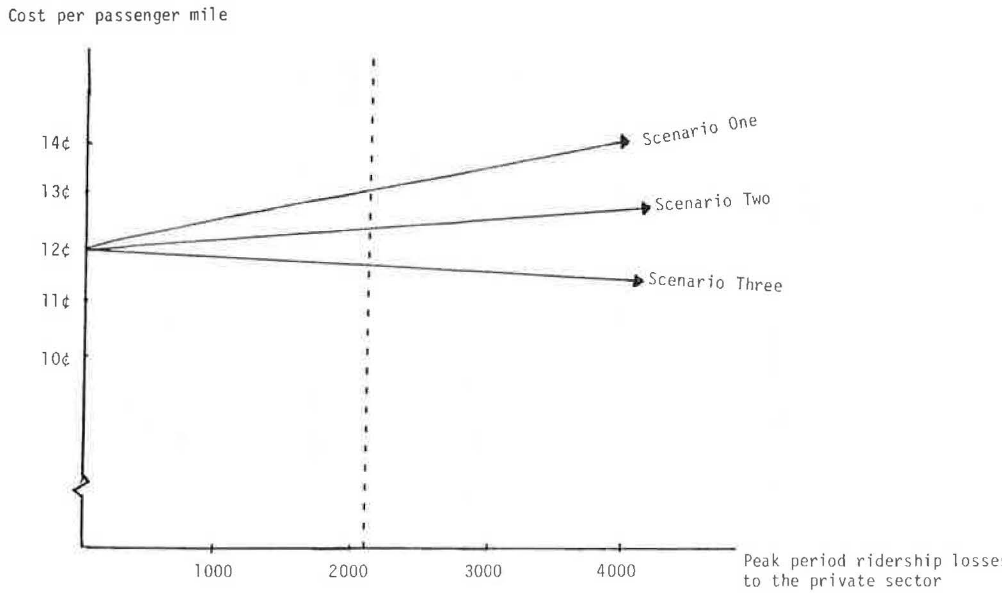

FIGURE 2 Effect of private sector competition on transit efficiency after adjusting for differences in quality.

At the current level of subscription bus ridership, the following inferences can be drawn:

- Scenario 1: If the public carrier is able to eliminate all excess capacity following ridership losses to private competition, market efficiency will increase by 0.33 cents per passenger-mile (2.7 percent).
- Scenario 2: If the public carrier is able to eliminate only half the excess capacity, efficiency will decrease by 0.17 cents per passenger-mile (-1.4 percent).
- Scenario 3: If the public carrier is unable to eliminate any excess capacity due to private competition, efficiency (including nonpecuniary costs) will deteriorate by 0.66 cents per passenger-mile (-5.5 percent).

Because, at this writing, the public carrier has not eliminated excess capacity brought about by private competition, the actual situation is best depicted by scenario 3. In the long run, if such practice continues, the agency can anticipate a 5.5 percent drop in operating efficiency, which might lead to an estimated loss to society of approximately $700,000 per year (1,p.70).

The simple yet important proposition to which this leads is that, before the new is welcomed, it must be understood exactly how well the old can be divested. In this case, competition can be regarded as a desirable element in the marketplace only if the public sector can eliminate service at least 60 percent as fast as the new private operators expand their market share.

OPERATIONAL FEASIBILITY OF EXCESS CAPACITY ELIMINATION

The evidence presented in the previous section plainly shows that the potential benefits of private sector participation in transit hinge on the ability of public transit operators to eliminate excess capacity. On the basis of an examination of RTA and subscription bus ridership in the corridor, an attempt is made to show that the temporal patterns of mode shift actually permit elimination of trains and thereby appear to make it feasible to eliminate nearly all the excess capacity brought about by the subscription bus.

A ridership survey was taken in October 1982 to explore the extent to which subscription buses had caused excess capacity on RTA trains in the corridor and specifically to determine if some trains could be eliminated as a result. Figure 3 shows the resulting estimates of excess capacity. The dark portions of the graph represent the approximate ridership of particular trains lost to subscription buses based on a survey of the schedule patterns and destination points of the new services (1,p.74). As can be seen, some trains, particularly those departing at the height of the peak period, appear to have suffered ridership losses of more than 250 passengers per day.

This evidence suggests that the public carrier does have an opportunity to eliminate the excess capacity brought about by the subscription bus. The ridership losses have, for example, made it possible to eliminate as many as three trains per peak period. The number of trains to each zone, the evidence shows, could be reduced from five to four in each peak period without causing a capacity problem or a major reduction in level of service. These service curtailments, reducing available seating by 17.6 percent each peak period, would eliminate over 90 percent of the excess capacity caused by the private sector.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Chicago's private sector transit operators are at a critical stage in their development. On one hand, their future seems bright, particularly when one considers that government agencies are considering additional increases in fares on the financially ailing commuter rail system. On the other hand, the private carriers operate with the realization that at any given moment regulatory agencies could paralyze them by invoking regulation to protect the public sector transit monopoly.

In this paper the widespread belief, apparent in

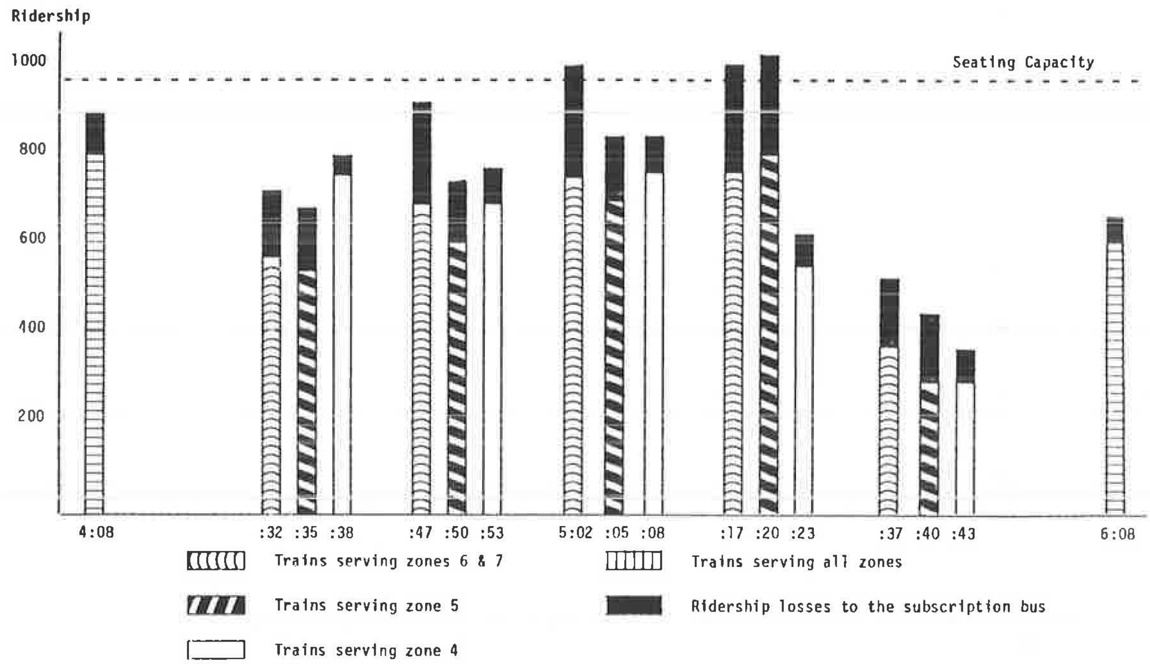

FIGURE 3 Ridership losses of RTA commuter trains to subscription bus in Illinois Central Gulf corridor.

both regulation and political opinion, that urban transit is most efficiently operated as a government monopoly has been challenged. Table 1 gives a summary of the principal findings, listing the predicted effects of competition on the public carrier and the transit corridor as a whole. The results are presented both with and without the statistical adjustment for the differences in quality between the public and private services.

TABLE 1 Impact of Competition on the Operating Efficiency of Transit in the ICG Corridor *(1)*

	Impact on Efficiency of the Public Carrier (%)	Impact on Overall Efficiency of Transit (both modes combined) (%)	
		Without Quality Adjustment	With Quality Adjustment
Scenario 1 (complete excess capacity elimination)	-2.5	+4.9	+2.7
Scenario 2 (partial excess capacity elimination)	-5.0	+0.2	-1.2
Scenario 3 (no excess capacity elimination)	-7.5	-2.3	-5.5

An important conclusion is that the presence of private sector transit operators has created an opportunity to improve the long-range efficiency of transit in Chicago's ICG corridor if the public sector appropriately reduces service. Even after taking into consideration factors such as severance pay to furloughed rail employees, the high fixed cost of maintaining railroad right-of-way and station facilities, and the differences in quality between the two modes, it was shown that a shift in resources from public to private control (i.e., subscription buses) would lower the average cost of transit service in the corridor.

It is important to note that the efficiency of the public carriers was found to suffer slightly because of private sector competition. However, the system as a whole (both public and private operators) can be made more efficient and deficits need not rise if the public sector responds, as a private business would, by divesting service that is rendered unneeded by competition.

In this case, the accusation that private operators destructively "skim the cream" is not supported, and thus it may be in the public's best interest to have private sector competition in the marketplace. Similarly, the natural monopoly argument--that the public is best served by a single, government-regulated transit carrier--does not appear to be valid in the case of Chicago's subscription buses.

In the light of these conclusions, the following four recommendations warrant serious consideration:

1. Chicago's public sector decision makers should acknowledge the impact of low-cost transit operators on public commuter rail ridership and explore rail service reductions in proportion to lost demand. It appears that subscription buses have made it possible to eliminate three round trips each business day in the ICG rail corridor.

2. Given the evidence that the private sector can play a constructive role in Chicago's transit system, it is appropriate to free subscription bus service from legal ambiguities that have hampered its growth. More specifically, it should be clearly established that the emerging industry will not be forced to comply with the complex web of common carrier regulations under the Illinois Public Utilities Act.

Not only would common carrier status be inappropriate in light of the private, closed-to-the-public nature of the service, but the evidence shows that, from an economic perspective, it could result in a net welfare loss to the consumer by discouraging entrepreneurship. Ironically, it is the consumer that transit regulation is intended to protect.

3. Government should use the presence of the private sector as a basis for strengthening its bargaining position with organized labor and contract carriers. Efforts to modernize work rules, eliminate featherbedding, allow split-shifts and other cost containment measures should be intensified. Unlike previous policy makers who tried to attain such re-

forms when publicly subsidized rail carriers and organized labor enjoyed a virtual monopoly in the transit marketplace, today's policy makers are in a strong position to bring forth such changes (1).

4. Finally, on the basis of a survey of the various strengths and weaknesses of the growing subscription bus industry, it is recommended that the public sector permit free market forces to guide its growth. It was consumer dissatisfaction with publicly provided transit services that led to the rapid growth of the industry in Chicago; to attempt to stimulate its growth artificially through subsidies and government planning would destroy much of its appeal to the consumer. Although the temptation to intervene in the name of "protecting the consumer" or "coordinating service between the private and public sector" may be great, such policy would inevitably reduce the industry's flexibility in responding to changing market conditions and discourage entrepreneurs from entering the industry.

Publicly subsidized operators, with a vested interest in maintaining a powerful market position, are likely to oppose these recommendations. However, the evidence presented in this paper suggests that the most common arguments against private competition are not supported. The conclusion seems clear: Unregulated subscription bus competition creates an excellent opportunity for reducing Chicago's financially ailing transit systems.

The transferability of the results to other cities, or even other corridors in Chicago, of course, is limited by the fact that different transit systems have different cost structures. But the analytic process set forth in this study, though only a beginning, may serve as a useful guideline in answering similar questions in other contexts. This process is not only easily applicable to different transit scenarios, it is able to consider some of the important economic considerations that cannot be properly addressed in a more qualitative approach.

It is possible that competition is economically desirable in some transit systems and undesirable in others. However, analysis of the subscription buses in one Chicago corridor reveals that there are strong economic arguments in support of deregulation of the transit industry, even when the public sector has invested heavily in a fixed-guideway transit system.

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Urban Transportation Deregulation in Arizona

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ABSTRACT

On July 1, 1983, privately provided common carriage urban transportation was completely deregulated in Arizona. Deregulation did not directly affect subsidized public transit, but in all other respects the former regulatory framework was abolished. The impacts of deregulation in the first year are reported. All urban transportation industries are included in the analysis, although the primary impacts occurred to the taxi, airport limousine, and demand-responsive transit contract industries. The study focused on entry, exit, prices, service innovation, market growth (or decline), and productivity and profitability of the various industries. An adaptation of the industrial organization methodology was used to focus attention on the key economic factors influencing the outcome of the issues of concern. In general, results of the first year of deregulation conformed to those that were hypothesized. There was no significant impact on the overall urban transportation system or on the modal preferences of travelers. No unsubsidized competitors to public transit appeared in the form of jitneys or commuter buses. The major effects were felt within the taxicab and airport limousine industries, in which significant new entry occurred. Prices in the taxi market increased substantially, resulting in a reduction in demand. Productivity and profitability declined in both the taxi and airport limousine industries. Any major benefits to consumers were eliminated when the Phoenix airport authorities prohibited passenger soliciting inside the terminals, which had led to lower ground transportation prices. Prices to consumers are now almost uniformly higher than before deregulation. The prime beneficiaries of deregulation are entrepreneurs, who previously were denied entry to the common carriage market, and public agencies who contract for local transit service and have seen contract rates drop because of increased competition.

Among the most widely discussed policy issues in transportation is that of economic deregulation and its impacts. Regulatory change (in the form of total or partial deregulation of rates, entry, and other service aspects) at the federal, state, and local levels of government has affected all transportation industries within the past decade.

Recent legislation in Arizona ended all state regulation of the motor carrier industries effective July 1, 1982. This affected industries moving both passengers and freight within the state. Research conducted to determine the impacts of deregulation on urban passenger transportation for the first year following implementation of the legislation is reported. Major tasks of the Arizona project were (a) extensive review of the transportation literature pertaining to deregulation, (b) development of a methodology to form predictive hypotheses about impacts of deregulation, and (c) collection and analysis of empirical data from Arizona for the first year following deregulation.

The initial hypotheses used in the deregulation study and the results of the empirical work are discussed. The literature review and methodology are discussed in detail in a working paper along with the background of the previous Arizona regulatory environment and its judicial interpretation. In the first section of this paper some background material on the Arizona urban transportation environment is provided, in the second the methodology and the predictive hypotheses are briefly described, in the third results of data collection are presented, and in the fourth conclusions and policy implications are presented.

THE ARIZONA ENVIRONMENT

Regulatory Changes

The previous regulatory framework in Arizona had been one of "regulated monopoly"; its legislative intent had been to protect existing motor carrier operators from further competition. The state had the authority to prevent "unnecessary duplication of service." No new certificates could be issued if the existing carrier showed a "willingness" to provide the service proposed by a new applicant.

Deregulation was accomplished through a legislative bill and a subsequent referendum passed by a two-to-one majority. Effective July 1, 1982, motor carriers were no longer regulated by the state, permitting freedom of entry, exit, pricing, and service levels. In place of the former certificate of public convenience and necessity, common carriers now obtain an operating license from the Motor Vehicle Division (MVD) of the Arizona Department of Transportation (ADOT). The MVD requires only that the applicant is fit and proper, meets financial responsibility for insurance, and that the proposed service not endanger the public. Rates are no longer subject to state regulation. The regulatory revision, however, did not alter the environment of subsidized public transit in the larger Arizona cities nor the practice of exclusive city and county contracts for dial-a-ride and other specialized transportation services.

Before the change, Arizona was one of only three states in the United States where taxis were regulated at the state level. Although several large U.S. cities (San Diego, Seattle, Portland, and Milwaukee) and some smaller cities (Oakland, Berkeley, and Fresno) have instituted taxi regulatory change at the local government level, Arizona is the first state to have complete economic deregulation of taxi rates and entry in all urban areas. The Arizona case differs from other taxi deregulation studies because the entire common carriage urban transportation market was relieved of legal restrictions on entry, pricing, and types of services offered, and thus the markets potentially affected are large.

Urban Travel

Urban transportation deregulation affects only a small portion of Arizona urban travelers because the vast majority move either by private automobile or subsidized public transit. The urban travel market affected by deregulation in Arizona consists of taxi, private bus, and airport limousine (point-to-point shared-ride service) operators, as well as all other demand-responsive and fixed-route services available to the public on a common carriage basis. These modes collectively comprise less than 1 percent of all urban motorized travel, because the other 99 percent travel by automobile or public transit (1).

In Arizona urban travel is dominated by the private automobile; the state has the third highest rate of household automobile availability (approximately 94 percent) of all states (2). Among standard metropolitan statistical areas (SMSAs) of more than 1 million population, Phoenix has the third lowest rate of transit used for work trips (2 percent) and only about 1 percent of all travel in the region moves by transit (3). Within Arizona, only the Phoenix and Tucson metropolitan areas have significant public transit operations.

Because urban travel in Arizona is almost totally dominated by user-operated transportation, the state is not an ideal test case for the economic impacts of urban passenger deregulation in large metropolitan areas. On the other hand, the urban transportation environment in Arizona probably bears important similarities to that of many low-density, automobile-oriented regions or other smaller metropolitan regions. For example, in 15 of the 38 large metropolitan areas in the United States, less than 5 percent of all workers use public transit and in the smaller SMSAs an average of only 2 percent of all workers use transit.

METHODOLOGY

Critical Factors Affecting Deregulation Impacts

Specific short-run adjustments in the urban transportation industries were hypothesized for Arizona based on specific aspects of the demand for and supply of urban transportation in the state. From a review of the deregulation literature and microeconomic analysis based on principles of industrial organization (4), critical variables affecting the outcome of deregulation were identified. Hypotheses were then generated on the basis of this framework and of the transportation situation in Arizona. Empirical work included the collection and analysis of data from Arizona. Results were then compared with the predictive hypotheses for short-run impacts.

Because the dynamic element of deregulation is caused principally by the presence of new competitors in markets, the most important factors are those that affect the entry of these new competitors. Two factors appear to be of primary importance in this regard: entry barriers and growth in demand (or lack of it).

Entry Barriers

Entry barriers affect the supply of transportation service because they constitute impediments that may deter firms from entering markets or industries. When regulatory monopoly barriers to entry were removed in Arizona urban markets, the number of firms entering was limited only by certain economic barriers to entry: (a) capital requirements to enter the various industries and (b) subsidies given to public transit agencies, which keep transit fares artificially low.

Market Growth

The second critical element affecting entry is market growth, a demand factor. Obviously, new entry in the absence of growing demand causes the total quantity supplied in any transportation market to be apportioned among more suppliers, affecting the pricing strategy of firms and their profitability. The pertinent aspect of growth in demand (i.e., an upward shift in the demand curve) is that there has been little or none in the case of common carriage urban transportation. In such circumstances, the opportunities for new competitors are much less attractive than in growing markets.

Hypotheses: Expected Impacts in Arizona

To generate hypotheses about deregulation impact, assumptions about the relative values of entry barriers (high or low) and growth rates (growing, stable, or declining) were used to formulate possible combinations of competitive conditions. The expected configuration of competition in the Arizona deregulated environment was derived from those combinations and resulted in the following hypotheses:

1. Deregulation impacts will be at the industry level, not the urban transportation system level. Although industry impacts will be apparent, system results are likely to be limited; market conditions are not appropriate, in the context of demand and supply characteristics, to support major changes in modal preferences or price-quality combinations.
2. Deregulation will result in new entry into markets and industries with low entry barriers by firms with versatile equipment. Industry lines will become less distinct as diversification in services occurs to (a) take advantage of existing overhead and (b) use existing equipment (by companies that have lost market share). This will include van, limousine, and some taxi companies.
3. Deregulation will result in increased competition in the taxi industry because of the ease of entry, despite lack of market growth. The taxi industry will undergo changes similar to those observed in San Diego and Seattle: many new entrants concentrated at airport markets, price instability with overall rising prices, a trend to independents, market specialization, and a decrease in industry concentration ratio (5,6). Changes will be focused on the biggest potentially profitable markets in Phoenix and Tucson, because new entrants will seek out existing markets rather than explore new ones. Entrants will be small businessmen or independents, and larger companies will seek more secure revenues in contract markets.
4. Deregulation will not stimulate new competition in the fixed-route transit industry because new entrants cannot compete with subsidized service at the low-price end of the market. Prices are prohibitive for better quality service, given the characteristics of the captive transit market. If lucrative, specialized markets develop, jitney-type operations may appear to take advantage of any economies of density. Otherwise, declining demand and transit subsidization discourage new entrants.
5. Deregulation will result in increased competition in contract markets; this results from a desire for secure revenues in an uncertain economic environment of price competition and declining

demand, plus the need to put to work equipment of companies that have lost market share.

Data Collection and Analysis

Urban transportation impacts were studied in both the metropolitan Phoenix and Tucson areas, as well as the small cities of Arizona. The Phoenix airport (Sky Harbor International), the state's single largest market for private common carrier urban transportation, was also a major focus of the analysis. Entry, exit, prices, productivity, and profitability were included in the analysis as were service innovation, changes in market size, effects on competing modes, and implications for public transportation. All existing modes affected by deregulation (taxis, airport limousines, private buses, and so on) were considered, as well as any new modes that might be initiated after deregulation, such as jitneys.

Because complete economic deregulation has meant that no public records are kept on transportation firms and their service offerings, data collection was a problem in the Arizona study. Economic data were collected from airport permits and directly from the providers via personal interviews and data forms. In addition, a Phoenix airport data collection effort provided a means of verifying the self-reports from taxi and limousine operators. The largest taxi company in Phoenix and Tucson provided detailed information on its operations before and after deregulation.

Elsewhere in the state, as well as for the private bus industry in the metropolitan areas, inventories compiled by local governments served as the starting point for data collection. Telephone surveys of providers and local governments were the source of much information about small cities and private buses (some personal interviews were necessary for large companies or unusual local cases).

Limitations of the data collection must be emphasized. Researchers were forced to rely on estimates by providers to a much greater extent than desirable. Also, some errors may be introduced by the seasonality factor. Most before-and-after comparisons reported in this paper use the summer months as a base because deregulation was implemented on July 1, 1982. Thus, the 1-year benchmark for examining deregulation effects meant that data on the year's impacts were collected in June and July of 1983.

CHANGES IN THE TAXI INDUSTRY IN METROPOLITAN PHOENIX

Entry, Exit, and Turnover

Before deregulation, the metropolitan Phoenix area was served essentially by two companies. Yellow/Checker Cab served the city of Phoenix with the 300 taxis it owned (about 225-250 were in service) and had service rights in some of the suburbs as well. Village Cab, a radio-dispatching company, had service rights in the Scottsdale area and provided dispatching service for approximately 15 cabs. Both companies were full-service taxi operations; they served the telephone market, hotels, resorts, and the airport.

Deregulation led to an immediate surge of entry into the taxi business, especially in the airport markets. As the data in Table 1 indicate, both the number of taxis owned and those in active service increased more than 50 percent in the first year following deregulation. About 50 of the owner-drivers previously affiliated with Yellow/Checker left the company to become independents, to start new companies, or to affiliate with another of the new companies. In addition, another 150 taxi vehicles entered the industry, either with new companies or as independents. The majority of the new operators focused on the airport market, because it was the single largest source of taxi patrons in Phoenix and could be served without radio-dispatching capability. Few of the new operators had the equipment needed to serve the telephone order market, and in any case they could not match the name recognition of Yellow/Checker. Only one new entrant has made a concerted effort to compete in the telephone market and to become a full-service taxi company.

TABLE 1 Taxicabs in the Phoenix Area

	FY 1981-1982	FY 1982-1983	July 1983
Yellow/Checker	300 (225)[a]	250 (150)	220 (135)
Village	15 (15)	25 (25)	25 (25)
Other	0	200[b] (200)	300[b] (290)
Total	315 (240)	475 (375)	545 (440)

[a]Numbers in parentheses are estimated active vehicles.
[b]Estimate based on airport permits to serve Sky Harbor Airport and taxi company reports of vehicles owned.

A majority of the new taxi operations are small (Table 2). Many operate only a single vehicle and virtually all the small operators are based at the airport. At present, only five new entrants of significant size (10 or more vehicles) are serving the market. These firms are trying to capture some of the telephone order business in Phoenix previously monopolized by Yellow/Checker, but with limited success. None of the companies is generating more than 150 telephone orders per day in the summer compared to 1,800-2,000 calls per day for Yellow/Checker. The latter firm and Village Cab still control at least 80 percent of the telephone market, which also includes package delivery.

TABLE 2 Fleet Size of Phoenix Taxi Operations

	Before 7/1/82		7/1/82 - 6/30/83		July-August 1983	
Fleet Size	No.	Percentage	No.	Percentage	No.	Percentage
1-3	0		54	78	32	71
4-9	0		7	10	6	13
10 or more	2	100	8	12	7	15
Total	2		69		45	

Although only two companies controlling four or more vehicles have failed since deregulation, there has been substantial turnover among the small operators. The data in Table 2 indicate that more than 40 percent of the operations with three or fewer vehicles were no longer active as of July 1983. These were companies or independents that served the airport during 1982-1983 but did not purchase an airport permit for the first quarter of 1983-1984. As the data in Table 3 reveal, the number of airport taxi permits declined precipitously between those two periods. Much of this decline was due to the decision by Yellow/Checker to abandon airport service except for passenger drop-offs (for which no permit is needed). Yellow/Checker took this course of action because taxis serving the airport now spend an average of 2 to 3 hours waiting for passengers and the company could not afford to use its fleet so unproductively. In addition, there was a decrease of more than 40 percent in permits purchased by new entrants, paralleling the decline in the number of companies that service the airport. (If a company did not purchase an airport permit, it was assumed not to be active in the industry,

TABLE 3 Taxicab Permits at Sky Harbor International Airport

	FY 1981	FY 1982	July-August 1983
Yellow/Checker	300	114	6
Village	15	16	6
Other	0	191	111
Total	315	321	123

because none but the largest companies were able to rely solely on telephone orders.) Some of these operators are probably waiting to reenter the market in the fall or winter when taxi business improves significantly, but many apparently have left the industry. Of the operators who exited (at least temporarily), 29 had but a single vehicle. This indicates substantial instability among the independent operator segment of the taxi industry. (Note that entry increased in the fall, but it remains undetermined whether the entrants are new or former taxi operators.)

Prices

Taxi fares increased substantially with deregulation. Previously, Yellow/Checker's fares were $0.85 per flag drop, $0.85 per mile, and $7.50 per hour waiting time. These fares were well below the level that prevailed in other large western cities, so an increase was probably inevitable. After deregulation, Yellow/Checker increased its fares to $1.20 per mile (retaining the $0.85 drop charge) and $12.00 per hour waiting time. This represents an increase of 33 percent for the average 4-mile trip. These fares, however, were the lowest in Phoenix after deregulation. Operators who served only the airport charged considerably more, with the majority of rates between $1.40 and $1.60 per mile and some as high as $2.00 per mile. Many cabs serving the airport did not have taximeters, moreover, and fares had to be estimated from the odometer, charged on a destination-by-destination basis, or negotiated with passengers. In addition, when the airport authorities forced taxi drivers into a holding lot to mitigate congested conditions at terminal entrances, many companies and drivers instituted minimum fares for airport trips regardless of length. Those minimums ranged from $10 to $20 in an effort to avoid short hauls. Although the minimums were gradually eliminated after the holding lot scheme was abandoned, a diversity of prices continued to characterize the industry during the first year of deregulation.

Airport taxi prices stabilized in July 1983, partly as the result of regulations imposed by the airport authorities requiring that all taxi vehicles have a taximeter and post fares on the vehicle doors. The majority of airport taxi operators worked out an agreement to charge identical fares because the new airport regulations also prohibited drivers leaving vehicles to enter passenger terminals for the purpose of soliciting business, which often involved competitive price bargaining. With the first in, first out taxi queue arrangement that now prevails at the airport terminals, there is little incentive to compete on the basis of price. Most airport fares are now $1.40 per mile plus $0.85 per drop, although the range is from $1.20 to $1.50 per mile. Four of the five major new entrants also charge $1.40 per mile, with the exception charging $1.20 per mile. The fare for an average 6-mile airport trip has thus increased significantly, up 55 percent since deregulation (from $5.95 with Yellow/Checker to $9.25 with a new operator). Airport taxi operators are willing to price bargain for lengthy trips, but even these are likely to be significantly more expensive than they were before deregulation.

Service Innovations

There has been essentially no service innovation by the Phoenix taxi industry since deregulation. No shared-ride operations have been established, nor have any jitney services been initiated. About one-quarter of the airport taxi drivers stated that they would do shared riding from the airport on an ad hoc basis with negotiated fares, but 3 days of observation did not reveal a single instance of this practice actually occurring. Formal shared-ride schemes on an areawide basis appear to be infeasible with the prevailing taxi demand densities in Phoenix (less than 1 passenger trip per square mile per hour).

Market Growth

Data obtained from Phoenix area taxi operators and at Sky Harbor Airport indicate that taxi patronage has declined since deregulation in spite of the substantial increase in the number of cabs. Table 4 gives estimates of the number of passenger trips (not passengers) per month for summer conditions immediately before deregulation and 1 year later. A range is given for the airport estimates because they were generated from 1 day's field observation. The decrease in demand for taxis almost certainly resulted from the higher fares that have accompanied deregulation (Yellow/Checker's patronage had been gradually increasing before deregulation.)

TABLE 4 Taxi Passenger Trips Before and After Deregulation in Phoenix

	June 1982	June-July 1983
Yellow/Checker	86,000	52,000
Village	4,500	3,000
New entrants (nonairport trips)		13,500-14,500
New entrants (airport trips)		9,000-12,000
Total	90,500	77,500-81,500

Productivity and Profitability

By any measure, the productivity of the Phoenix taxi industry has declined significantly since deregulation. As the data in Table 5 indicate, the number of passenger trips per active taxi per day has declined by about one-third for the entire industry, and the number of trips per shift has decreased by about one-quarter (the difference reflects lower use of taxis by operators after deregulation). Yellow/Checker, for which detailed data are available, suffered a 14 percent drop in trips per shift from the spring before to the spring after deregulation, despite a decline in shifts per day of nearly 30 percent in response to reduced patronage. The productivity of the new entrants appears to be substantially less than that of Yellow/Checker. This is due to their concentration at the airport, where empirical data indicate that taxis average one trip every 2 to 3 hours, and to the much lower volume of telephone orders that new-entrant companies serving this market receive.

These productivity levels have squeezed the income of taxi drivers and management. Drivers at the airport report an average gross revenue of $68 per day in the summer, from which they net about $30 per day after lease payments and gasoline purchases. Em-

TABLE 5 Taxi Productivity in Phoenix

Company	Trips per Shift per Day: Prederegulation[a]	Postderegulation[b]	Change (%)
Yellow/Checker	9.8[c]	8.4[d]	-14
Yellow/Checker	8.2	7.8	-5
All taxi operations	8.1	6.2	-23
Airport operations (empirical data)		5-6	NA[e]
Airport operations (driver self-report)		7	NA
	Trips per Cab per Day		
All taxi operations	12.8	8.5	-34
New companies (self-report)		5-8	NA

[a]June 1982.
[b]June 1983.
[c]March 1982.
[d]March 1983.
[e]NA = not applicable.

pirical data indicate that as low as these estimates are, they are probably optimistic with net revenues more likely to approximate $20-$25 per day in the summer. Drivers for the large companies apparently do somewhat better because these companies serve the telephone market and tend to have higher vehicle productivity. Overall, drivers work an average of 10 to 14 hours per day, 6 days a week for a meager income, averaging only about $2-$4 per hour worked. During the winter months, income increases with drivers reporting that they can net at least $25 more per day. (Taxi drivers, however, tend to be optimistic about estimates of their income.)

How taxi companies are faring economically in the deregulated environment is more difficult to determine. Two of the large new companies are reported to be in financial difficulty and Yellow/Checker has suffered a 30 percent decline in leasing and dispatching fees, with a less than proportional decrease in expenses. Despite the fare increases that accompanied deregulation, the average monthly fare revenue per cab (based on summer months) is estimated to be 10 percent lower than in 1981-1982. Whether management or the drivers are bearing most of the burden of this reduction in income is unclear. In the short run, management is better able to maintain revenues than drivers because of the driver leasing arrangements that prevail in the industry.

IMPACTS ON THE AIRPORT LIMOUSINE INDUSTRY IN PHOENIX

The impact of deregulation on the airport limousine industry in Phoenix has been similar to the effects on the taxi industry. Two types of point-to-point transportation services are provided at Sky Harbor Airport: prearranged transportation and unscheduled demand-responsive service. Before deregulation, three limousine companies with a combined fleet of 47 vehicles operated out of the airport. (The number of vehicles actually in service was smaller.)

In the first year of deregulation, seven new companies and independent operators, with a combined fleet of 15 vehicles, entered the airport limousine market. They concentrated on the unscheduled service market. One of the existing providers expanded its fleet from 9 to 13 vehicles, but the other two prederegulation companies reduced their fleet size because of increased competition and loss of market share. By July 1983 one of these companies had reduced its active fleet to four vehicles (from at least 12 vehicles during 1981-1982) because eight more companies had entered the market. The 25 vehicles operated at the airport by the new entrants now exceed the number of vehicles operated by the preexisting companies. Most of the new entrants have three or fewer vehicles, and several are one-vehicle operations.

The effect of the new entries has been to divert business from the established companies. Competition for passengers is intense, and many drivers will bargain over rates. This is particularly prevalent among the new entrants. One reason for price bargaining is that fares are based on a zone system, with a minimum of two passengers to a destination. When business is slow, however, some drivers will take a single passenger to a destination for a negotiated fare that is less than the comparable taxi fare. The established companies are reluctant to engage in this practice and, as a consequence, have lost market share. Their revenues have declined 20 to 30 percent since deregulation. The frequent price bargaining prevents any accurate comparison of the actual fares charged before and after deregulation. Consumers have benefited from the price and service choices offered by the Phoenix airport limousine industry, which is an alternative to the more expensive deregulated taxi services.

Airport rules have had a critical impact on the rates and patronage of Phoenix airport limousine operators. During the first year following deregulation, both limousine and taxi drivers with airport permits were allowed to enter terminals to solicit business and bargain for rates. The unscheduled limousine operators often had signs offering cheap shared rides to downtown or resort locations, which were much lower than taxi fares. According to several company owners, this practice resulted in increased business that was probably diverted from taxis.

This situation changed July 1, 1983, when new airport rules prohibited drivers entering terminals to solicit. In addition, taxis and limousines were physically separated at the busiest Phoenix terminal, with limousines located at a door infrequently used by departing passengers seeking ground transportation. Limousine operators report a drastic decline in patronage that reportedly has been captured by taxis. The unfortunate consequence of these airport rules, which effectively restrict bargaining opportunities, is to limit consumers' choices. It is now difficult to obtain information about price-service options (inadequate signs compound this problem).

Figures indicate that the prearranged airport limousine market shrank (estimates ranged from 5 to 16 percent) while unscheduled service registered a 10 to 20 percent increase in passengers before the July 1983 rule change at the airport. With more vehicles serving the airport market, however, driver productivity is less than before deregulation, with obvious adverse impacts on profitability. This factor, when combined with the higher daily revenues needed for profitability compared with taxis, accounts for the willingness of many operators to function like taxicabs and to bargain over price even for low-fare trips.

IMPACTS ON OTHER TRANSPORTATION SERVICES IN THE PHOENIX AREA

There has been a small amount of new entry into the charter bus industry in Phoenix, but rates have not been altered significantly. No fixed-route bus or van services have appeared. The private bus industry does not believe there is a market for regular-route or commuter bus services, at least at fares necessary for them to be self-sustaining. No jitney services have been established in the metropolitan area. The only privately provided commuter bus service involves workers traveling to the Palo Verde nuclear plant west of Phoenix, but this is a company-subsidized contract operation that was in existence before deregulation.

Two specialized demand-responsive transit (DRT) companies have begun service in Phoenix since deregulation. One company provides many-to-one contract service from certain locations to a Phoenix hospital. The service is subsidized by the hospital and free to customers. Otherwise, the company provides home pickup services to the hospital for $2.50 per pickup and $0.50 per mile. Another company expanding into DRT following deregulation is a division of a paramedic and ambulance company. It provides prearranged service with five wheelchair-equipped vans for elderly and handicapped people. These DRT services are provided by companies that are diversifying into other markets to improve the usage rate of versatile equipment.

Three public agencies that contract for local demand-responsive transit have benefited from deregulation because it has generated intense competition for DRT contracts and led to price reductions. Mesa, Scottsdale, and Sun City have all selected new contractors for their DRT systems at significantly lower rates than under regulation. Contracts are now changing hands with every rebid as companies are apparently willing to reduce profits drastically (and to charge short-run marginal, rather than fully allocated, costs) in order to obtain guaranteed revenues. Eventually, however, contract prices must reflect true (long-run marginal) costs, so it is uncertain how long public agencies will enjoy benefits of lower rates.

IMPACTS ON URBAN TRANSPORTATION IN TUCSON

Deregulation has had impacts in Tucson that are similar to but more limited than those in Phoenix. New entry has occurred in both the taxicab and airport limousine markets, contract prices for DRT services have declined, and no new jitney or transit-like services have been established. Subsidized fixed-route bus transportation continues to be provided by Suntran, which has a management contract to run the city-owned buses. The major impacts of deregulation thus have been within established taxi and limousine industries.

Before deregulation, the only taxi company in Tucson was Yellow Cab, which operated 60 vehicles. When regulatory barriers were eliminated in July 1982, Allstate Cab Company entered the market with 20 taxis. (Allstate was in the car rental business and had attempted unsuccessfully to obtain a Tucson taxi certificate before deregulation.) In addition, 13 other taxi operations with a total of 17 vehicles have been started in the year since deregulation. These small independents, most of whom operate a single vehicle, rely on the Tucson airport for business. The two larger companies compete in the telephone order market and also serve the airport, where competition is not yet as fierce as in Phoenix. Airport permits in Tucson are $3.00 per vehicle per month, in contrast with the Phoenix charge of $75 per quarter (initially $300 per year). No taxi operations have left the Tucson market since deregulation even though 60 percent more vehicles are now involved in the industry.

Taxi fare increases were more modest than in Phoenix, in large part because fares were already much higher under regulation ($1.10 drop charge plus $1.40 per mile), having been raised several months before deregulation. After deregulation, only the waiting time charge increased (as a result, Yellow Cab's average fare per trip has risen 16 percent). There has been no price competition. Because of the small price increases, deregulation has had no adverse effect on the demand for taxi service in Tucson. Patronage estimates indicate that ridership has at least remained at the same level.

The competition from new entrants has cut into the market share of the previous monopoly operator. Yellow Cab has lost 27 percent of its passengers and 15 percent of its revenues while maintaining its service level. At the same time, competition has prevented new operators from making much money. Independent operators report net income of only $35 per day for approximately 10 hours of work.

New competition has had similar effects on the airport limousine market. Two new companies, which together operate 8 vehicles, have entered the market. Arizona Stagecoach, the existing operator under regulation, has increased its fleet from 5 to 15 vehicles, although not all are in active service. (The owner of this firm has diversified into a variety of transportation services in a number of geographic locations in the Phoenix-Tucson areas, providing limousine, van, and DRT services.) Airport limousine fares are based on zones with rates differentiated for residential and hotel or resort pickups. Posted rates have remained the same since deregulation, although special rates for tours and long trips are available.

In the Tucson area deregulation has had major impacts on the city and private providers of DRT. Following deregulation, Yellow Cab was able to enter the market and underbid the previous holder of the city DRT contract (Handi-Car). In response, Handi-Car shifted vehicles to the Phoenix area and underbid Yellow/Checker (same owner as Tucson Yellow Cab) on its previous contract for the Mesa Dial-A-Ride service. In recent rebidding for the Tucson DRT contract, Handi-Car's bid (less than $9.00 per vehicle service hour, including provision of vehicles) represented a 40 percent reduction from its prederegulation city contract price in 1981-1982. (Yellow Cab retained the contract because of other contract disagreements.) The city of Tucson has thus benefited from the price competition.

IMPACTS ON LOCAL TRANSPORTATION IN SMALL CITIES

Deregulation apparently has affected the local transportation situation in only two of Arizona's small cities. In Yuma, four independent taxis have entered the market, although all these drivers previously drove for Yuma Yellow Cab, which remains in business. In Prescott, a one-vehicle taxi company has initiated operations and a new private local bus service has begun since deregulation. There had been both private bus and taxi service in Prescott before deregulation. In all other cities surveyed, deregulation has had no discernible impact on transportation, except for enabling taxi companies to increase fares easily without regulatory approval. The extent of such rate changes is not precisely known.

Prescott has been the small city that experienced the largest impacts of the removal of regulatory barriers. Before deregulation, one company provided all common carriage local transportation in the city, owning both taxis and buses (Ace City Cabs with five taxis and Prescott Whipple Stage with two 22-passenger buses on fixed routes). Following deregulation, fares were increased for both taxi and bus service. Following the rate increase and the new taxi entrant, Ace City Cabs had a 21 percent decline in taxi revenues. Doubling the bus fare from $0.50

to $1.00 led to a 40 percent reduction in ridership while revenues increased by 20 percent.

At the same time, another private bus company entered the market (the Prescott Trolley System sponsored by the Downtown Prescott Association). This service uses a single bus resembling a trolley and operates on routes and headways similar to those of Whipple Stage. Advertising on the bus and in the Whipple Stage schedule, plus a $0.50 fare apparently have made the service self-sustaining in the summer tourist season. Ridership is about 120 passengers per day, 85 percent of whom are tourists. Local patronage (about 20 passengers per day) on the trolleybus was undoubtedly diverted from Whipple Stage because of lower fares.

CONCLUSIONS AND POLICY IMPLICATIONS

Predictive Hypotheses

The six hypotheses advanced previously have largely been confirmed by the first year of experience with urban transportation deregulation in Arizona.

As expected, deregulation impacts have been felt at the industry level rather than the urban system level. Most impacts have occurred in the taxicab and limousine industries. Individual entrepreneurs have benefited from the freedom to enter markets and the transportation industries, but this freedom is constrained by unfavorable market conditions (lack of market growth) in most cases.

According to the evidence, no significant changes in modal preferences or price-quality combinations have taken place in the Arizona urban transportation markets. In the state's two major metropolitan areas, no innovative services have been initiated other than some small shared-ride van services. Consequently, deregulation has had virtually no effect on automobile users and transit-dependent travelers. The portion of urban travelers affected by deregulation still remains small, and the impacts of removing regulatory barriers have not significantly altered urban transportation at the system level (when the relevant system is defined as common carriage urban transportation).

Since the removal of regulatory restrictions, there has been diversification of services in industries with versatile equipment, making industry lines less distinct in the small-vehicle industries (taxis, limousines, vans, and minibuses). Providers have tended to deploy equipment wherever they could find a market or a contract, irrespective of previous geographic service areas or type of services offered. The evidence from Phoenix and Tucson shows vans offering taxi-like services and single companies providing taxi, limousine, and contract services, moving vehicles from one geographic market to another or to entirely different services. Firms are able to reduce overhead by managing a variety of services from a single base.

Despite deregulation, opportunities to provide innovative services in markets and industries once closed by the regulated monopoly restrictions have probably not been totally exploited in the short run. Instead, most new entrants try to capture a share of existing markets, reducing revenues for companies and drivers in those markets.

As expected, there has been increased competition and a reduction in the concentration of the taxi industry in Phoenix. This is similar to results in San Diego and Seattle. There has been the predicted entry by independents, and the airport markets are the primary focus for new owner-operators. Prices have been unstable for a time, and there has been an overall increase in rates. Until new Phoenix airport rules were instituted, there had been some price competition between taxis and limousines.

The major impacts from new taxi entry have been decreases in the market shares of the largest metropolitan Phoenix company (90 percent to approximately 65 percent) and the largest Tucson company (100 percent to about 67-70 percent). In Phoenix, however, the market has also declined in size as the result of about a 35 percent increase in fares, leaving fewer patrons whose business must be spread among more providers. The result has been a reduction in company and driver profitability and some exit from the industry by independent drivers. The limousine industry has experienced similar declines in profitability.

The situation shows few signs of being self-correcting. Moreover, the ease of entry into small-vehicle urban transportation services is likely to result in continual turnover in this market. Entry requirements such as the 10-vehicle minimum company size, radio-dispatch capability, and 24-hour service, which were imposed in Portland, would probably eliminate many of the new entrants in Phoenix as it did in Portland. Opportunities for part-time employment and the recent economic recession have exacerbated the problems of taxi supply, particularly at the airport.

Instead of forcing prices down in the airport taxi markets, new competition has had the reverse impact. The productivity declines caused by new entry have encouraged operators to increase prices in order to generate sufficient revenues to make a profit. New Phoenix airport rules prohibiting solicitation have limited consumer information on price-service options and adversely affected limousine patronage. The taxi queue at the airport, which facilitates first in, first out service, effectively limits price competition. Competition meanwhile has greatly lowered prices in contract markets. The distributive effects mentioned previously are common when markets are adjusting to different institutional rules affecting the flow of resources into the industry.

Taxi service and productivity improvements are unlikely to occur in the Arizona metropolitan areas. Shared-ride services require greater demand densities than currently exist in the general Phoenix and Tucson taxi markets and are feasible only from the airport, where they already exist in the form of limousine service.

There has been no new competition for fixed-route bus transit in the two major metropolitan areas in Arizona and service continues to be provided by the local transit agencies, which are subsidized. The most significant nonmetropolitan impact has been in Prescott, where a second local bus service has been initiated. There have been no jitney-type services developed in Arizona urban areas, indicating a lack of lucrative specialized markets in the state's major cities. The absence of growing market demand plays a critical role in the entry of such new competitors to a market or industry. Despite the removal of regulatory barriers to transit-like services, entry will not occur unless profitable market opportunities exist, and this is effectively precluded by the presence of subsidized public transit already serving the market.

Increased competition caused substantial price reductions in the contract markets (dial-a-ride) as predicted. Evidence in Arizona shows deployment of equipment from one geographic area to another to capture secure revenues from public agency contracts. One of the most active competitors in this market is the state's major taxi company whose market share was significantly eroded after deregulation. Under regulation, this company had been precluded from competing in other specialized markets (e.g., for the Tucson DRT contract). Contract rates, however, may not remain as low in the long run.

Advantages and Disadvantages of Deregulation

The economic rationale for transportation deregulation is that of efficient resource allocation. Regulation of pricing, entry, and operating practices in the transportation industries impedes the optimal distribution of scarce resources among alternative uses in the economy. The economic and social benefits of deregulation, therefore, are not strictly linked to direct consumer benefits. In the Arizona case, consumer benefits resulted from the increased competition between taxis and limousines at metropolitan airports and the reduction in contract rates to local governments. Positive benefits from deregulation also have been realized by the providers of the service; their new opportunities include competing in transportation markets on an unrestricted basis, starting up innovative new services, exiting from unprofitable services and markets, and increased flexibility in equipment use. A final benefit of deregulation has been the incentives for efficiency created by the potential of competition in various markets and industries, which acts as a deterrent to excessive rates and to service deterioration except where new rules prevail (airport markets).

These advantages must be weighed against the disadvantages of deregulation. In some areas, consumers are worse off because of higher taxi fares without any significant service improvements, although van and limousine services are providing some cheaper substitutes in some markets. Taxi fare increases were inevitable in Phoenix, but the price rise since deregulation is probably greater than would have occurred under the regulated system, particularly at the airport. A modest decline in the level of taxi service may also have resulted from deregulation because the number of vehicles serving the telephone market seems to have declined. A third adverse impact has been the airport problems generated by attempts to control ground transportation competition. New rules have restricted both intermodal competition and consumer choice. Finally, although not actually worsening Arizona conditions, deregulation has not produced innovative services to alter the predominantly negative economic trends of the urban common carriage transportation industries.

Policy Implications

The important policy lesson to be learned from the Arizona experience is that favorable impacts do not necessarily follow the removal of institutional barriers to competition in the transportation industries. When transportation demand is stable or declining and attractive substitutes to the deregulated modes exist, the impacts of deregulation may be largely confined to increased competition within existing industries with few or no corollary benefits to consumers and providers. The Arizona results are in striking contrast with the numerous consumer benefits that have resulted from airline deregulation, a second example of complete economic deregulation of a transportation passenger industry. The difference between the two experiences is primarily a function of the rate of growth of demand and the size of the market. The air travel market is expanding and providers have little competition from user-operated transportation, whereas the demand for unsubsidized common carriage urban transportation has been declining for more than 30 years. As this research indicates, a number of economic variables affect the outcome of deregulation and these must be identified in a systematic way.

In addition, the Arizona experience illustrates that a major impediment to more widespread positive impacts on the deregulated industries is the continued presence of subsidized public transit in the otherwise deregulated urban environment. Further barriers to competition and service innovation are created by the new ground transportation rules at the Phoenix airport.

Another policy implication relates to the distinction between the urban experience and that of other transportation industries regarding productivity improvements. In other deregulated industries, deregulation led to significant gains in efficiency, which resulted in lower costs for producers and lower rates for consumers and shippers. Opportunities for productivity improvements in urban common carriage transportation are limited by the basic economics of the industries inasmuch as costs for most factor inputs can hardly to reduced. The lack of market growth, in the context of increased entry, also works against productivity improvements.

Although impacts at the level of the entire urban transportation system have been minor, impacts at the industry and market level demonstrate some merit for urban transportation deregulation as a public policy. New entry into small-vehicle urban markets and industries, price competition between taxis and limousines before the establishment of restrictive airport rules, lower contract rates to public agencies, and some new specialized demand-responsive operations indicate that removing regulatory barriers provides a positive environment for the provision of urban services, subject to the economic and institutional constraints discussed previously. It cannot be concluded from the single significant adverse impact to date, increased taxi fares, that deregulation is an unsatisfactory public policy.

A final policy implication relates to the generalizability of results from Arizona to other geographic areas. Because of the state's transportation characteristics, Arizona's deregulation experience is limited in its applicability to other urban transportation environments. It is clearly not indicative of what would occur in large, densely populated metropolitan areas where transit is stronger and the private automobile less dominant. Nonetheless, in those urban areas where population densities are relatively low, where transit is used only by a small transit-dependent population, and where virtually all other travel is by automobile, the Arizona experience does appear to be applicable.

The lesson for these areas from Arizona would appear to be that deregulation has both advantages and disadvantages, but that both are quite limited in their magnitude and scope. There is little likelihood of deregulation having any significant impact at the urban system level (e.g., major new services or substantial diversion of travelers to deregulated modes), and impacts at the industry level have not been dramatic. At the same time, the rationale for continued regulation of these markets is not particularly compelling. In short, urban transportation deregulation in Arizona has been neither a disaster nor a panacea for the affected markets and industries; a similar outcome might be expected in similar environments elsewhere.

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Feasibility of Profitable Transit Service in Radial Urban Corridors

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ABSTRACT

In view of the rapid escalation of deficits in urban public transit operations and of the increased interest of private firms in providing transit services, this research investigates the possibility of profitable provision of service in a particular but highly significant market. A model is constructed in which a private carrier, competing with the automobile, chooses capacity, service quality, and price to maximize profits. The general conclusions of the study are that profitable operation is possible in corridors that have a wide range of market and automobile competitive conditions. This is true for corridors with volumes as small as approximately 1,000 persons per peak hour.

Results of research on the question of the feasibility of operating conventional fixed-route, scheduled bus transit service at a profit are presented. This question is important at present because of the rapid escalation of transit costs and deficits. Governments at all levels are resisting further increases in subsidies from general tax monies, and the federal government is planning to eliminate operating subsidies. This naturally raises the question of whether at least some transit service might be operated at a profit, with passenger revenues exceeding costs by an appropriate margin, thereby obviating the need for any government funding.

The specific question addressed in this paper is whether it is possible to operate for profit fixed-route, scheduled bus services in radial urban corridors. These services are envisioned as connecting central business districts (CBDs) and outlying areas that are predominantly residential. The study also focuses on relatively long trips in which a portion of each bus run could be operated essentially as an express, making few or no stops. Although this represents only one type of transit service, it is a type found in almost all medium and large metropolitan areas and hence is important.

Because discussions of profitability in urban transit often become highly emotional, it is important to note that the present discussion is focused exclusively on the question of the possibility of a profit. Even if a profit is possible, that does not mean that services designed to be profitable should replace existing services. The question of desirability is quite distinct and cannot be settled by analysis alone. Some aspects about which analysis can provide guidance are covered in Viton et al. (1).

APPROACHES TO THE PROFITABILITY QUESTION

There are basically two approaches to the question of whether a profit can be made in transit service: (a) examination of actual systems in case studies and (b) mathematical modeling of transit markets. Each of these approaches has certain desirable features and certain weaknesses.

Case studies are particularly attractive because they represent results achieved in the real world. They are not subject to the problem of misleading outcomes of modeling efforts, which result from poor or unrealistic assumptions, incorrectly estimated model parameters, and so forth. Case studies are also usually persuasive to decision makers. However, to yield generalizable results, the cases must be sufficient in number and in variety of conditions to span the spectrum of influencing factors. Herein lies the problem of the case study approach to the question of the possibility of profitable transit service in the United States.

Regulatory and legal constraints prohibit private firms from providing transit service in almost all U.S. metropolitan areas in which exclusive franchises have been given to regional public authorities. These authorities certainly do not have profit as a primary goal; they typically seek other goals according to their charters and legislation. Among these goals are to ensure adequate transit service, to keep fares as low as possible, to provide mobility for the handicapped, and to use transport to further regional land use objectives. Other objectives and considerations also enter in as a result of the political context of many critical decisions regarding transit, such as the magnitude of operating subsidies and of capital grants. Most of the relatively few remaining private transit firms are regulated as to routes, fares, service quality, and capacity and are subsidized in accordance with the same considerations as apply to public authorities. Virtually none of the present providers of transit are actively seeking to maximize profit based on fare-box revenue, and thus the fact that they do not turn a profit is not sufficient evidence to conclude that a profit is not attainable. For this reason the case study approach, applied to U.S. transit systems as a whole, is inappropriate as a means of dealing with the question.

Modeling offers a means of dealing with the question of the possibility of a profit in transit. It provides a means of analyzing what would happen if barriers to provision of transit by profit-maximizing firms were eliminated, and enables the exploration of the effect of providing transit service with characteristics of the product, in quality and price, that differ from those of transit service now offered.

For these reasons, the modeling approach was used for this study. This approach should be helpful in understanding the influence of various conditions such as size of the market on the possibility of obtaining a profit. Moreover, the modeling results could be tested against the case studies of profitable transit (2). A satisfactory model would presumably be able to replicate the conditions and profitability of the relatively few recently observed profitable firms.

MARKET MODELING APPROACH

The general approach to modeling a transit market can be understood by considering the case of a single route, which can easily be generalized to many routes or to an entire system. The basic question asked is: How would a carrier that wishes to maximize profit supply transit service? This carrier presumably would attempt to select all the characteristics of its service in such a manner as to maximize profit. The characteristics under the control of the carrier are the fare charged (F), quality of service features such as the percentage of passengers seated (T), the frequency of buses operated on the route (V), and the capacity of the buses (Q). (In practice most carriers operate with the standard 40-ft bus.) The choices made by the carrier providing this service will naturally influence the demand realized (D) for that bus service. Potential riders will presumably compare the bus service features with those of an alternative means of transport (A), which for these purposes is presumed to be the private automobile. The carrier's choices with regard to some of these features will also determine its costs (C). In particular the frequency of bus trips and the size of the buses will determine capital and operating costs.

The problem, for maximum F, V, and Q, can thus be written in the following form, in which the decision variables are selected to maximize profit (P) with demand related to transit price and service characteristics and those of the automobile alternative:

$$P = F \cdot D - C \quad (1)$$

$$D = f(F,V,P,A) \quad (2)$$

$$C = g(F,Q) \quad (3)$$

$$T = h(D,FQ) \quad (4)$$

where

D = demand,
C = cost,
T = percent seated, and
lower case letters = functions.

This can be viewed as a constrained optimization problem. Depending on the situation, various interactions, such as the influence of the number of riders of the bus system on the number of automobiles on the highways and hence on highway congestion, would have to be taken into account. In some situations this influence would be significant, whereas in other situations, such as those in which the bus line serves essentially CBD-bound trips and the bulk of highway traffic is to non-CBD locations, this effect might be ignored.

The general form of these relationships is shown in Figure 1. In this figure, the effect of variations in the frequency of service both on travel demand, and hence revenue, and on costs are shown. In this case the revenue function follows the general form that would be expected; that is, for a given or fixed fare, it is proportional to traffic that follows the normal logistic curve of most demand (mode choice) models. This figure is of course drawn holding fixed all other service choices of the carrier.

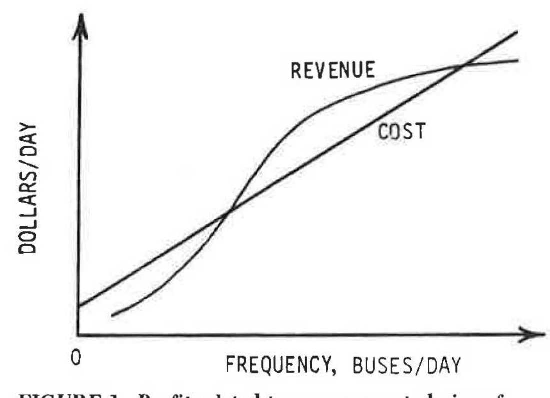

FIGURE 1 Profit related to management choice of frequency, with other service features and fare constant.

More generally, the problem is one of optimization in many dimensions. Figure 2 shows this for the case of two dimensions, fare and service frequency. This figure presents a profit surface, or contour map, on which are shown lines of constant profit (isoprofit lines). The profit levels in the applicable Figure 1 would be represented as a plane inter-

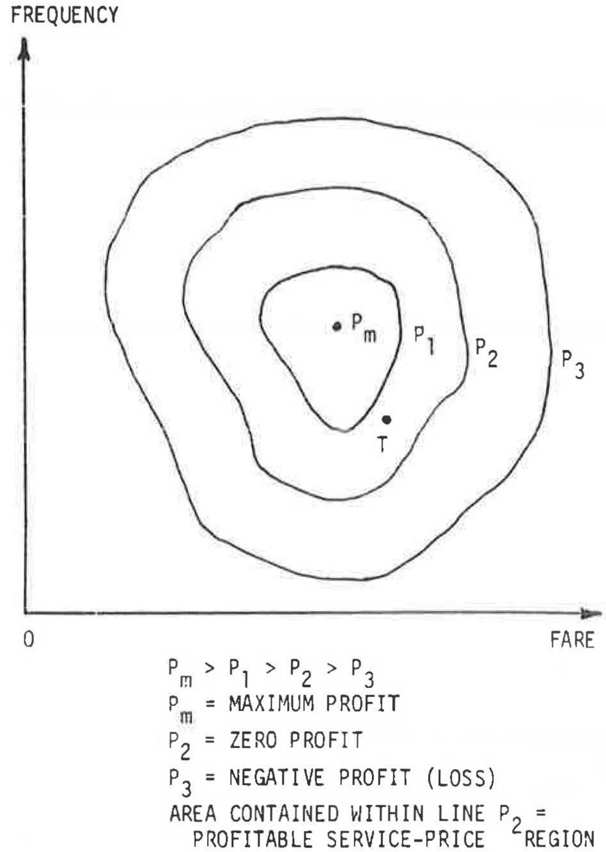

FIGURE 2 A profit contour map showing the profitable service-price region.

secting the fare axis at the applicable fare, parallel to the frequency axis, and perpendicular to the plane of this figure.

Although the primary interest is in the maximum-profit selection of service features and price, it is also important to obtain information on the degree to which a profit could be realized at levels of price and service different from that optimum. This question is important partly because demand information is known only imperfectly, and in fact so are cost characteristics, although to a far lesser extent. With such imperfect information, a carrier would not normally select the true maximum-profit characteristics of output, but would deviate from them to some extent. The important question is: Could the carrier still operate profitably? To answer this, the range of service features and price over which a positive profit is still possible can be identified. This range can be termed the "profitable service/price region." In Figure 2, a positive profit is possible anywhere within the boundary of the isoprofit contour (P_2), which means that any combination of price and frequency in this boundary would yield a profit. When a carrier has entered the market at some point in this region (e.g., T), various techniques including market surveys and actual experimentation could be used to identify higher profit positions, and there might be some change in service offerings. The significance is that if the profitable output region is rather large, it is relatively easy for a carrier to enter the industry and to make a profit, even if the initial choice of price and service is nonoptimal. This substantially diminishes the risk of loss. Therefore, in addition to identifying the maximum-profit service features, an attempt is made to identify this profitable service/price region.

MARKET AND MODEL

Now that the general approach has been described, the specific urban travel market and bus and automobile transportation alternatives can be described. As mentioned earlier, this research specifically focuses on a bus service connecting suburban areas with the central business district. The buses operate in an express mode between the suburban area and the downtown and make no or perhaps a few stops at connecting routes.

Market

The market to be considered is shown schematically in Figure 3. There is a circular residential area of radius r miles, connected by an expressway or major arterial to a central business district. It is assumed, for mathematical convenience, that all types of trips with which the model is concerned take place in this market in the following way: For automobile trips, the driver first drives along the residential streets to the expressway entrance at A. She then proceeds along the expressway to C, a distance of L + XL/2 miles. The driver then proceeds along city streets a distance (XL + 1)/2 miles to a parking lot near the work location.

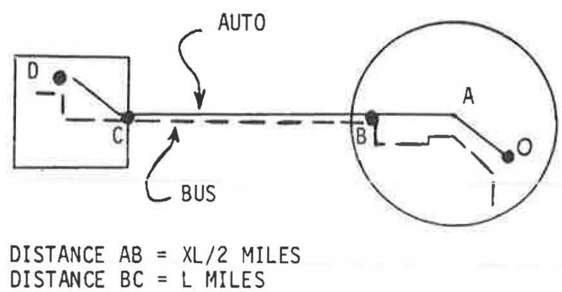

FIGURE 3 The transit market.

The bus trip is somewhat more complicated, because the fact that, in general, bus trips are more circuitous than automobile journeys must be taken into account. Proceeding along the residential streets, the bus collects its passengers. Instead of getting on the expressway at A, however, the bus proceeds a further XL/2 miles on residential streets before joining the expressway at B. From this point on, the trip is the same as the automobile trip except that the expressway portion is only L miles. Thus, the disadvantage of the bus trip (for modal choice) is not that it covers a greater distance but that it takes longer than an automobile to cover the same distance. The parameter XL is referred to as a "circuity factor" in what follows although, as the previous discussion indicates, it is actually a proxy for circuity. The assumption that the circuity in the residential area equals the circuity in the relevant part of the downtown distribution area is made only to economize on parameters; clearly, it is easily modified. The additional 1 mile of distance at the CBD end of the trip is included to allow analysis of the case in which circuity is zero. Without the additional distance, zero circuity would be equivalent to assuming the expressway delivers the commuter directly to the parking lot.

In the analyses the speeds at which all vehicles move on the expressway (S), and the different automobile (ASPD) and bus (SPD) speeds on residential and city streets are taken as parametric. This is a reasonable approximation, if residential-area-to-CBD traffic is not a large proportion of the total expressway traffic. Moreover, as will be noted later, these are varied to replicate various road types and levels of congestion.

Demand models developed for transit/automobile choices typically reveal three measures of transit service that are important to consumers: fare, in-vehicle time, and excess time. For fixed speeds in-vehicle time is given. Excess time is the sum of access time to get to the nearest stop and time spent waiting for a bus. Each of these measures of service quality is determined by the bus carriers' selection of three variables: the number of routes covering the residential area (R), the bus headway (H) as observed on the expressway, and the fare (F). The connection between these is derived in the research report (1,pp.2-17), and the relationships are

$$\text{Walk} = \pi r/6R \tag{5}$$

$$\text{Wait} = HR/2 \tag{6}$$

Bus Cost Model

The bus cost model is of the unit cost variety, in which the total operating and capital costs (C) are related to the number of vehicles required (B), the number of driver pay hours required (G), and the vehicle-miles operated (M). In a situation in which the number of buses required to operate the service during weekday peak periods is sufficient to enable the service to be provided at any other period during weekdays and weekends, and in which the number of drivers required during weekday peak periods is greater than that required during the midday and evenings periods, unit cost models are typically written of the following form:

$$C = \alpha B + \beta M + \gamma_1 G_1 + \gamma_2 G_2 + \gamma_3 G_3 + \gamma_4 G_4 \tag{7}$$

The vehicle-mile parameter (β) is normally the same regardless of the period of day, reflecting such expenses as fuel consumed and maintenance, and hence there is no distinction between miles logged in different periods. However, the vehicle-hours of operation variable differs for weekday peak periods (G_1), weekday middays (G_2), weekday evenings (G_3), and weekends (G_4) because many drivers working during the weekday peak periods are paid for hours between those peaks even when they operate no vehicle. To the extent that this is the case, the additional cost of operating a more frequent service during midday periods would consist simply of the mileage-related cost because drivers for those buses are available and are already being paid as a result of their working during the peak periods. Thus parameter γ_2 will often take on a value of zero. This is the case in the Northwestern bus transit cost model, which is the only model calibrated for the United States that was singled out in a recent review of bus cost models conducted by Simpson and Curtin for UMTA (3,p.92) as a model especially well suited to dealing with peak/off-peak cost variations and incremental service charges. Further details on this model are provided elsewhere (4). The significance of these cost characteristics will be apparent in a later section.

Demand Submodel

The demand submodel takes a given total volume of trips between each residential area and the downtown (specified exogenously and varied as a market characteristic) and estimates the number of travelers who would use the bus service (and the alternative, the automobile) as a function of bus service and cost characteristics and similar measures for the automobile. The model used is one developed for this type of market by Train (5) for a similar situation of work travel in the San Francisco Bay area. The model is a relatively standard logit model. The probability of choosing the automobile (p^a) is

$$p^a = \exp[\theta'(z^a - z^b)]/\{1 + \exp[\theta'(z^a - z^b)]\} \tag{8}$$

where z^a and z^b are vectors of cost and service characteristics for the automobile and bus, respectively, and θ is an estimated weighting vector.

In the particular implementation used, the characteristics of the automobile and the bus transit mode include the cost of travel divided by the post-tax wage of travelers, the in-vehicle travel time, and the out-of-vehicle travel time. Thus the model is sensitive to the major service characteristics to be chosen by the bus operator, with the exception of comfort level (e.g., percent seated). In the case of this feature, it is assumed conservatively that the bus service must provide sufficient seats for all travelers. This consideration did not characterize transit alternatives in the sample, and thus demand for transit was probably underestimated at least slightly.

The model's parameters were estimated using a sample in the San Francisco Bay area in 1973. Therefore income distribution data for travelers in the San Francisco region for the same period were used, and the costs of traveling by automobile for that same year were estimated. It should be noted that these data are for a period before the oil embargo when gasoline became difficult to obtain and there were long waiting lines at service stations. It is possible to claim that Bay Area automobile costs are atypically high; however, demand and cost data from other regions of the United States did not significantly alter qualitatively the nature of the conclusions presented here. After the model was run, these costs were inflated to more recent values for purposes of comparison, using the Consumer Price Index.

In principle, a similar demand model for travel for purposes other than work could be used for the remainder of travel. However, because a model that was entirely satisfactory in terms of including all of the relevant price and level of service features, and encompassing the range of purposes desired, could not be identified, it was impossible to approach nonwork (presumably nonpeak) travel in the same way. Nonpeak analyses were also hampered by a surprising lack of information on travel volumes of trips to central business districts via all modes relative to peak-period flows. The solution to this problem follows.

Peak-Period Versus All-Day Travel

Rather than rely on guesses about total volumes and on relatively unsatisfactory demand models, it was decided to focus the analysis on peak periods only. This was done in a manner that would underestimate the daily profit, and hence the analysis gives a conservative answer to the question of potential profitability of all-day service. It should be borne in mind that, although a firm might attempt to initiate a profitable peak-period-only transit service, it is also likely that one would initiate an all-day service, as is typical of many of the line-haul services that have been profitable (2).

To understand why the estimated profitability is almost certain to err on the conservative side, it is useful to reexamine the revenue and cost relationships in a manner that distinguishes between these items for different periods. If the weekly operating activities are divided into the four periods defined previously, the revenue and cost picture is as follows:

$$P = FD_1 - \gamma_1 G_1 - \beta M_1 + FD_2 - \gamma_2 G_2 - \beta M + FD_3 - \gamma_3 G_3 - \beta M_3 + FD_4 - \gamma_4 G_4 - \gamma\beta - \beta M_4 \qquad (9)$$

where D_i is the demand for period i (1 is weekday peak, 2 weekday midday, 3 weekday evening, and 4 weekends). Vehicle-hour related costs, which have different values for each period, are paired with the corresponding revenue term and the corresponding vehicle-mile term.

The estimate of profitability would be understated if the incremental profit from the nonpeak periods taken together were positive or, more conservatively, if the incremental profit in each nonpeak period were positive. That this is likely to be the case can be readily seen. First, with respect to the weekday midday period, the only incremental cost associated with operating buses is the mileage cost because q_2 is typically zero as noted earlier. The one-way fares that are calculated as optimal in the ensuing analysis are typically at least twice the cost of operating a bus for 1 mile, and hence a midday bus run need only have a number of riders equal to half the miles run, on average, to fully cover its additional cost.

This is certainly a likely situation. For weekday evening services, the additional cost of operating a bus would consist of the mileage cost plus a labor cost that is substantially less than that of the nominal wage rate. The reason is that if bus service were operated after the evening peak period, a single bus driver who in the peak-only case operates a bus in both the morning and the evening peak periods would be replaced by two drivers. One driver would operate in the morning and continue to work into the middle of the day and be paid straight time rather than overtime. A second driver would operate the evening peak period and continue to work into the evening. The replaced single driver would typically work and be paid for 10 or 11 hours, with time-and-a-half after 8 hours, for a total of approximately 12 or 13 pay hours. Two straight-time drivers would be paid only for 16 hours. Thus the incremental cost of bus service in the evening is relatively low, and again relatively minimal passenger loading should more than cover these expenses.

Weekend service would typically be operated in a manner that avoids any significant amount of overtime payments, and hence it is likely--although somewhat less so than in the preceding cases--that revenue would cover the additional cost of both mileage and labor. Note that in all of these cases the entire cost of bus ownership is determined by the peak period, so that none of the other three periods must generate additional revenue to pay for vehicles. Thus it is highly likely that the operation of any or all of these nonpeak services would increase total profit as a result of the relatively low incremental cost associated with such additional operation. If this is the case, then the analyses to follow understate profits and hence err conservatively in estimating the condition for profitable operation. It might be noted that this conclusion is similar to that reached by others in analyzing bus cost-revenue relationships (6,pp.116-119).

Conditions for Profitability

To identify conditions under which peak-period service could be profitable, a wide range of travel market characteristics and competitive characteristics with the automobile was explored. The characteristics that were varied included

- Length of line-haul portion, L (8-15 miles, 13-24 km);
- Line-haul speed, S (20-50 mph, 32-80 km/hr);
- Residential area transit speed, SPD (7-12 mph, 11-19 km/hr);
- Residential area automobile speed, ASPD (12-25 mph, 19-40 km/hr);
- Circuity, XL (0-4 miles, 0-6.4 km); and
- Total demand from residential area to CBD (600-5,000 persons per hour).

In the following paragraphs an attempt is made to identify the general pattern of these results and their interpretation.

Maximum Profit Analysis

It is useful to begin by examining the general pattern of profitability, assuming that the carrier does select the service characteristics and price in a manner that in fact maximizes its profit. For this a formal optimization model was solved; a separate run of the model corresponded to each market/service condition.

Typical results characterized by a single residential-area-to-CBD service are presented in Table 1 that gives the profit and selected optimal bus service and fare characteristics and the modal split. In general, the optimal fare increased with total corridor (automobile and transit) volume as of course did frequency.

Figure 4 shows the results for various situations. The variation in profit level is explained primarily by the total travel volume, as would be expected, and to a somewhat lesser extent by other market characteristics. First, for the highest level of potential profits, the circuity via transit had to be low and the speed at which transit could operate had to be relatively high, with line-haul speed between 30 and 50 mph. As can be seen from the figure, profitability under these conditions seems to be possible down to total corridor volumes (i.e., automobile plus transit) of 600-800 persons per hour.

A substantial reduction in potential profit, and truncating of the range of volumes over which profit is possible, occurs with a reduction of transit speed--in this case, a reduction of local speeds to approximately 7 mph. Profitable service is possible down to a volume of approximately 1,300-1,500 passengers per hour.

A further reduction of profit potential occurs when the circuity increases; the lowest band of results refers to a situation with extreme circuity of 4 miles. It might be noted that this implies that each bus run requires an additional 20 minutes more than that with zero circuity. Hence this result is not surprising.

Region of Profitable Service Characteristics

In addition to the maximum-profit situation, the degree to which the achievement of profit is dependent on choosing the precise profit-maximizing values for service and price characteristics is of interest. If the range of possible profitable service and price characteristics in any market is large,

TABLE 1 Example of Optimal Profit Bus Service: Profit, Fare, Level of Service, and Mode Split

Market (persons per peak hour)[a]	System Profit ($ per day)	Fare ($)	No. of Routes	Buses per Hour	Overall Bus Share[b]
5,000	22,596	3.27	9.0	38.7	0.387
4,000	16,368	3.13	8.0	30.2	0.378
2,000	4,988	2.55	5.3	13.5	0.338
1,000	632	2.14	3.7	6.7	0.254
800	45	1.98	3.2	5.0	0.213
600	(deficit)				

Note: S = 30 mph, L = 8 miles, XL = 0 mile, ASPD = 25 mph, and SPD = 12 mph; fares and profits are in 1981 dollars.

[a]Total corridor volume via automobile and transit.

[b]Total transit volume is share times corridor volume (e.g., 0.387 x 5,000 = 1,935 persons per hour for the 5,000 persons per hour corridor, and 0.213 x 800 = 170 persons per hour for the 800 persons per hour corridor.

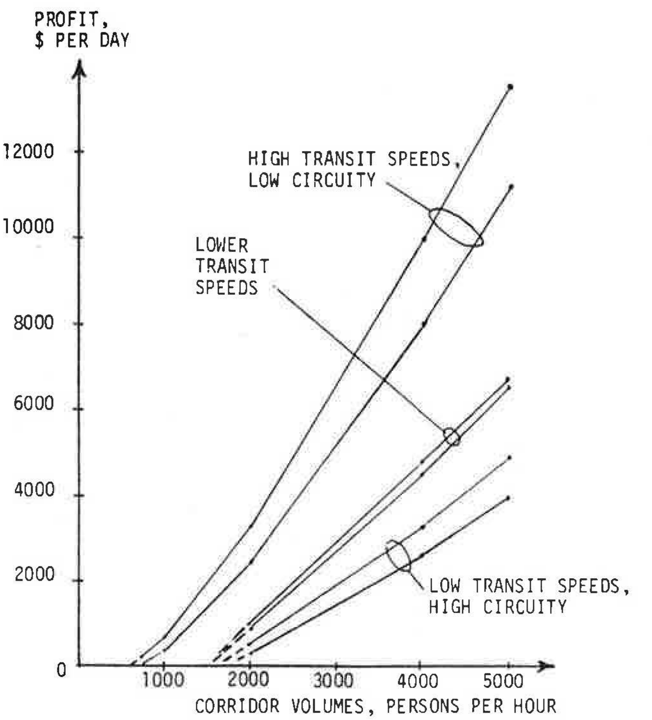

FIGURE 4 General patterns of profitability and market characteristics for maximum profit choices.

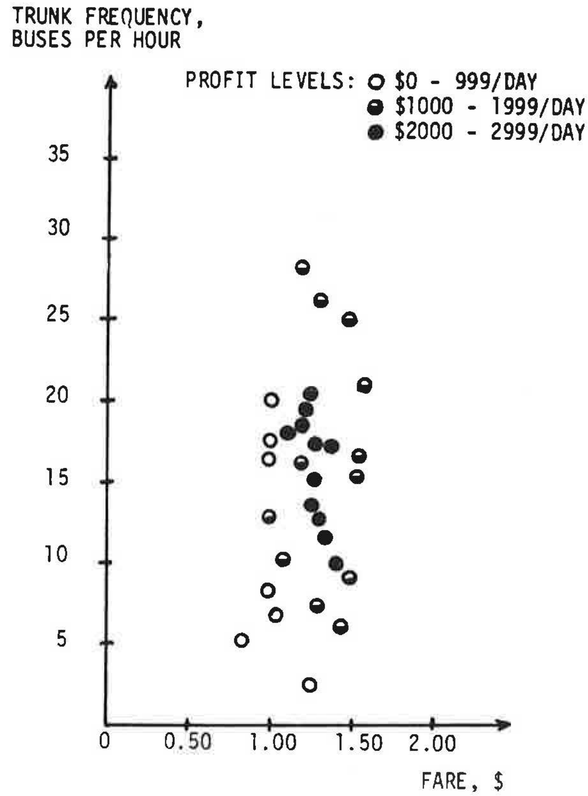

FIGURE 5 Example of ranges of fare, trunk frequency, and profit for peak-hour travel volume of 2,000 persons per hour. Other conditions are S = 30 mph, SPD = 12 mph, ASPD = 25 mph, XL = 0 mile, and L = 8 miles.

this reduces the risk to the carrier that results from imperfect market information and makes entry into the industry much more attractive.

By a serendipitous exploration of the feasible region of service characteristics, a large collection of feasible points for selected market characteristics was obtained. Although these points do not necessarily indicate the precise boundaries of the region of profitability, they do give some idea of the size of that region.

The general pattern of the results is shown in Figure 5, which is for a market situation of 2,000 travelers per peak hour and other conditions as given in the figure. Profitable points are obtained for a range of frequency from 2.5 to 26.1 buses per hour and for fare values from $0.83 to $1.53 (1973 dollars). The general pattern here is roughly an ellipsoidal shape covering a substantial range of values. The highest profit seems to be toward the center of this region. This is the general pattern obtained from analysis of other markets as well. It clearly indicates that a carrier can select a value of price and of service characteristics anywhere within a substantial range and still operate at a profit.

Competitive Conditions

In interpreting these results, it is important to bear in mind three features of the situation modeled. First, the transit firm is left completely free to choose its service and fares. It is not limited in any way by a regulatory agency of the sort that has existed in all states and has regulated transit when it was provided by private firms. Such an agency could set fares or other conditions of service such that a profit was impossible, and thus the existence of such an agency would act as a deterrent to private investment in transit.

Second, the private transit firm does not face any transit competitors, in particular one that is subsidized. A subsidized competitor could easily set its fares or service levels so as to drive a private firm out of business. This situation was modeled with an extension of the model presented earlier, and under almost all conditions an unsubsidized operator could be driven from the market (3).

Finally, there is only one transit operator in each market. Behavior and results for more than one operator could be quite different. The reason for assuming a single operator is that at present this is the general pattern. With this situation a profit-maximizing transit operator could be either the present transit authority or a new private firm. Allowing more than one operator in a market may be desirable but was not analyzed here.

Comparison of Fares and Service Characteristics

In this section the fare and level of service offered by the profitable bus operation are compared with those of typical U.S. transit systems. In the case of fare, comparison is done with reference to the major U.S. bus transit systems as well as one large commuter or regional rail service. The latter comparison was done because the average trip length considered is rather long compared to that for bus systems, but it is similar to the average for commuter rail systems. In the comparison of level of service, vehicle frequency of the profitable bus service is compared with peak-period frequencies typically found on bus routes with the same passenger volume.

Figure 6, taken from Morlok and Schueftan (8,pp. 2-168), shows the average fare and trip length for Chicago Transit Authority (CTA), Massachusetts Bay Transportation Authority (MBTA), New York City Transit Authority/Manhattan and Bronx Surface Transportation Operating Authority (NYCTA/MABSTOA), Southeastern Pennsylvania Transportation Authority (SEPTA), and Washington Metropolitan Area Transit Authority (WMATA) systems and those for profitable bus operations for the year 1979. For the profitable bus operation, the range of fares corresponding to maximum profit, as well as the lowest fares in the profitable service-price region, are shown. These ranges apply to peak hourly travel volumes of 5,000 and 2,000 persons per hour for the spectrum of the conditions described earlier. Lines L1 and L2 mark the upper and lower bounds of fare per unit distance prevailing in the major U.S bus systems. It is clear that in the case of maximum-profit operation the fares per unit distance for profitable bus operation are well within the upper bound. As for the lower fare per unit distance (with positive profit) they are much less than even the lower bound of the existing major U.S. bus systems. Of course, the total fare for the profitable bus service is considerably higher than that for the city bus services, reflecting in part the considerably longer trip length.

Figure 7 shows the minimum fares with positive profit of the profitable bus service and commuter rail fares of SEPTA's Philadelphia Division (excluding the state of Delaware) as of March 1982. The SEPTA fares were obtained by dividing the unlimited calendar monthly fare over 44 trips, assuming 22 workdays in a month. It is clear that for both the 5,000 and the 2,000 persons per hour cases, the minimum fares are in most cases about the same as SEPTA fares.

A final comparison focused on the quality of service, specifically frequency. In general, transit operators increase frequency with increasing passenger volume (above the peak-load point), so the relationship between frequency and passenger volume for the maximum profit express bus service was compared to the relationship observed on the CTA bus routes [a regression equation, $f = 4.10 + 0.013p$, with f in buses per hr, p in passengers per hr (8,p.16)]. The results of the comparison were that the maximum-profit service frequency was greater for any given passenger volume of more than about 590 passengers per hour. In general, the trunk portion of radial transit routes would be expected to have a passenger volume greater than 590 persons per hour, so in general the profitable service would have a higher frequency than the usual public authority service. Furthermore, even the apparent superiority of the CTA service at low volumes should be considered in the light of the fact that the Chicago relationship was developed from data for a 2-hour peak period. It is highly likely that if data were available for the peak hour alone, the profitable bus service would be superior in frequency even at low volumes. This is based on the general observation that virtually all large city radial transit routes have many standees

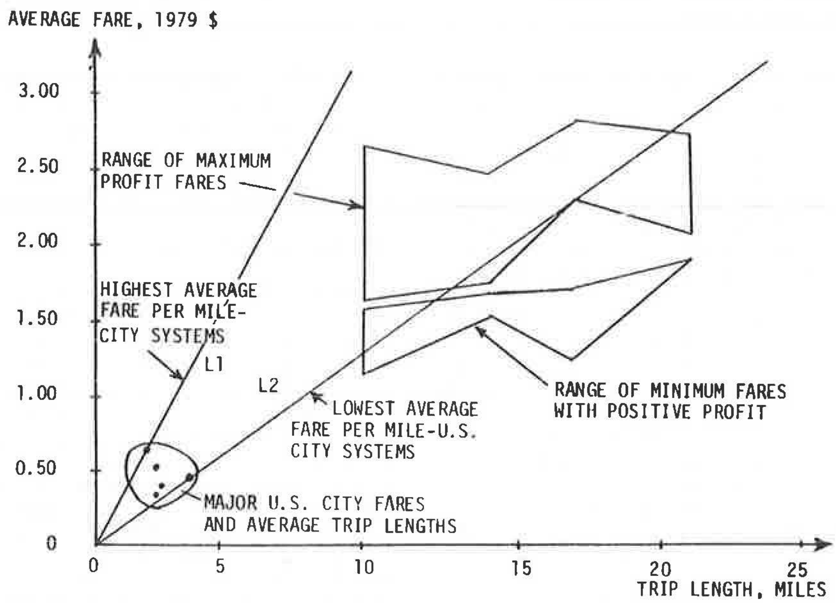

FIGURE 6 Comparison of fares in profitable service-price region with major U.S. bus system fares (in 1979 $) for various trip lengths *(8)*.

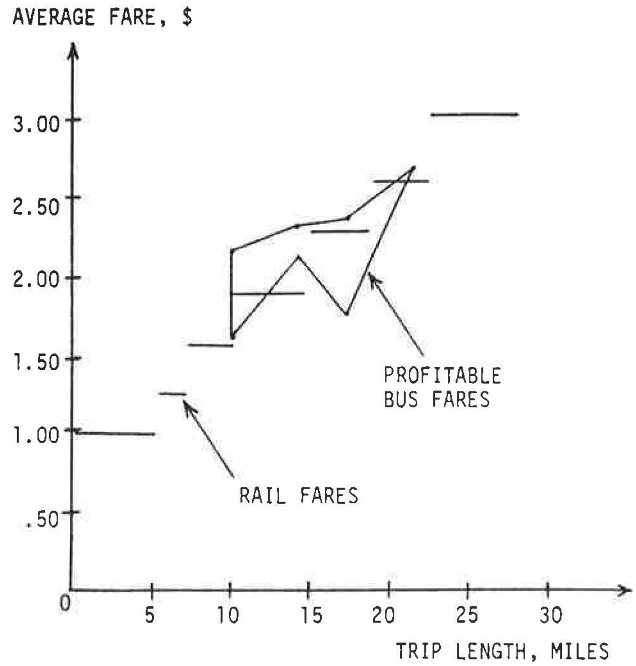

FIGURE 7 Comparison of lowest fares in profitable service-price region with Philadelphia (SEPTA) regional rail fares (in 1982 $) for various trip lengths.

at peak hours, whereas a profitable bus service is modeled to provide seats for all.

Empirical Validity

An important question is naturally the empirical validity of these results, by which is meant the extent to which real-world observations conform with (or vary from) the results. Such an analysis is naturally hampered by the very fact that led to the choice of the modeling approach in the first place, namely that virtually all providers of public transit in the United States do not have as a primary goal the maximization of profit. However, there are a few instances of profitable transit in the United States, and some tests can be applied to conventional, unprofitable U.S. transit.

The only large-scale example of profitable conventional bus transit identified in the literature appears to be the express bus services connecting the Manhattan business district with the residential boroughs of New York City. This type of service was introduced in 1967 by a private firm operating a route from Queens to Manhattan, under a franchise granted by the city's Board of Estimate, which controls rates, fares, and certain aspects of service quality (2). This initial route was a success in terms of passenger traffic and profit, and its success stimulated other private firms as well as the city-owned transit authority to seek approval for routes, which now number more than 50. Until recently those routes operated by private firms were provided without any form of subsidy; fares were increased to cover cost increases. These routes were surely profitable, for firms willingly entered the business and service was sustained. Moreover, detailed studies made by the city of New York of costs and revenues of selected express routes indicated profitability.

These services fit the pattern of profitable service resulting from the preceding modeling analysis. Almost all of the express routes serve person-trips from 12 to 18 miles (19 to 29 km) in length, and the fares are higher than traditional transit (typically two to three times the flat city transit fare). Service quality is very high compared to conventional transit; buses are usually of the suburban or intercity design with high-backed seats and air-conditioning, and most operators provide seats for most if not all passengers.

Although the services offered and fares charged are qualitatively as predicted by previous modeling work, the institutional structure is not ideal from the standpoint of a profit-maximizing operator. The Board of Estimate must approve any fare change, and in a period of rapid inflation refusal to grant increases could result in deficits. In addition, the city-owned transit authority provides regular lower quality transit service (rapid rail or bus) parallel to the express lines and could engage in predatory competition designed to drive the private express bus lines out of business. But apparently many New York firms have been willing to take the associated risks.

In recent years some minimal subsidy has been offered to private express bus operators, but the two largest private express bus operators have refused such subsidies, operate profitably, and pay the city a 4.5 percent gross receipts tax. Four other operators are covered by state data for 1980. Of these, three had passenger revenue (before subsidy) exceeding costs, and the fourth had a deficit of less than 10 percent of revenue before subsidy (9,pp.68-71). The profit or closeness to profit--despite direct competition from subsidized transit, offers of subsidy, fare regulation, and the gross receipts tax--certainly does not contradict the results of the modeling.

A few other instances of provision of medium-distance transit service (10-18 mile routes) by private firms exist in the United States, including service in the metropolitan areas of New York (from New Jersey), Hartford, Boston, Houston, and Los Angeles (2,10). Fares, routes, and in some cases schedules are regulated for all of these services. Thus management is not free to choose service and price to achieve a profit. That most operate at a deficit is not inconsistent with the previous analysis.

Commuter bus clubs represent another relevant set of examples. Because these clubs are not for-hire carriers, fares and service are usually not regulated. Such clubs exist in many areas, but data are largely unavailable. However, the clubs must usually cover all costs from fares (generally monthly tickets). One club operates between Columbia, Maryland, and Washington, D.C., with about 600 passengers per day each way, at a fare of $2.55 for the approximately 30-mile trip. In the Chicago area Spartan Services totaling about 75 buses each way serve suburb-to-CBD trips at about one-half the corresponding fares on the regional rail lines. Again these data are broadly consistent with the results of the present modeling.

An interesting study was recently completed in the Los Angeles area of the degree to which some existing medium- to long-distance peak-period-only express bus services could be operated at a profit. Although all 13 regular-service routes now produce a deficit, six were estimated to be profitable under private operation because of lower cost alone, and an additional five were estimated to be profitable with fare increases of up to 53.0 percent (11,pp. 28-31). The resulting service would be similar to that emerging from the modeling efforts.

Finally, there exist a number of profitable transit services abroad, and these have been reviewed

(12). Although they vary widely in service type, many of the profitable services, especially in higher income areas (relatively so, for developing nations), are of the high-quality and high-price type compared to other transit service in the same area or nation. Again, this is broadly consistent with previous findings.

To summarize this section, it must be reiterated, first, that in general private firms are prohibited from entering the transit field in most metropolitan areas of the United States and, second, that even if they did enter they would be subject to regulation of fares and service that could easily result in deficits or bankruptcy. Thus the fact that there are few instances of profitable privately provided transit is to be expected. However, the service offered by the express bus operators in New York City and the results of the independent analyses of potential profitability of such services in Los Angeles do conform to the modeling results.

CONCLUSIONS

The first conclusion is that, in general, it appears to be possible to operate a workday peak-period-only bus service for medium to long trips (longer than 8 miles) at a profit under a wide variety of conditions. With typical income distributions, this seems possible with a total corridor passenger volume of 2,000 persons or more per hour and often is possible at much lower volumes depending on corridor road and traffic conditions. Furthermore, service can be made profitable by offering a price-service package anywhere within a rather large range of fares and frequencies, indicating that it should be relatively easy to implement such a service even with imperfect knowledge of the demand function for transit. Such service would have fares comparable to those of commuter railroads, graduated by distance. These fares would be considerably higher than typical flat in-city transit fares but would be lower on a per mile basis. The frequency of buses would, in general, be higher than that found on typical bus transit routes today, and all travelers could be provided with seats. Thus the level of service would generally be higher than that of typical city bus transit services except possibly at very low volumes.

Some important limitations must also be pointed out. The analysis assumed that there is only one transit operator in each market; that the operator faces no subsidized transit competition; and that the operator can choose service quality and fares freely, unrestricted by a regulatory body. The creation of such conditions would require major changes in transit institutions.

On the other hand, it is equally important to note that the present results may be far more conservative than the discussion indicates, because costs typical of large regional public transit authorities were used. Recent research has revealed that small, competitive, private firms generally have lower costs--often 50 percent lower--than do public carriers (13). If such costs were used instead of those typical of public carriers, the range of profitability would certainly increase substantially. Finally, the minimum fares required for profits should be far less than those reported here.

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Economics of Private Operator Service

EDWARD K. MORLOK

ABSTRACT

Current evidence suggests that private firms can operate urban transit service at about one-half to two-thirds the costs experienced by typical publicly owned regional authorities. Competition appears to be critical in disciplining labor and management, and hence a means of achieving such low cost is to have private firms bid competitively for contracts to operate service. A public agency would retain control over what service is provided and act as a service sponsor engaged in planning, finance, and contracting with private service operators. Contracting service to private firms has already begun in many metropolitan areas; in smaller systems all services are often contracted, and in larger systems contracting has been used for services for which the cost savings are expected to be especially large.

If there is a single, major driving force behind the consideration of having private firms produce urban transportation, it is surely the belief that substantial cost savings would result. The purpose of this brief review is to examine the evidence about the relative cost of private producers of urban bus transportation compared with that of publicly owned producers, and to attempt to draw conclusions about the magnitude of possible cost savings and the conditions under which cost savings are likely to result. Other benefits from involving the private sector are likely to be important, and these will be discussed briefly.

DEFINITION

When discussing the involvement of the private sector in transit service, it is important to distinguish clearly between two different roles. These are the roles of service sponsor and of service operator. A service sponsor decides what service is to be provided and its characteristics, such as routes, schedules, and fares, and arranges for provision of the service. The sponsor's role is essentially one of policy making, planning, and facilitation. The service operator, on the other hand, actually produces the service--operates the vehicles, maintains them, hires the drivers, and so forth. There is no reason why these two roles, sponsor and operator, must be fulfilled by the same organization, and in many public services the two roles are separate--waste disposal, for example, where a city contracts with private firms for garbage and trash collection, or roads where governments contract with construction firms for road building and often for maintenance. Transit has evolved into a pattern where the same organization typically is both the sponsor and the operator, but this need not be the case. The economics of private firms as service operators will be focused on because it is through the production of the service that cost savings are expected. The public sector would remain the sponsor of the service and retain control over the amount and quality of transit service provided.

BACKGROUND

Before turning to the comparative costs, it is useful to put this discussion in the perspective of the trend of escalating transit costs since public takeover. Table 1 gives data on the average cost per vehicle-mile of operating transit vehicles in the United States from 1950 to 1980. All costs have been adjusted for inflation using the Consumer Price Index. The costs for all modes have generally been increasing, and the average cost for all transit modes (except commuter rail) in 1980 was two and one-quarter times the average cost in 1950. (Commuter rail data from before 1970 are not available.)

In the same period transit in the United States went from a situation in which revenues exceeded costs to one in which revenues covered less than 40 percent of operating costs and virtually no capital expenditures. The rapid escalation of costs and of deficits is of course a primary motivation for considering alternative ways in which the service might be provided at less cost.

TABLE 1 Trends in Transit Costs in Dollars per Vehicle-Mile, 1950-1980[a]

Year	Bus and Streetcar[b]	Rail Rapid Transit[b]	Bus and Streetcar and Rail Rapid Transit	Commuter Rail
1950	n.a.[c]	n.a.	1.38	n.a.
1955	n.a.	n.a.	1.56	n.a.
1960	n.a.	n.a.	1.65	n.a.
1965	n.a.	n.a.	1.71	n.a.
1970	1.87	3.20	2.07	3.56[d]
1975	2.45	3.93	2.63	n.a.
1980	2.95	3.79	3.11	5.93[b]

[a]In 1980 constant dollars, adjusted using Consumer Price Index.
[b]From Pucher et al. *(1,p.158)*.
[c]n.a. indicates not available.
[d]From Morlok *(2)*.

PRIVATE VERSUS PUBLIC COSTS: EVIDENCE

Data on the costs of producing essentially identical service in the United States by public agencies and private firms are scarce, mainly because so few transit services involve private firms, so data from a variety of sources will be used.

The first type of cost comparison is between entire systems operated by public organizations and ones operated by private firms. The comparisons should be between services that are similar in quality and other features, and are in the same region, so that possible regional differences in some costs, such as wage rates, do not affect results. The results, including data for the United States and two other developed nations where studies of comparative costs have been completed, are given in Table 2. The results are striking: Private operator costs are about one-half of public operator costs.

TABLE 2 Comparison of Average Costs per Vehicle-Mile for Private and Publicly Owned Transit Services in Various Countries

Location	Service Type	Year	Ratio of Private to Public Costs
Australia[a]			
Melbourne	Urban bus	1970-1977	0.55-0.58
Other areas	Urban bus	1972-1973	0.50-0.65
United Kingdom[b]	Local rural and interurban bus	1977	0.58
United States			
Cleveland[c]	Urban bus	1982	0.60
Los Angeles[d]	Peak-period-only bus	1982	approx. 0.50
New York City Suburbs[e]	Urban bus	1980	0.53

[a]From Wallis (3,p.606).
[b]From Tunbridge and Jackson (4,p.6).
[c]Private communication.
[d]From Southern California Association of Governments (5).
[e]Calculated from UMTA data (6).

In addition, there have been a few instances where counties (or other local governments) have decided to have transit provided by the least expensive producer of the desired service rather than by the regional transit authority. Counties have selected an operator (or operators) by arranging competitive bidding for service contracts, and usually both the regional transit authority and various private firms have made bids. In all known cases, a private bidder has won; and a few examples of the cost saving resulting from choosing a private firm instead of the public operator are given in Table 3. The general pattern is clearly one of substantial savings from use of private producers, on the order of 50 percent. Furthermore, because of the very nature of the contracting process, these are situations in which the bids of private and public operators are for identical service. It is also important to note that savings have been realized both in large metropolitan regions and in smaller areas.

TABLE 3 Examples of Cost or Deficit Reduction from Competitive Contracting

Location	Service	Cost Savings (%)
Hammond, Indiana	All local bus service[a]	Approx. 50
Yolo County, California	Local and commuter bus service[b]	Approx. 50
Santa Clarita Valley, California	Local and express bus service[c]	40-50

[a]Private communication with P. T. Coulis, Yellow and Checker Cab Co.
[b]Private communication with W. Bourne, Commuter Bus Co., Sacramento.
[c]From Cox (7).

Although this evidence reveals that small private firms can and often do produce transit service at much less cost than do public authorities, it is important to realize that operation by private firms does not guarantee drastically lower costs. This is illustrated by the situation in New York City, where private firms continue to provide about 15 percent of the local transit service. Each local-service bus firm, which also provides some express bus service, has exclusive or monopoly rights to the routes it operates. But fares and other service features are regulated, and these firms are subsidized. In 1980 the average cost per bus-mile, exclusive of depreciation, of the five primarily local-service carriers was 17 percent below that of the transit authority (8). Some of this difference was accounted for by the higher average speeds on their routes--their average speed was 25 percent greater than that of the transit authority. Further complicating any comparison of costs is the fact that any major rehabilitation costs are included in the private firm costs but not the public authority costs. However, it is clear that the effect of having private firms produce transit under these traditional monopolistic conditions, with subsidies making up deficits, is little if any reduction in cost.

Additional examples of the effect of monopoly power were reported in a recent study of noncompetitive service contracting (9). The operations examined were in relatively small communities: Sioux Falls, S.D., Reno, Nev., Worcester, Mass., and a number of towns in Connecticut that are served by the same company. In two of the cases, costs were not comparable, but in the other two cases (Worcester and Connecticut) is appears that noncompetitive service contracting was slightly more expensive than production of the service by public authorities. In addition, other disadvantages of noncompetitive contracting were cited, such as cost-cutting that led to service degradation when contracts were of the fixed-cost type.

This discussion would be incomplete without reference to the recent study by Philips and Rat (10) on the costs and benefits of public ownership of transit, which has received wide publicity (see, for example, 11). Some reviewers interpreted this study as demonstrating that public sector production of transit service is more efficient than alternative forms that involve private sector participation in production. But such conclusions cannot be drawn on the basis of that study, for in reality the study did not compare the costs or benefits of public agency operation of service with the costs and benefits of private sector involvement.

It is clear that, in a significant number of instances, the observed costs of private carriers are substantially lower than the costs of public providers. But private firms are not always cheaper. Why is this so? The examples presented here point to three factors to be examined: competition, labor costs, and economies of scale.

FACTORS INFLUENCING COSTS

Competition

That competition would work to keep costs down is a proposition that hardly needs support. Although market imperfections can thwart this in some cases, the effect of competition on costs and prices is so widely seen that few would question its validity or its importance.

The examples described in the previous section illustrate the power of competition to keep transit costs low. The best examples are in service contracting: Noncompetitive service contracts were judged to result in costs somewhat higher than those of the public authorities that replaced them, and there were other service disadvantages. In contrast, those cases in which competitive bidding was used resulted in private firms being able to produce the transit service at a lower cost--typically about 50 percent less--than the public regional authority could. But there need not be overt competition between prospective service producers to provide the pressure necessary to keep costs low. All that is necessary is the possibility that another firm could enter the market if the present producer became inefficient. This explains why some private transit firms that do not face any direct transit competition would continue to remain efficient. Also crucial are the ability of the firm to make an adequate profit in the transit business, with or without subsidy, and the absence of a motive to sell out to a public authority. There is pressure to keep costs low enough that no incentive exists for public bodies to transfer the franchise to another firm or to a public authority. Given the typical institutional arrangements of transit, one or more of these conditions are generally absent as a result of regulated monopoly status and need for subsidy, so that there is little pressure to keep costs low. But creation of competitive contracting can bring these forces into play.

In the rare case in which the transit firm tries to make a profit without government subsidy, competition with alternative means of transport would work to contain costs and also to provide service quality and price tailored to the market. In general, regulation constrains management, but in at least a few cases it does not do so to the point of eliminating the possibility of self-supporting service. Examples include the very successful express bus services in New York City, the new suburb-to-central business district (CBD) commuter buses in the Chicago area, and a few small services elsewhere. (See Morlok and Viton elsewhere in this Record for a discussion of these.)

Labor Cost Differences

In general, labor costs are lower for small private firms and small public agencies than for a typical large regional transit authority. This stems from a combination of lower basic wage rates, including benefits, and less restrictive work rules. Because labor costs typically account for 50-70 percent of transit operating costs, the effect of reduced labor costs can be substantial.

The most comprehensive study of this was done in the Philadelphia metropolitan area. As has been the case in other studies of labor costs, it was found that driver pay per unit of work performed (vehicle-mile driven) increased substantially with increases in the size of the organization, the effective wage rate in the larger organizations being twice that found in the smallest. Furthermore, this holds even with an adjustment for the difficulty of the job as reflected in the size of the vehicle operated (measured by its capacity).

The data given in Table 4 reveal this pattern. The relative cost of drivers, including wages and benefits, is expressed here on a per vehicle-mile basis, with the cost for various vehicle and firm sizes given as a percentage of the cost for the largest firm and largest vehicles. This suggests that if a single regional (monopoly) transit organization were to be replaced with a number of smaller organizations, one would expect the wage bill to diminish substantially. The halving of total operating costs found in aggregate comparisons of the sort presented in Tables 2 and 3 is entirely consistent with this result for wage rates.

TABLE 4 Effect of Firm Size and Vehicle Size on Driver Costs: Wages Plus Benefits in Dollars per Vehicle-Mile as Percentage of Costs for Largest Firm and Vehicle[a]

Vehicle Seating Capacity (and type)	Firm Size (total operating revenue in $000s/yr)		
	400	100,000	275,000
5 (taxi)	30	45	71
11 (van)	33	48	74
25 (minibus)	38	53	81
45 (charter bus)	48	63	90
66 (transit bus)	59	74	100

[a]Calculated from Equation 3.2 in Morlok and Krouk (*12*, p.111).

Actual examples can be found of this pattern of lower wage rates prevailing among firms providing transit services. In the area served by the large Alameda-Contra Costa (AC) Transit System (840 buses) in the San Francisco area, AC Transit pays its drivers $12.21 per hour. But two small transit systems in the same area--one serving the central part of Contra Costa County and the other the eastern part--pay only $8.01 and $5.25 per hour, respectively. In the Philadelphia area, the small private Schuykill Valley Lines had paid its drivers about 70 percent of the wage rate of the regional transit authority before the service was taken over by that authority. Since then the drivers' union has successfully negotiated with the authority to reduce the pay difference (13). In the Boston area, a recent study found that the transit authority's labor costs are as much as three times those of private, nonsubsidized operators of transit (14).

Further supporting the important effect organizational size has on the wage rate is the fact that the same pattern has been observed in all types of industry (15). Among the various factors that explain this phenomenon (16), the most important seem to be the following: First, workers seem willing to trade off the increased recognition of their work and importance of their position in a smaller firm for somewhat lower wages. Second, differences in wage bill per unit of output might be due to more fully using the time paid for in small firms. There is probably less chance of a labor-management agreement in small firms specifying regulations that lead to some workers being paid for time during which no work is performed. In a small firm there tends to be a lack of anonymity among workers, and workers in jobs that require a full effort would be aware and resentful of other workers with an easy job or nothing to do. Third, firms with smaller market shares tend to face more intense competition than do larger ones and hence would have little opportunity to provide workers with higher wages. Finally, it has been observed that smaller firms are less likely to be unionized than larger ones, reflecting in part union targeting of organizing efforts on firms in which the increase in membership is likely to be greatest. In addition, in the case of transit, firms that are successful in keeping wages low seem to choose their workers carefully. Often they try to hire persons who want to work part time only and who are not the main breadwinners for their families. Although these explanations apply primarily to private firms, they also could apply to carefully managed small public transit authorities.

Scale Economies

An important reason often advanced for having transit services provided by a single regional authority is that it is less costly for all service to be produced by one organization than by many. The evidence simply does not support this assertion.

As has been said, small organizations have substantially lower costs as producers of transit service than do much larger regional authorities. Even within regional publicly owned authorities, diseconomies of scale are evident. A recent study of this (17), using data for almost all public firms in the United States in 1975, resulted in the following conclusions: For the smallest systems, increases in bus-miles result in cost per bus-mile declining slightly; for firms producing between 1.0 and 5.5 million bus-miles per year (the latter being the size of the public system in Albany, N.Y.), average costs do not vary with output; and for the largest

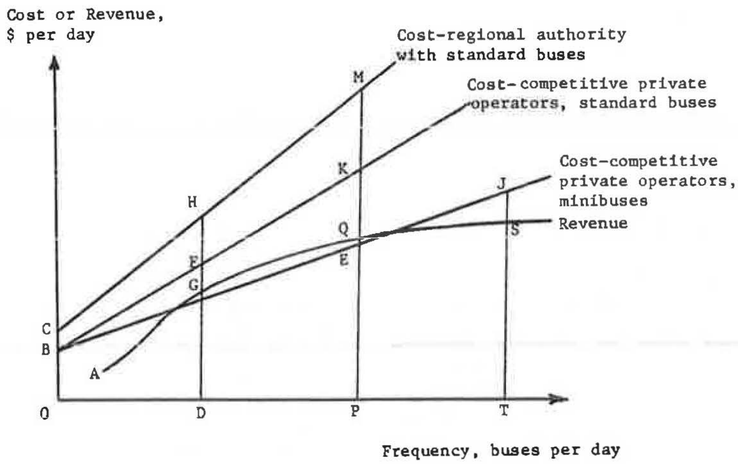

FIGURE 1 Impacts of cost reduction on service quality and deficits.

systems, increases in bus-miles increase average costs substantially. Although there are undoubtedly economies of scale in some aspects of bus operation and diseconomies in others, the net effect at the present time is that, in general, there are no economies of scale in total cost in medium to large publicly owned systems.

IMPLICATIONS FOR SERVICE QUALITY AND QUANTITY

It is appropriate to discuss some of the benefits that might result from dramatically lower costs. These benefits will be described in terms of the impacts on a single transit route. A single route was chosen for ease of presentation. The discussion will focus on Figure 1. This figure is intended to show various effects of changing the departure frequency of buses operated on this single route. All other service features, such as the fare, and other measures of quality, such as air conditioning, are presumed to remain constant.

In Figure 1, the curve AGQS is a revenue curve that is simply the product of the constant average fare and the number of passengers using the system. The form is the S-curve that is typically found in transit demand studies. The line above this, CHM, represents the cost of producing service, as a function of frequency, by a regional authority with relatively high costs. A likely departure frequency is D, for which the costs DH exceed the revenue DG by an amount HG. This would be the subsidy required for this route, and limitations on that subsidy would determine the maximum service level that could be provided.

The effect of providing the service at lower costs is illustrated first by the line BFK; the lower threshold cost as well as the lower slope reflect the effect of operation of the service by private firms through competitive contracting. The subsidy required at frequency D is much less, only FG. The frequency could be much higher, perhaps equal to P where the subsidy required is QK, approximately equal to HG. Going one step further, if this service were provided with smaller vehicles, such as minibuses, the cost per departure would decrease (for illustrative purposes) even more, according to the data on labor costs of Table 3, to the level of line BEJ. Here a positive profit is shown at some frequency levels, such as P. If a subsidy were still to be provided, even more service could be offered--frequency T.

CONCLUSIONS

In the discussion of the private provision of public transportation, a return to bygone days when tightly regulated private monopolies provided virtually all urban transit service was not advocated. That arrangement clearly did not work, and there is no evidence to suggest that it would now. Instead, what is being discussed is a way of achieving two desirable objectives in the provision of public transit service: having the service provided at the least total cost to society and retaining public control over what service is provided, so that it continues to be responsive to overall community needs.

Achieving these goals requires a fundamental change in the planning and provision of such public services. This change is to abandon the idea that the only way to provide such service is by a single regionwide government-owned organization. Instead, buses would be operated by whatever organization is most appropriate, be it public or private. Often the most efficient operators are private, and these would operate service under contract to an appropriate public body. Through this arrangement the efficiency of private firms acting competitively can be harnessed to serve the public interest.

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Effect of Ridesharing Programs on Suburban Employment Center Parking Demand

JAN ALEXANDER AARTS and JEFFREY HAMM

ABSTRACT

There are several notable examples of successful ridesharing in the United States. There is, however, currently no general body of evidence that can be used by employers, government officials, and developers to predict the percentage reductions in both long-term parking demand and in employee automobile trips that can be achieved at a specific employment site as a result of establishing an organized ridesharing program. To gather information about the effects of a ridesharing program, Seattle/King County Commuter Pool initiated a parking use study in the winter of 1983 that involved 14 office sites in suburban King County. Suburban sites were selected because they tend to minimize the number of extraneous variables that can complicate a parking use analysis. The 14 sites selected were similar in terms of (a) surrounding land use, (b) employee density, (c) employee activity, (d) site configuration, and (e) level of available transit service. The only notable difference among the sites was that 7 of the 14 operated organized ridesharing programs for their site employees. Average parking use rates for these two groups were compared to determine if a measurable difference in parking demand, which was due solely to the presence of the organized ridesharing programs, could be detected. The study's objectives, research methodology, and basic findings are discussed and some key factors that emerged in association with the ridesharing programs and the different levels of parking demand are analyzed.

The Seattle/King County Commuter Pool is a regional transportation agency involved in the promotion and organization of commuter ridesharing options in the region. A significant portion of Commuter Pool's activity involves interaction with employers, local government officials, and commercial real estate developers in an effort to encourage these groups to provide the region's commuters with incentives to rideshare.

There are several notable examples of successful ridesharing in the United States. A number of large employers (e.g., 3M Company, Bechtel Corporation, Lawrence Livermore Laboratories, TVA, Conoco, Arco, and Aetna Life Insurance Company) have achieved significant reductions in long-term parking demand and employee automobile trips as a result of providing their employees with incentives to rideshare. There is, however, currently no general body of evidence that can be used by employers, government officials, and developers to predict the percentage reductions both in long-term parking demand and in employee automobile trips that can be achieved at a specific employment site as a result of establishing an organized ridesharing program. Such evidence would be very valuable to local agencies involved in promoting ridesharing and to administrators of rapidly growing communities faced with limited financial resources to improve the capacity of their transportation system. For example, some suburban communities are being asked by developers and employers to reduce local minimum parking requirements in return for establishing an organized ridesharing program for site employees. Information of this type would aid in evaluating such a request.

To gather information about the effects of a ridesharing program, Commuter Pool initiated a parking use study in the winter of 1983 that involved 14 office sites in suburban King County. Suburban sites were selected because they tend to minimize the number of extraneous variables that can complicate a parking use analysis.

The 14 sites selected were similar in terms of (a) surrounding land use, (b) employee density, (c) employee activity, (d) site configuration, and (e) level of available transit service. The only notable difference among the sites was that 7 of the 14 operated organized ridesharing programs for their site employees. Average parking use rates for the two groups were compared to determine if a measurable difference in parking demand, which was due solely to the presence of the organized ridesharing programs, could be detected.

The study's objectives, research methodology, and basic findings are discussed and some key factors that emerged in association with the ridesharing programs and the different levels of parking demand are analyzed.

OBJECTIVES

Suburban office complexes are fairly common in King County and their numbers continue to increase as demand for non-Seattle central business district (CBD) office space remains strong. A number of these office complexes have established employee transit and ridesharing programs either on their own or with the assistance of Commuter Pool. Typically, these transit and ridesharing programs include some combination of the following components:

- An on-site employee transportation coordinator who promotes and organizes transit use and ridesharing,
- Ridematch services to aid in the formation of carpool groups,
- Convenient parking reserved specifically for carpool and vanpool vehicles,
- Flextime to allow employees the freedom to adapt their work schedules for ease of pooling,
- The provision of commuter vanpool or carpool vehicles,
- A direct monetary bonus to those employees ridesharing, and
- Ongoing promotional marketing efforts.

The objective of this study is to determine what effect organized ridesharing programs have on the long-term employee parking demand at suburban office sites in King County. Specifically, this inquiry is to test the assertion that transit and ridesharing incentive programs can produce a reduction in parking demand at a suburban office complex. Accurate information of this type is becoming increasingly important as local jurisdictions look for ways to reduce traffic congestion in the face of continued growth and as developers seek to reduce the amount of land devoted to parking.

METHODOLOGY

Site Selection

The intent of the site selection procedure was to create two separate groups of office sites that had in common as many site characteristics as possible, except the presence or absence of an organized ridesharing program. To accomplish this, a number of qualifying criteria were established for use as a selection guide to achieve a high degree of intergroup comparability.

All of the qualifying criteria had to be met in order for a particular site to be selected. The criteria were as follows:

1. Location in suburban setting: This criterion ensures that the sites chosen are situated in low-density settings where employees rely most heavily on the automobile for commuting.

2. Minimum 50 percent of site's work force in office-related activities: This criterion standardizes the employment profile for all of the sites and eliminates the possibility that employment type might be controlling the relative propensity of employees to rideshare.

3. Day-shift work force minimum of 150 employees: One hundred fifty employees are considered a threshold level below which an organized ridesharing program will have little effect. The logistics of forming a ridesharing arrangement require that the pooling members live reasonably close together. The home and trip distribution pattern of fewer than 150 people, in a metropolitan area, will not yield a sufficient number of potential carpools or vanpools.

4. Maximum 5 percent peak-hour transit mode split: High transit ridership could account for low parking use at a site. Therefore, this criterion ensures that each of the sites selected has similar high levels of ridesharing potential.

5. Designated free parking area adjacent to building: This criterion permits an accurate accounting of all vehicles belonging to site employees. This eliminates possible distortions in parking use counts that could result if off-site parking were being used.

Initially 220 Seattle-area employment sites were considered and evaluated for participation in the study. Many were participants in a recent employer/employee survey conducted by the U.S. Department of Transportation (1).

Sites that scored favorably during the initial investigation were further evaluated through personal contacts and site visits. In this manner the field of 220 prospects was systematically reduced as those sites not meeting all established criteria were eliminated from consideration. Eventually seven eligible nonridesharing sites were found to represent group 1, and seven additional sites, each currently operating active ridesharing programs, were found to represent group 2 (Tables 1 and 2). The sites composing group 2 have at least the three following program elements in common:

- An on-site employee transportation coordinator who actively promotes and organizes ridesharing activities,
- Ridematching assistance to aid in the formation of carpool groups, and
- Preferential parking for carpools and vanpools.

Four of the sites in group 2 provided ridesharing incentives beyond the three listed above. At one site the employer sponsored company vanpools. Two sites provided monetary subsidies to employees who used alternative forms of transportation. At the last site the employer sponsored a fleet ride program using the organization's pool vehicles.

Ten of the 14 sites selected involve at least 80 percent of their work force in office-oriented activities such as administrative, professional, and clerical functions. The remaining four sites, two from each group, involve at least 50 percent of their work force in such activities, the balance being involved in light manufacturing and assembly work.

Of the 14 sites selected, 11 are occupied by a single tenant. The remaining three are occupied in varying proportions by a mix of tenants. Each of these sites has one major tenant who represents at least 50 percent of that site's total employees.

TABLE 1 Background Information on Group 1 (nonridesharing)

	Employees				Supply	
Facility	Total	Per 1,000 Gross Square Feet	Square Footage Occupied[a]	Parking Spaces Available	Ratio per 1,000 Gross Square Feet	Supply Ratio per Employee
Branch office of a regional telephone company	325	5.68	57,200	315	5.51	0.969
Headquarters of a large local retail store and others	160	2.91	55,000	261	4.75	1.631
Large engineering firm and financial services	404	3.87	104,443	413	3.95	1.022
Headquarters of a small local telephone company	240	5.56	42,500	180	4.24	0.750
A large computer firm and data processing services	226	3.77	60,000	278	4.63	1.230
Pharmaceutical company	700	2.33	300,000	736	2.45	1.051
Pharmaceutical company	850	4.52	188,000	720	3.83	0.847
Average	415	4.09	115,306	415	4.19	1.071
Standard deviation	261	1.26	94,938	549	0.954	0.290

[a]Square footage occupied is, in all cases, 100 percent of total square footage.

TABLE 2 Background Information on Group 2 (ridesharing)

Facility	Employees Total	Employees Per 1,000 Gross Square Feet	Square Footage Occupied[a]	Parking Spaces Available	Supply Ratio per 1,000 Gross Square Feet	Supply Ratio per Employee
Regional office of an international aerospace corporation	780	5.91	132,000	510	3.86	0.654
Insurance company headquarters	530	4.19	126,600	402	3.18	0.758
High-tech research and assembly plant	1,025	4.66	220,000	650	2.95	0.637
Municipal government center	465	5.31	87,536	310	3.54	0.666
Headquarters of a regional utility company	410	5.20	78,869	272	3.45	0.663
High-tech research and assembly plant	1,280	3.66	350,000	1,247	3.56	0.974
Headquarters of a large truck manufacturer	329	5.13	64,100	343	5.35	1.042
Average	688	4.87	151,301	533	3.70	0.771
Standard deviation	353	0.755	76,078	339	0.784	0.168

[a]Square footage occupied is, in all cases, 100 percent of total square footage.

Site Location

Of the 14 sites chosen to participate in this study, six are located in Bellevue, two in Renton, two in Redmond, and one each in Kirkland, Lynnwood, Woodinville, and Seattle (Figure 1).

Two of these sites, 12 and 13, are located in settings more characteristically urban. However, they were included in the study because both (a) experience poor transit service, (b) are located in relatively low-density areas, (c) use private surface parking lots, and (d) operate organized ridesharing programs for site employees.

Information on average employee commuting distance was not available for all of the sites. For analysis purposes it was assumed that average employee commuting distance did not vary significantly between sites.

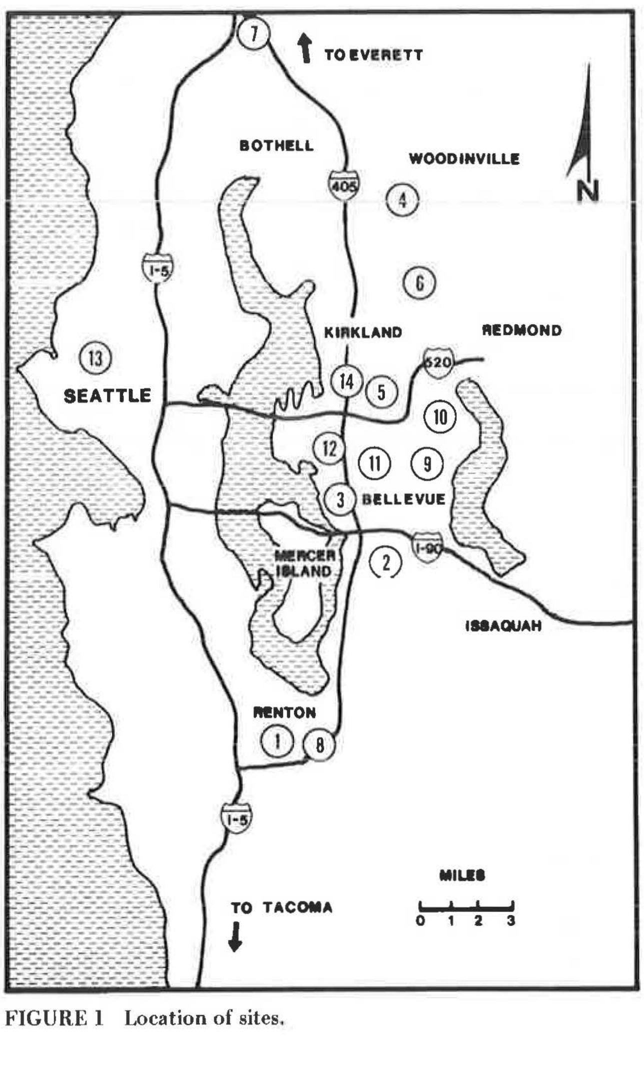

FIGURE 1 Location of sites.

Method of Analysis

Average parking use rates were collected for the seven suburban employment sites with ridesharing programs. These averages were then compared to the average rates collected for the seven employment sites without ridesharing programs.

This approach is commonly referred to as the "criterion-group" design. Subjects are selected because they represent one or another population of interest. As described by Richard J. Shavelson, this approach "sorts subjects into two distinct groups based upon some individual difference variable [in this case, presence or absence of an organized ridesharing program]. The two groups are then compared on some particular measure thought to be related to group membership [i.e., parking use]" (2).

Method of Observation

Visual parking counts were carried out for each of the 14 sites during January and February 1983. Surveys were conducted between the hours of 9:00 and 11:00 a.m. and 1:30 and 3:30 p.m. because these periods are commonly believed to accurately represent peak parking demand. Surveys were also confined to Tuesdays, Wednesdays, and Thursdays to minimize a day-of-week variation due to typically higher-than-normal employee absenteeism at the beginning and end of the week. Each site was surveyed a minimum of three times; the highest use rate observed was selected as best representing peak parking demand.

All sites provided parking areas clearly designated for visitors and guests. The amount of visitor parking available was included initially in the total parking supply figures because visitor parking can act as a parking supply reserve for regular employees if all employee parking is being used. However, because this situation was not observed at any of the sites, visitor parking was subsequently excluded from the analysis.

STUDY RESULTS

Parking use, like parking supply, is most commonly discussed as spaces used per 1,000 gross square feet (GSF) of building area. This approach is useful when dealing with a single site, but can be misleading when a comparison is being made among several separate sites each of which experiences a slightly different employee density. A more accurate method of representing true parking demand in this case is to compare the number of spaces used on a "per employee" basis, thereby controlling for any variation in employee density.

Parking Use per Employee

Observations revealed that the average parking use rate for nonridesharing employment sites (group 1) was 0.783 space per employee, with a standard deviation of 0.059 (Table 3).

On the other hand, employment sites with ridesharing programs (group 2) experienced an average use rate of 0.607 space per employee, with a standard deviation of 0.051 (Table 4).

TABLE 3 Parking—Group 1 (nonridesharing)

Facility	No. of Automobiles	No. of Automobiles per 1,000 Gross Square Feet	No. of Automobiles per Employee
1	258	4.51	0.794
2	130	2.36	0.813
3	326	3.12	0.807
4	156	3.67	0.650
5	179	2.98	0.792
6	566	1.89	0.809
7	691	3.68	0.813
Average	329	3.17	0.783
Standard deviation	218	0.879	0.059

TABLE 4 Parking—Group 2 (ridesharing)

Facility	No. of Automobiles	No. of Automobiles per 1,000 Gross Square Feet	No. of Automobiles per Employee
8	505	3.83	0.647
9	330	2.61	0.623
10	564	2.56	0.550
11	256	2.92	0.551
12	232	2.94	0.566
13	816	2.33	0.638
14	222	3.46	0.675
Average	418	2.95	0.607
Standard deviation	228	0.530	0.051

These findings suggest that an organized ridesharing program can have the effect of reducing employee parking demand, on the average, by approximately 0.176 space per employee or by about 22 percent.

Statistical Test Results

A t-test statistical procedure was carried out to determine the confidence level at which the observed difference between the two groups' average use rates would be considered not to have occurred by chance. An initial level of significance of 95 percent was selected because this is the level most commonly accepted as presenting "scientific proof."

Calculations resulted in an initial observed t-score of 1.40. This value does not equal or exceed the critical value of t, for 12 degrees of freedom, which is 1.782. Therefore, the null hypothesis that the two groups' parking use rates are equal cannot be rejected at this particular level of significance. The difference observed between the two groups' average use rates was in the expected direction but was not substantial enough to allow the conclusion that anything other than chance was the cause.

When the level of significance is reduced to the 90 percent level, however, the observed t-score does become significant because the critical value of t (which then becomes 1.356) is exceeded. Therefore, it is 90 percent certain that the difference observed between the two groups' average use rates does represent a true difference and is not merely the result of chance.

ANALYSIS OF RESULTS

A major objective of this study was to determine if an observed difference in parking use between the two groups was due solely to the presence of organized ridesharing programs. However, despite best efforts to achieve intergroup comparability by screening through the qualifying criteria, three categories of background information were found to contain differences between the two sample groups. Each of these and their potential for distorting the study's finding will be discussed briefly.

Employee Density and Total Number of Employees

Background information tends to vary between the two groups in terms of employees per 1,000 gross square feet and total number of site employees. The seven nonridesharing sites in group 1 are, on the average, 16 percent less dense and have 40 percent fewer employees than do the seven ridesharing sites in group 2.

The 16 percent difference in employee density does not appear to be a serious distorting factor. Parking use was intentionally computed on a per employee basis in order to avoid the effects of varying density. The 40 percent difference in total number of employees, on the other hand, may have had an influence on the results. Consider the following:

In the sample of 14, there exists a range in total employees per site from a low of 160 to a high of 1,280. Nonridesharing sites have an average of 415 employees, and ridesharing sites average 688. The number of employees working on a particular site may naturally account for the amount of ridesharing taking place. For example, higher average employee figures might account for lower parking use rates because more employees would rideshare of their own accord. The larger the pool of commuters at a particular site, the more likely it is that substantial numbers of them will share similar commuting patterns and become ridesharing partners. Lower parking use figures would then result regardless of the presence or absence of an organized ridesharing program.

However, despite the fact that larger sites are more likely to be in the ridesharing group and smaller sites more likely to be in the nonridesharing group, there are examples in which size appears to be of no consequence. Contrary to what one would expect, the parking use rate for the smallest ridesharing site (329 employees, 64,100 GSF), which is 0.675 space per employee, is significantly less than that for the largest nonridesharing site (850 employees, 188,000 GSF), which is 0.813 space per employee. In fact, this relationship persists for the next two smallest and largest sites, respectively.

Therefore, considering the 14 sites participating in this study, size alone does not appear to be the reason for the presence or absence of an organized ridesharing program, nor does it appear to be a factor that adversely affects parking use results. However, the larger, denser employment site is more likely to be associated with a ridesharing program and lower parking demand rates.

Parking Supply

There is also a difference between the two groups in the average amount of parking supplied at the sites. Nonridesharing sites provide a supply of parking per employee that is 28 percent greater than that of their ridesharing counterparts. This raises the possibility that the supply of parking may account for the amount of employee ridesharing. Limited parking, not the existence of a ridesharing program, may be acting as the agent motivating employees to rideshare. Employees perceiving a parking shortage might rideshare simply to increase the probability of finding an available parking space.

The study does supply some evidence to support this assertion but is not conclusive. If the seven ridesharing sites in group 2 were to discontinue their emphasis on carpooling and vanpooling, and vehicle occupancy were reduced to a level equal to that characteristic of the nonridesharing sites, the average peak parking demand for that group would exceed the actual available average parking supply (539 space demand, 533 space supply). However, the amount by which average demand would exceed average supply is very small. In two of the seven ridesharing cases, if parking demand were equal to the average level found at the nonridesharing sites (0.783 space per employee), there would still be a parking surplus at the site. Also, three of the facilities surveyed in group 2 (ridesharing) display parking supply ratios per employee that are greater than some of their counterparts in group 1 (nonridesharing) (see Tables 1 and 2).

The data appear to suggest that relatively lower parking supplies are more likely to be associated with the existence of a ridesharing program and lower levels of parking demand. However, the relationship is not universal across all of the sites surveyed.

CONCLUSION

The intergroup comparison of 14 Seattle-area suburban office locations showed that work sites classified as having an active ridesharing program displayed an employee parking demand ratio approximately 20 percent lower than that of comparable nonridesharing sites. Analyses of the study results and other background data also revealed that the ridesharing sites experienced slightly higher average employee densities and lower average parking supply ratios. This suggests that in the Seattle area efforts to promote ridesharing may be more successful when employee densities exceed 4.5 employees per 1,000 gross square feet and parking supply dips below 0.80 space per employee as indicated by the data given in Tables 1 and 2.

The types of ridesharing services provided at the ridesharing sites included as a minimum the following program elements:

- An on-site employee transportation coordinator,
- Ridematching assistance, and
- Preferential parking for carpools and vanpools.

Four of the sites with ridesharing programs provided additional incentives, including

- Company-sponsored vanpools,
- Subsidies to employees who do not drive alone to the work site, and
- Fleet-ride program.

SUGGESTIONS FOR FURTHER STUDY

The issue of employee ridesharing will remain an important concern of both the public and the private sectors for years to come. Further inquiry is needed to expand the body of knowledge currently available on the impact of ridesharing activities and to improve decision making when balancing between ridesharing programs and parking supply. Suggestions for further study follow:

1. Expand the scope of land use activities investigated beyond the suburban office complex. The task may be more involved than the procedure followed in this particular study. For example, it would be appropriate, if not necessary, to gain more insight into both the worker and employer profile for each site investigated. Employer/employee questionnaires would be the most efficient method of gaining such insight.

Questions asked of the employer could inquire about the employment center's size, its employee population, surrounding land use, parking supply. It could also be determined whether the employer is involved in employee transportation issues, if so why and to what extent, and what kinds of ridesharing incentives are provided.

Questions addressed to the employee could inquire about present commuting mode, parking location, frequency of carpooling, availability of transit service, distance from home to work, travel time, work schedule, type of work activity, reasons for forming a carpool, incentives available to employees who carpool, and so forth.

Questions of this type will identify factors that tend to encourage or discourage employees to rideshare.

2. Conduct further study to determine what kinds of ridesharing incentives produce the greatest ridership results. For example, does a direct transportation subsidy to carpooling employees raise the percentage of workers ridesharing above the percentage achieved with an employee transportation coordinator and preferential carpool parking?

3. A final suggestion would be to conduct before-and-after parking demand-vehicle occupancy studies at sites previously without organized ridesharing programs. In this way, ridesharing success stories could be accurately documented.

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Increasing Mode Split Through Parking Management: A Suburban Success Story

KAY L. KENYON

ABSTRACT

Accommodating commuter trips in rapidly growing suburban cities that do not have high levels of transit service is a difficult challenge. Many cities, including Bellevue, Washington, must face this challenge if development is to continue at the current rapid pace. A new employee transportation program at 450 Bell Terrace, the first building in downtown Bellevue to be constructed under the terms of a new zoning code, is described. The transportation program, serving 900 Pacific Northwest Bell Telephone employees, includes a substantial ($60 per month) parking fee as a disincentive to drive-alone commuting and discounted or free parking for carpools. Parking demand must be accommodated by 410 parking stalls in the monitored Bell Terrace parking garage. The intensive assistance provided by the Commuter Pool Program (the regional ridesharing program) and by the city of Bellevue ridesharing staff was instrumental in achieving a 60 percent employee carpool participation rate. Only 19 percent of the employees are driving alone to work. Seventeen percent use transit. Other factors critical to success are the ability of a single firm to coordinate a program and the predisposition of employees accustomed to high levels of transit service in Seattle to form carpools in Bellevue.

In the spring of 1983, 900 employees of Pacific Northwest Bell (PNB) Telephone were transferred to a new computer center in downtown Bellevue, Washington, 450 Bell Terrace. Most of these employees had been working in downtown Seattle, and most of them had enjoyed high levels of transit service that would not be available in Bellevue. The telephone company, in keeping with the city's new zoning practices and philosophy, provided only 410 parking spaces in the new building. It was clear from the start that extraordinary levels of ridesharing would be needed for PNB to meet the demand for on-site parking.

By July of 1983 the move was completed, and PNB employees had made a general shift in commuting mode from driving alone and using transit to carpooling. In fact, 60 percent of the telephone company employees in Bellevue now carpool to work. Seventeen percent use transit. This unusually high ridesharing participation rate is the result of extensive planning and coordination on the part of PNB, Commuter Pool, and city staff. The nature of the company move from Seattle, where a large number of PNB employees commuted by bus, was also a major determinant of the transportation program's success.

THE RIDESHARING ENVIRONMENT

Understanding the Bell Terrace transportation program, and its possible applicability to other work sites, requires a close look at the ridesharing environment to see what factors had an impact on company and employee decision making.

Suburban-Urban Setting

Downtown Bellevue, with a work force of more than 13,000 people, is in a transition phase between a low-density suburban business district and an urban center. This transition is a planned redirection of the central business district (CBD) on the part of city planners and the business community, and received approval from the Bellevue City Council in 1981 with the passage of zoning legislation allowing high-rise, high-density office and retail development with lowered parking requirements.

Spurred by the new zoning laws, the downtown has sprouted four major office buildings in 2 years, transforming the Bellevue skyline and underscoring the dramatic side-by-side suburban and urban character of the present downtown. For example, the Bellevue CBD is characterized by spacious surface parking lots between low-rise buildings, and in their midst a few office towers rise 16 to 21 stories. Beneath the office towers, below-grade parking structures may provide a maximum of 3 parking spaces and a minimum of 2 spaces per thousand square feet of office space. Compared with what they could do under the old requirement of at least 3.3 spaces per thousand square feet of office, developers can realize a substantial saving in parking construction costs (below-grade construction costs for parking are approximately $10,000 per stall). Lower parking supplies at some sites are bringing substantial parking fees to Bellevue for the first time.

Average automobile occupancy in the Bellevue CBD has increased slightly from 1.15 in 1981 to 1.17 in 1982. Compared with Seattle, which has an average automobile occupancy of 1.33, Bellevue is still predominately an automobile-oriented community.

Parking Supply

Commercial parking facilities are not available in Bellevue. Each building supplies its own parking, whether surface or covered, and parking built before 1981 is generally free and plentiful. On-street parking is, for the most part, not available.

Transportation Program Conditions of Building Permit

The city's policy of encouraging carpools and vanpools must be implemented primarily through the efforts of building owners, with assistance from Commuter Pool. Therefore the building permits issued by the city for the new large office buildings are conditioned with employee transportation program requirements. These requirements, in PNB's case, include the following: (a) no more than 30 percent of the total parking stalls can be used by single-occupant vehicles (SOVs); (b) flexible working hours are to be arranged for as many employees as possible; (c) a permanent employee transportation coordinator is to be designated; (d) preferential parking garage assignments are to be made for carpool and vanpool vehicles; (e) an inverted parking rate formula is to be used as an incentive to high-occupancy vehicles; (f) a transit ridesharing center in the building is to provide information on transit routes, carpools, vanpools, and Commuter Pool services available; and (g) a carpool and public transit information day is to be held twice a year.

In 2 years PNB must submit a report to the city to determine if parking demand exceeds the on-site supply. If spillover is occurring, PNB will be required to modify or add programs to eliminate the problem. A maximum dollar amount of $35,000 was set as a ceiling, in order to identify what (at the time of issuance of the permit) was considered an acceptable future expenditure for the company should its transportation program prove ineffective. 450 Bell Terrace was the first building in downtown Bellevue to be built and occupied under the terms of the new zoning code. Major building permits issued subsequently have set maximum expenditure as high as $475,000. The dollar value is based on the cost of enough vans to reduce parking demand to equal building supply.

Transit

Transit service in Bellevue has been typical of suburban locations. Peak hour use in 1981 was about 4 percent of the downtown work force of 12,000 people. The city's goal is for this service and use to increase to 25 percent of the work force by 1990-1995. To help achieve this goal, the Metro (transit) and Bellevue councils adopted a transit incentive agreement, which awards Bellevue transit service hours based on increased employment density and lowered parking ratios. Some of these new service hours are already operating. Aided by a new downtown transit center, a few of the larger CBD employers have achieved an 11 percent mode split for employee transit use.

450 Bell Terrace is within walking distance of all transit routes serving the CBD because an interim transit center is located three blocks (660-ft blocks) away. Thirteen Metro routes converge on the transit center during the peak hour. (A permanent transit center, even closer to Bell Terrace, will be constructed by 1985).

Employee and Company Characteristics

The work force of 900 people at 450 Bell Terrace consists primarily of professional-level data systems programmers and analysts with above-average salaries ($30,000 midrange). About 25 percent of the employees are clerical and support staff.

Peak hour transit use in downtown Seattle is about 52 percent of the work force. A majority of the employees at Bell Terrace were transferred from downtown Seattle and were accustomed to getting to work on the bus.

Before the move to 450 Bell Terrace, the company had not become actively involved in employee commuter programs. With their Bellevue move, Pacific Northwest Bell was entering two new employee programs at once: parking management and employee ridesharing.

Ridesharing Assistance

The ridesharing program in King County is Commuter Pool, a regionally funded agency providing public vanpools, ridematching systems, parking management assistance, and extensive marketing assistance to employers willing to sponsor company ridesharing programs. Before the spring of 1981 Commuter Pool had helped several Bellevue employers (e.g., Unigard Insurance and Bellevue City Hall) sponsor outstanding carpool and vanpool programs for their employees and had provided support to two downtown employers (ENI and Puget Power) with somewhat limited parking. However, 450 Bell Terrace was the first building in downtown Bellevue with a critical need for ridesharing services. The Commuter Pool Bellevue representative and two half-time assistants housed at Bellevue City Hall dedicated approximately 20 percent of their time to the telephone company ridesharing project during a 4-month period.

TRANSPORTATION PROGRAM FEATURES

The Bell Terrace transportation program has focused primarily on a parking management program providing incentives to carpoolers and strong cooperation between PNB staff and Commuter Pool. The project was coordinated at the work site by Michael Brown, the PNB employee transportation coordinator.

Parking

The new parking garage is managed to give priority to high-occupancy vehicles. Of the 410 spaces available, 298 are reserved for poolers. Parking for SOVs is restricted to 112 spaces and may be further restricted as carpool parking needs exceed the present allotment. Registered carpools receive a permit to be displayed on the window or dashboard of the carpool vehicle. Carpool vehicles may leave and return to reserved spaces in the garage during the day, but SOVs must pay a fee to return to the garage. SOV parking is allotted on a first come, first served basis from day to day.

Employee parking fees are the highest yet charged in Bellevue. Employees driving alone to work may park in the garage for $3 per day when space is available. Individuals place the $3 parking fee in a slotted coin box marked with the number of the corresponding parking space. A parking monitor makes daily rounds of the garage, checking for proper payment.

Carpools of two employees can purchase monthly parking permits for $45.00. Carpools of three or more and vanpools park free, as do motorcycles and bicycles. Carpools are registered quarterly. Employees have been notified that abuse of parking privileges will result in memoranda to supervisors and department heads and revocation of the parking permit for 6 months.

Carpooling

Both PNB and Commuter Pool staff realized that, for the program to succeed, carpools would have to carry the majority of employees, and therefore planning for carpool formation began 9 months before occupancy of the new building.

Initially, PNB had considered setting up an internal computer matching program using PNB staff resources at the new computer center. Eventually this plan was abandoned in favor of Commuter Pool's readily available computerized program, presumably in the interest of saving time and costs (Commuter Pool's ridematching system had been operating region-wide since 1974). A further advantage is that as more employers sponsor ridesharing programs downtown, Commuter Pool will be able to provide carpool matches with several other nearby buildings.

In the fall of 1982, a survey, compiled with the help of Commuter Pool, went out to all employees to be transferred to Bellevue, inviting employee participation in the computerized ridematching effort. Even though the move would not occur for several months, the matching process was initiated at this time to alleviate employee anxiety about commuting and parking; the applicants would receive match lists well in advance of the move, and could make tentative pooling arrangements.

Through the survey, 456 PNB employees applied for free Commuter Pool carpool matching help. Matches were found for all applicants, with an average of seven matches per match letter. The substantial parking fees and carpool discounts had just been announced at the time of the survey.

In February 1983 the telephone company began holding "move seminars" to brief transferees on the impending move. At PNB's request, Commuter Pool produced a custom-designed brochure explaining the carpool, vanpool, and parking management program. This brochure was printed in quantity and distributed to all employees.

In March, when the first contingent of employees moved into the building, Commuter Pool initiated a telephone follow-up procedure designed to personalize the ridematching process through individual telephone calls to each applicant. Commuter Pool staff housed at Bellevue City Hall placed 260 calls to PNB employees during a 12-week period. (Approximately 75-100 employees were transferred every 2 weeks until full occupancy was reached in late June.)

In these telephone follow-up calls Commuter Pool staff encouraged applicants to call the names on their match lists if they had not already done so, updated file information (employees will continue to receive updated match lists), and helped commuters solve individual transportation problems. Although most PNB employees had already been successful in forming carpools by the time they received a Commuter Pool staff call, the PNB transportation coordinator received many positive comments from employees about the extra assistance offered through this personalized telephone method.

Vanpooling

Two Commuter Pool public vanpools are carrying Bell Terrace employees at the time of this writing. One is driven by a telephone company employee and is parked in the PNB garage.

Commuter Pool's analysis for the Puget Sound Council of Governments 1990 Ridesharing Plan estimates that as many as 130 vans could be serving the Bellevue CBD in this decade if employment growth occurs as rapidly as forecast by city planners. Therefore, at a large employment site like Bell Terrace, vanpools right now are probably underused. The telephone company has chosen not to pursue vanpools aggressively as an employee transportation mode, at least not as long as carpools meet their ridesharing goals.

Two of the vanpools serving the PNB site are carrying passengers from other downtown firms including Puget Sound Power and Light Company and Bellevue City Hall. Because the downtown area is fairly small, many vanpools will be able to carry passengers from more than one building. The city is considering ways to address the need for pull-outs and loading facilities for vanpools in the CBD.

Transit

As the direct result of Metro Transit and PNB cooperation in market analysis and planning, Metro added a new trip to an existing route serving the PNB building. In addition, a new transit route will be added this fall. Although many employers in King County (150 companies representing 20,000 employees) subsidize a portion of the bus pass for their employees, Pacific Northwest Bell is not participating in Metro's employer subsidy program.

Other Features

PNB will be placing a commuter information center in a prominent location just outside of the employee cafeteria. The centers are three-paneled information kiosks that provide transit and ridesharing information along with timetables and carpool and vanpool applications.

Flexible working hours for as many employees as possible is a company policy at 450 Bell Terrace. Employees are able to set their own start times, within limits, in order to make the most convenient carpool and transit arrangements. It has not been determined how successful this policy has been at the department level, but follow-up will be undertaken by Commuter Pool. Pacific Northwest Bell Telephone is also providing a company car for employees who, when they work late, must miss their bus or ride home.

PROGRAM RESULTS

With the exception of some temporary (and undesirable) on-street parking, the employee transportation program at 450 Bell Terrace has been an extraordinary success. The high levels of ridesharing and transit use at Bell Terrace, however, should not raise unrealistic ridesharing expectations for multiemployer office towers in Bellevue, where employee populations may not be as accustomed to leaving their cars at home as are PNB employees.

Parking Spillover

In an effort to avoid high parking fees in the garage, some PNB employees are parking along 110th Avenue N.E. and some minor arterials near the building, such as N.E. 3rd Street and 111th Avenue N.E. City staff believe approximately 140 cars belonging to PNB employees are parking off site, despite company and neighborhood objections. The city plans to impose time-restricted parking on these small side streets and will begin to tow vehicles found in violation of these restrictions.

Commuting Mode

Seventy-nine percent of the daytime work force regularly commute to Bell Terrace using a mode other than a single-occupancy vehicle. Approximately 175, or 19 percent, drive alone to work. Commuting mode in early July was as follows:

Mode	No. of Employees	Percentage
Carpools of two	64	7
Carpools of three or more	460	51
Vanpools	16	2
Transit	153	17
Motorcycle and bicycle	13	2
Drop off	16	2
Drive alone	174	19
Total	896	100

The commuting mode information was compiled from PNB parking management data and a recent employee survey supplied by PNB and was confirmed through a telephone follow-up survey conducted by the Commuter Pool Bellevue office. On-site vehicle occupancy counts are being conducted by the city in spot checks throughout the month of July.

Both the transit ridership and the carpool participation rate are of special interest to those watching transportation issues in Bellevue. The 17 percent mode split for transit exceeds the city's current goals. However, it is not an unusual figure, given that these PNB employees were transferred from Seattle and enjoyed very high levels of transit service there. The carpool program yields the most surprising results. Certification of carpools by PNB staff indicates that 60 percent of all employees are in carpools of two or more. Because of this unusually high figure, it may be of interest to note some of the characteristics of this carpooling group.

Carpooler Characteristics

A telephone survey conducted by the Commuter Pool Bellevue office this spring revealed that many of those employees carpooling today were taking the bus to work before the company moved. Most of the carpools were not in existence before the move, and almost all were formed exclusively with other Bellevue PNB employees. One hundred sixty carpoolers were interviewed by telephone.

Before moving to Bellevue, the carpoolers interviewed used the following commuting modes:

Mode	Percentage
Single-occupancy vehicle	25
Transit	48
Carpool or vanpool	25
Other	2

Almost 30 percent of those interviewed said they used the Commuter Pool ridematching service (printed lists) to form their carpool. Nearly 75 percent have elected to remain in the computerized ridematch file to receive updated lists to maintain or improve their carpools.

Forty-four percent of the carpoolers said they are picked up at their home for the morning commute. Twenty-eight percent meet at a Metro park-and-ride lot. The Wilburton park-and-ride lot was most frequently mentioned, with nine carpoolers meeting at this facility just south of the CBD.

CONCLUSIONS

The 450 Bell Terrace employee transportation program confirms that carpools can, under certain conditions, regularly carry a large number of employees to and from work in Bellevue. Although the Bell Terrace employee transportation program has just begun, some tentative conclusions about its success and future directions can be drawn.

Success Factors

Today most ridesharing agencies in the country concentrate on working with major employers because of the number of employees with a common destination and the advantages of a firm's resources for communicating with employees and setting policies. The Bell Terrace transportation program was carried out under this ideal circumstance.

A crucial aspect of this employer setting is the appointment of an employee transportation coordinator with sufficient influence, ability, and staff assistance to carry out plans. Although it may seem obvious that a major program cannot be operated without someone to execute it, employee transportation may have low priority at firms where management does not see a direct company benefit in ridesharing. PNB, however, had appointed a management-level staff person to oversee their program almost a year before occupancy.

The company move from Seattle was a major determinant in achieving the 60 percent participation rate in carpools. Because most of the employees were transferred from a work site with very high transit service, few of them were accustomed to driving to work. Forty-eight percent of the carpoolers at Bell Terrace report that their previous commuting mode was transit.

The restricted supply of parking (0.45 spaces per employee) and its high cost (three times the cost of a one-zone bus pass, two times that of a two-zone pass) are clearly major disincentives to driving alone. At the same time, carpools and vanpools are assured of parking spaces and have further incentives such as discounted monthly rates and in-and-out privileges.

The company's cooperative relationship with Metro (including Commuter Pool) was undoubtedly of central importance in establishing alternate commuting opportunities for Bell employees. An ideal ridesharing environment and carpool and transit incentives must be matched by the provision of ridesharing and transit services. The willingness of Metro to adapt transit service near Bell Terrace and Commuter Pool's intensive staff support and ridematching services are additional reasons for the success of the program.

Future Plans

The Bell Terrace transportation program will need to make some changes and adjustments in the near future. Parking will soon be prohibited along 110th Avenue N.E., and many of the employees now parking there will have to make alternative commuting arrangements. Vanpool use may increase, especially when the summer ends and employee vacation schedules decrease. In addition, a new transit route from northeast Seattle and the university district will begin service in September.

Enhanced ridesharing opportunities will occur as the new downtown office towers are occupied, because more Bellevue commuters will be seeking carpool partners. For example, Puget Sound Power and Light Company's employee transportation coordinator has already planned a ridesharing program there and is currently working with Commuter Pool to coordinate ridematching on site and between downtown buildings.

The PNB transportation program in Bellevue is the first program to be instituted under the city's new zoning code. Although the company program was developed under favorable circumstances that are not likely to be duplicated at downtown office towers, it can serve as a positive example and encouragement to the ridesharing effort in downtown Bellevue. City staff will continue to follow the results of this program as well as those of employee transportation programs soon to come at major downtown Bellevue office buildings.

ADDENDUM

By the spring of 1984, 1 year after Bell Terrace began its program, the mode split at the site had changed somewhat. A survey undertaken early in the year indicated that, although the carpool rate was still extremely high for Bellevue, the number of employees commuting by single-occupant vehicle had increased to 32 percent. Current mode splits are given below:

Mode	Percentage
Carpools of two or more	53
Transit	11
Other	4
Drive alone	32

Although the city of Bellevue has eliminated the problem of illegal on-street parking by placing signs restricting parking to 2 hours, resourceful commuters have managed to find parking in nearby parking lots where excess spaces exist. This type of spillover is expected to disappear as nearby properties redevelop and begin monitoring their parking lots.

ACKNOWLEDGMENT

The employee transportation program at 450 Bell Terrace received assistance from the Commuter Pool program, both through Commuter Pool's program services and partial funding support of the city of Bellevue's ridesharing office. The Commuter Pool program is supported in part through U.S. Department of Transportation Federal Aid to Urban Systems funds and National Ridesharing Grant funds.

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Data Base Management System for Transportation Improvement Program Development, Monitoring, and Analysis: A Case Study

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ABSTRACT

The Chicago Area Transportation Study, as metropolitan planning organization (MPO), is charged with providing its Work Program Committee and Policy Committee with feedback on the impact of the 5-year transportation improvement program (TIP) and on the region's transportation, social, and economic needs. In fulfilling this requirement it became apparent that MPOs are lacking adequate means for managing TIP data that could be very valuable to TIP development, monitoring, and analysis. Those inadequacies are described and efforts to address them through the development of a structured data base management system (DBMS) are discussed. Problems encountered are noted and the potential for future refinement of DBMSs for TIPs are suggested.

In an effort to fulfill the federal requirement for comprehensive, continuing, and cooperative planning, the Chicago Area Transportation Study (CATS), as metropolitan planning organization (MPO), initiated an impact analysis component in its unified work program (UWP) (1). The purpose of this activity was to provide information to programmers, planners, and implementors about the progress of the transportation improvement program (TIP) in accomplishing the region's transportation goals (2). In fulfilling this requirement it became apparent that MPOs were inexperienced in managing TIP-related data, which could be very valuable to TIP development, monitoring, and analysis. Inadequacies that were realized at CATS through the impact analysis efforts are described. Efforts to address those inadequacies through the development of a structured data base management system are discussed. Problems encountered are noted and the potential for future refinement of the data base management system for TIPs is suggested.

INADEQUACIES OF THE TIP DATA BASE

In a fiscally constrained environment the major function of the transportation improvement program (TIP) should be to select the combination of projects that provides for the most effective achievement of the region's goals and priorities. This function requires that the metropolitan planning organization (MPO) process information about the entire transportation system's needs and rank implementation in an organized and logical manner. The information needed for this function includes operating characteristics of the system, physical deficiencies of the system, estimates of future demands on the system, and relative costs of projects as well as impacts of projects on pertinent transportation and urban planning issues. Unfortunately the information for this process has not been available in a readily usable form for the following four reasons:

First, various components of the system (bus, rail, urban highway, and so forth) are programmed, built, acquired, operated, and maintained by separate, autonomous agencies. Therefore, data on the needs of each system are often incompatible with each other.

Second, funding procedures for federally aided projects require that the TIP be constantly modified. The dynamic nature of the TIP makes monitoring of trends and of accumulated impacts of the TIP on the transportation system difficult.

Third, the need for maintaining detailed, standardized information about the TIP had not been recognized in the past. Therefore, previous TIPs contained little more than descriptive information.

Fourth, data generated for and by other transportation planning functions (i.e., long-range plans, projected travel demand, and the state's roadway condition data) were not compatible with one another or with TIP data.

To provide the best possible information to programmers for use in TIP development, these basic data problems had to be resolved. It soon became clear that both needs and existing files were complex enough to require a full data base management system (DBMS). What has occurred since has been a gradual progression toward developing a model DBMS. The purposes of such a system include

- The ability to assess the relative deficiencies of all components of the system;
- The ability to monitor trends of past and present TIPs;
- The ability to quickly retrieve, amend, manipulate, and summarize available information for analysis purposes; and
- The ability to develop numerous alternative programs, which show the costs and benefits of various trade-offs between goals and priorities, for review by programmers.

To develop a DBMS that would meet these objectives three steps had to be undertaken: (a) the information about the TIP had to be standardized, (b) a software system for routinely updating this information had to be devised, and (c) a method for cross-referencing the standardized TIP and all other available, pertinent files had to be instituted.

When these three tasks had been accomplished, a DBMS for TIP development, monitoring, and analysis was initiated.

CURRENT CATS TIP DBMS

The TIP data base system that currently exists operates on the state of Illinois IBM 3033 OS/MVS computer. The data sets are both OS and SAS and are related and maintained with both FORTRAN and SAS software. The structure of the DBMS is shown in Figure 1. There are four types of files: TIP files, transaction files, impact files, and link files.

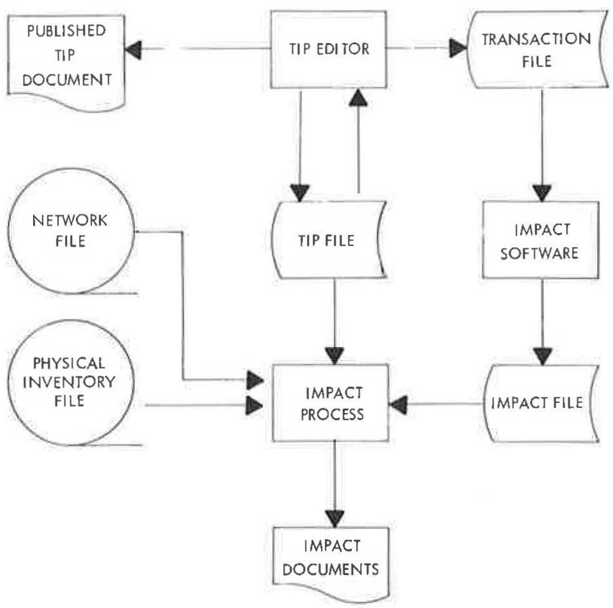

FIGURE 1 Structure of DBMS.

TIP Files

The TIP file was the first to be developed and is the most important. The TIP file is an OS file of about 1,500 150-byte records. It is stored on a mass storage device. It contains descriptive information about each project. The primary purpose of this file is to maintain information that can be easily amended and summarized for review and publication. It also contains standardized information about fund sources, costs, year (i.e., annual element or multiyear), regional council (a geopolitical programming unit), investment origins (3), award status, and a permanent identification number. Other information such as municipality, type of work, street, and limits of work are free-form character fields. At any time this file can be amended with FORTRAN software created for this purpose. The operation of this software is documented in the "CATS Interactive TIP System User's Manual," available from CATS. Back-up files are automatically created. However, copies of these backup files, as they are approved after any given amendment, are not retained.

Transaction Files

While the TIP file is being amended with the interactive software package designed for that purpose, a transaction file is automatically created to record all changes, additions, and deletions (4). Each record of this OS file contains a field for the date of the transaction, the permanent identification number of the project affected, and the type of action taken (change, addition, deletion). If the action is to add a project, the interactive program automatically assigns a permanent identification number based on the date and time of the transaction. Every transaction is recorded. Therefore, if a project is added, changed several times, and then deleted, each action, including every change, is documented in the transaction file in the order in which it occurred. Consequently this file is continually growing.

Impact Files

To maintain information about trends in TIP programming, impact files, which record the exact status of the TIP each time that an amendment is approved, were created. This entails approximately 10 official amendments each fiscal year. Therefore, there are about 10 versions of the TIP file, in the impact format, for each fiscal year. The impact files are SAS files and contain more detailed, standardized information than do the TIP files. This information includes a three-digit code for the municipality in which the project is located, a code for the description of the work type, and a total cost field. The total cost field contains the sum of the construction and all related preconstruction projects. Preconstruction projects have zeros in the total cost field.

Link Files

Link files are the connection between the project, as a line item in the TIP file, to its location in the physical system. Projects are mapped on highway network maps and coded by node to the current, base network. The permanent identification number ties the link file to the TIP and impact files. This is an SAS data set stored on tape because of its size: approximately 8,000 records.

INTERACTION OF FILES

The TIP, impact, and link files are updated with specially designed software. The TIP update program, mentioned previously, is an interactive program that allows the user to modify, add, and delete projects. It automatically creates the transaction files and assigns permanent identification numbers. The impact files are amended with a batch-entered SAS job, which gleans information from the transaction files and, where necessary and possible, assigns standard codes.

The impact file is then stored as a permanent record of the TIP as it was at the time of the batch update. The TIP file, however, continues to be modified in preparation for the next official amendment. Because of the inconsistencies permitted in the free-form fields of the TIP files, some standard codes must be manually added to the impact files. Currently the link files must be updated manually. When significant changes are made to the TIP the projects that have location and limits changes are selected and recoded. All the files are related by the permanent identification number. The key to other data files in the region's planning functions is the link file.

SYSTEM USES

The system, as it has been developed and refined, has been used for a number of years to continually amend the TIP and summarize various subsets of projects (5). Special listings and summaries are frequently requested by agencies involved in the MPO forum. As the new 5-year program is developed, the constantly changing program needs to be examined by all members of the work program committee (WPC). When approved, the program must be put in final form almost immediately for policy committee approval before the federal deadline. The ability to rapidly effect changes and produce various versions of project listings has become eminently useful.

The more recent additions to the DBMS (i.e., impact files, transaction files, and link files) have been used to generate several analyses of the TIP on issues pertinent to the regional programming of transportation dollars. The link files allowed the analysis of TIP programming on carbon monoxide hotspots (identified on the network by a travel demand model) and on congestion of the highway at the zonal level. The impact files permitted an analysis of trends in programming by virtue of the permanent identification numbers and the maintenance of each amended version of the TIP. The impact files, as well as the standardized investment origin category codes in the TIP files, made possible the analysis of the consistency of the TIP with the long-range plan (3). Other summaries that are readily available include changes in federal aid-urban programming caused by amendments, identification of projects positively affecting air quality (4), a carry-over analysis for the new 5-year program, and summaries of various subsets of the program by work types (6).

PROBLEMS IN IMPLEMENTATION

Several problems have become apparent as the system has evolved and been used. These problems involved all aspects of a DBMS including data, organization, and user understanding.

Data Problems

Because the previous TIPs had been basically nonstandardized descriptions of the projects, the information about the projects on which the DBMS was initially based was not consistent, complete, or unique. For example, a project described as "structures" may refer to patch work on the deck or major structural repairs. Numerous projects listed as structures or resurfacing actually include intersections, signals, parking lanes, or numerous other jobs within the scope or limits of the project description.

These basic inadequacies in the data can destroy any attempts at standardizing a data base. They occurred for two reasons: First, the incentive to give more complete, consistent, and unique descriptions had never existed before. Second, the information was input from several autonomous sources.

Communication Problems

Efforts have been made to standardize descriptions among and between sources. However, some problems still exist. Although they know that some general work will be done in a corridor, the engineers themselves do not always have the information necessary to give complete, consistent information on each project at progamming time, especially for a 5-year program. In addition, the providers of the information have yet to see how a well-operating DBMS can be useful and timely; therefore, the incentive does not exist to continue to refine and conform to the standard descriptions. Likewise, potential users of the DBMS (e.g., long-range planners, land use planners, those implementing system management projects) have not been made aware of the many applications and improved information that could be available if the data base were maintained in a consistent, complete manner. These problems would be alleviated to the extent possible with improved communication between the sources of the information, the users, and the systems analysts maintaining the system. A sincere and concerted effort on all parts is essential to eliminate enough of the problems to make the DBMS effort cost-effective.

Level-of-Organization Problems

All DBMSs should be organized to use the lowest common denominator as a means for cross-referencing the numerous files. The current system was developed using project identification numbers as the reference to other files. Then, the demand model's historical record was difficult to access; so a cross-reference was designed to relate the two files. Currently, there are problems in relating the state's roadway inventory to the other files. The TIP information should initially be coded to the state's highway inventory file, which is organized at the finest level of detail of all the files (5). Then aggregations could be made up to links, projects, zones, townships, regional councils, and counties in order to cross-reference other data sources.

Timeliness and Verification Problems

Another problem encountered is in the timeliness and accuracy of updates and summaries after changes are made to the TIP data base. Part of this problem is a lack of person-power. Another part is that the system has not yet been refined to the point of being able to produce standard reports for summary and control checking at key times in the TIP's metamorphosis. A consensus among users must be reached about what those key times are and what information should be reported in order to assure accuracy.

In all of the cases discussed in this section, problems could be minimized by refining software to draw a tighter relationship among data sources, files, and uses. In addition, more communication among users, technicians, and data sources is essential both for defining future directions of the DBMS and for adequate operation of the system currently in use.

FUTURE DIRECTIONS AND APPLICATIONS

Adjustments that should be made to the present DBMS are evident in the previous section. One of the most important changes that is needed is to adapt the system so the file with the most detailed information (in this case the state's highway inventory) is the key file for referencing other data files. Because each of the files involved is structured differently, this change will be a significant one. It will require careful planning and control checks to assure that no information is lost in the process. Another important change is the manner in which new information is input to the system. A systematic process for acquiring information, coding, and inputting must be developed and accepted by all users. The consensus and commitment of all involved parties are essential at this juncture.

A major addition to the current DBMS would be the incorporation of transit data. The system was initially developed for the highway portion of the TIP and relates to existing highway data files. The TIP files and impact files have standardized transit information. But other files (i.e., transit network and rolling stock inventories) are not cross-referenced by the DBMS. When the transit files are incorporated, a means of relating the highway and transit data files would allow for comprehensive analyses.

In addition, software for more timely entry and editing of the TIP project information in the DBMS should be explored. Currently, an interactive program allows the entry of TIP information into the TIP files (6). A similar program, which would allow entry directly into the state's highway inventory file, would make DBMS maintenance more timely and accurate. For example, when TIP projects are initially entered into the system, automatic checking for reference points along the length of the project could be done and a report produced for user verification. At the same time cross-references to all the files could be automatically summarized to check for missing or inconsistent data. The TIP file used for publication could be produced by machine through the interactive information entry program. Such a software package would essentially eliminate manual coding except in cases where erroneous or incomplete information is found.

Other software that could be built into a DBMS like this one should be applications oriented. Some of these applications would provide more and better feedback for TIP implementors and programmers (the original incentive for the development of the system). Others would enhance additional planning activities initiated by the region's transportation professionals.

To provide feedback, alternative program scenarios might be developed and evaluated in terms of various issues such as life cycle and condition of facilities, relation to other regional plans, and geographic and socioeconomic equity. Fiscal forecasts could be routinely generated based on physical deficiencies, historical costs of projects in previous TIPs, and cost benefits of various investment choices.

Other planning functions could benefit from the use of a DBMS such as this one by obtaining routine reports about awarded projects that effect the highway and transit network. The highway inventory also needs information about the TIP projects that affect the physical system described in the inventory file. Those planners implementing studies that require projections of future conditions would have a standard and accurate source of information about projects programmed for the next 5 years.

Although the benefits of this DBMS appear to be great, developing it to this point has been a tedious process of trial and error. Because there was no prototype from which to begin, the costs have been great. Further developments should prove to have increasing returns because the initial major investment has been made. However, an assessment should be made of the value of further development. In many cases the programming decisions are intentionally made without the aid of technical information. If this is the case more often than not, then developing further software capabilities would be a wasted effort. However, in those cases in which a DBMS for TIP is believed to be beneficial, the effort to set up such a system should be greatly diminished by the experience gained in this effort.

The DBMS for the TIP at CATS has proven to be useful for analyzing aspects of the program and the programming process. It is thought that further development of the system would greatly increase these benefits.

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Presentations of Alternative Demand Data Summaries

MICHEL VAN AERDE and SAM YAGAR

ABSTRACT

Automatic traffic counters collect volume data for every hour of the year. Some methods of illustrating or summarizing traffic demand data for the purposes of planning, design, or identification of systematic detection errors are presented. Alternative summaries are provided that permit a more detailed examination of peaking characteristics and time distribution, as well as of the frequency and magnitude of certain types of traffic loads. Yearly calendars, graphs of ranked hourly volumes, and various frequency distributions are illustrated using data from Ontario's permanent counting stations. Potential applications are discussed for each, sample locations are examined, and some types of useful information that can be obtained are pointed out.

Highway agencies plan the upgrading of old facilities or the construction of new ones based on anticipated traffic volume demands. Such demand data are collected by automatic counters for every hour throughout the year on the busiest highways. These data need to be summarized to identify the most critical conditions but, because of the large amounts of data that are obtained, more than one type of summary can be useful. The exact type of summary depends on specific needs. Some suggested types of summaries are illustrated using data collected at Ontario's permanent counting stations in 1980.

SUMMARY TABLES

The traditional method of summarizing the traffic demand for a given year is by means of a set of summary tables. These tables can list the total traffic demand, maximum hourly volumes, and some measure of the peaking characteristics. Values can be quoted either in terms of combined (two-way) traffic or as a function of direction.

Summaries for the counts obtained for 1980 at Ontario's permanent counting stations (PCSs) are shown in Figures 1 and 2. Figure 1 shows each PCS location and lists, for the combined directions, the maximum hourly volume, the average annual daily traffic, the 30th highest hour, and a peaking ratio (i.e., K = 30HV/AADT). Figure 2 shows a summary of the peak directional PCS volumes in Ontario for 1980, (i.e., north- and southbound, or east- and westbound).

YEARLY CALENDARS OF HOURLY VOLUMES

Summary tables provide only a simplified measure of the magnitude of traffic demand and its peaking characteristics. Often it is of interest to also know when, why, and how these peaking conditions occur. Therefore, a traffic calendar has been developed as a measure of the time distribution of the top traffic demands. A yearly calendar of hourly volumes provides a structured visual presentation of the time of day, week, or year during which the highest 300 (in this case) hourly volumes of the year occur. The calendar lists the year's top 300 hourly volumes according to hour (left to right) and day (top to bottom) of occurrence. The result is a sparse 366 x 24 matrix of traffic volume data containing only the largest 300 elements. Because data are all presented in a single, ordered picture, patterns of high demand such as problem days or peak demand periods can be identified quite easily.

Simple Calendars of Actual Hourly Volumes

This type of calendar lists the actual numerical volume counts for each given day and hour. Figures 3 and 4 show portions of such calendars for two sample locations. Volume counts for the late-summer months of 1980 are presented for stations 22 (Brampton) and 91 (Kirby), respectively. In each case the combined (two-directional) hourly count is presented. Station 22, at Brampton, is located on a commuter route that

STA	LOCATION	HIGHWAY DESCRIPTION	LANES	MAXH	AADT	30HH	30HH/ADDT
2	HOMER	QEW - E. of Hwy 405	4	4202	28004	3407	0.122
4	SHELBURNE	10 - Hwy 10-24-89	2	1426	7529	1135	0.151
5	GRAVENHURST	11 - N. of Washago	4	3523	11790	2904	0.246
21	BRADFORD	11 - Bradford S. Lts	4	1564	12000	1352	0.113
22	BRAMPTON	7 - W. of Hwy 50	4	3493	22940	3029	0.132
27	ROWENA	401 - W. of Hwy 31	4	2075	8335	1342	0.161
30	SIMCOE	3 - W. of Simcoe	2	620	5018	537	0.107
31	DIXIE	401 - W. of Hwy 10	6	7837	67261	7217	0.107
32	PORT-HOPE	401 - W. of Port Hope	4	4997	21945	3460	0.158
33	NIPIGON	11 - W. of Nipigon	2	504	2991	414	0.136
35	DUNVEGAN	417 - W. of Hwy 34	4	1278	6774	996	0.147
36	PORT-SEVERN	69 - N. of Port Severn	2	1787	5414	1355	0.250
37	MAPLE	400 - N. of Hwy 7	6	6687	44863	6009	0.134
74	OTTAWA	417 - Ottawa Queensway	4	6638	57323	6236	0.109
75	KEELE	401 - E. of Keele St.	12	23980	227954	22880	0.100
77	LIVERPOOL	401 - W. of Pickering	6	9225	82704	8593	0.104
90	SNELGROVE	10 - N. of Snelgrove	4	1842	11110	1289	0.116
91	KIRBY	115 - N. of Kirby	2	1920	10633	1644	0.155

FIGURE 1 Description of Ontario PCS locations.

STA	LOCATION	DIR	MAXH	AADT	30HV	"K"	DIR	MAXH	AADT	30HV	"K"
2	HOMER	W	2775	14045	1854	0.132	E	2710	13964	2187	0.157
4	SHELBURNE	W	1007	3693	736	0.199	E	1122	3833	808	0.211
5	GRAVENHURST	S	3119	5935	2375	0.400	N	2918	5872	2114	0.360
21	BRADFORD	S	1192	5986	844	0.141	N	1009	6000	803	0.134
22	BRAMPTON	W	2216	11208	1850	0.165	E	2693	11640	2087	0.179
27	ROWENA	W	1091	4111	710	0.173	E	1058	4222	722	0.171
30	SIMCOE	W	414	2514	294	0.117	E	398	2502	283	0.113
31	DIXIE	W	4606	33027	4334	0.131	E	5142	33948	4869	0.143
32	PORT-HOPE	W	3098	10865	2363	0.217	E	2335	11083	2096	0.189
33	NIPIGON	W	306	1476	238	0.161	E	348	1517	208	0.137
35	DUNVEGAN	W	881	3420	567	0.166	E	812	3352	573	0.171
36	PORT-SEVERN	S	1378	2746	981	0.357	N	1111	2678	932	0.348
37	MAPLE	S	5333	22649	4402	0.194	N	5067	22494	4403	0.196
74	OTTAWA	W	3723	28534	3560	0.125	E	3525	29457	3393	0.115
75	KEELE	W	12400	115423	11920	0.103	E	12110	112455	11600	0.103
77	LIVERPOOL	W	5937	40541	5383	0.133	E	5607	41938	5227	0.125
90	SNELGROVE	S	1328	5665	935	0.165	N	1037	5353	817	0.153
91	KIRBY	S	1535	5526	1339	0.242	N	1241	5098	1080	0.212

where :
MAX HR : the maximum combined hourly volume count observed
AADT : the average annual daily traffic
30HV : the 30th highest combined hourly volume count
"K" : peaking factor equal to 30HV/AADT

FIGURE 2 Directional peak PCS volumes in Ontario for 1980.

has corresponding peaks during the morning and afternoon rush hours on weekdays. Station 91, at Kirby, is located on a recreational route. Traffic on this stretch travels in a northbound direction toward "cottage country," and back southbound on Sunday evenings. This results in two peaks in traffic volume at the beginning and the end of each summer weekend. It is noted that the 4-month period, which is shown in Figure 4, contains 218 of the top 300 hours. Thus the most important part of the year can be illustrated on a single page.

Multidirectional Calendar of Actual Hourly Volumes

A variation of the calendars is shown in Figures 5 and 6 for stations 02 at Homer and 91 at Kirby. In these figures, the individual directional counts and the hourly counts for the combined directions are listed together for each hour of the year. Specifically, the combined hourly count is listed, followed by the east- and westbound, or south- and northbound, counts, respectively. This presentation illustrates most clearly offsets in peaking characteristics for individual directions with respect to each other and to their combined total.

Station 02 at Homer is located on the Queen Elizabeth Way. The summer traffic volume peaks in the eastbound direction (to Niagara Falls) in the early afternoon and in the westbound direction later in the afternoon. Although each direction has distinct peaks of its own, the combined peak tends to bridge the directional peaks.

For station 91 at Kirby, the nature of the traffic demand is illustrated more clearly using the bidirectional approach. The summer traffic peaks in the northbound direction on Friday evenings and Saturday mornings, with hardly any opposing volume. The reverse takes place at the end of these summer weekends, when people return south late Sunday afternoon and evening. The resulting top 300 combined volumes tend to reflect the top 150 or so hours in each direction.

Calendar of Relative Traffic Volume Intensity

A calendar of traffic volume intensity was introduced to provide a simple relative scale of traffic demand as an alternative to the actual numerical volumes presented in the previous section. This allows for quick yet comprehensive visual recognition of patterns of severity and time of peaking.

The traffic volume intensity calendar is produced by mapping every traffic volume between the highest and the 300th highest hour on a scale from 1 to 5. The difference between the highest and the 300th hour is divided by 5 to create five cells of equal volume increments. The position of the cell into which an hour falls is denoted by the corresponding number of asterisks (i.e., from 1 to 5) to indicate magnitude of demand. Hourly volumes slightly larger than those of the 300th highest hour are indicated by a single asterisk, and volumes approaching the year's highest hourly volume are indicated by five asterisks.

The traffic volume intensity calendar provides the reader with a global view of the peaking patterns throughout the year. Partial calendars for directional and total volumes are shown for stations 02 at Homer, 22 at Brampton, and 91 at Kirby in Figures 7-9. In general, Homer can be seen to have a summer afternoon peak that intensifies on weekends. The Brampton station encounters a clear commuter pattern with very distinct weekday morning and evening peaks. Station 91, near Kirby, experiences a typical recreational route demand with highly directional peaks at the beginning and end of nearly all summer weekends or holidays.

GRAPHS OF RANKED HOURLY VOLUMES

A standard method of representing annual hourly traffic demands consists of ranking the hourly volumes. Graphs of this type are shown in Figures 10 and 11. Special emphasis is placed on their peaking characteristics, and the analyses are based on a directional approach. All graphs have two abscissa scales and ordinates with dual labels.

Two scales are used for the abscissas to simultaneously show the detailed peaking characteristics of the top hours and the entire annual distributions on the same figure. The top abscissa, which should be used with the top curve, indicates the ranking of the top 100 (or 200) hours. The bottom abscissa, which should be used with the bottom curve, indi-

CALENDAR OF COUNTS FOR TOP 300 HOURLY VOLUMES IN 1980
LOCATION: 22 BRAMPTON HWY 7 - W of Hwy 50 4 Lanes DIRECTION: C

DAY	NUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	[redacted]	23	24
SA	187																								
SU	188																								
MO	189								2788																
TU	190																								
WE	191								2792																
TH	192																								
FR	193																	2918							
SA	194																								
SU	195																								
MO	196																								
TU	197								2781																
WE	198								2880																
TH	199																								
FR	200																	2872							
SA	201																								
SU	202																								
MO	203																								
TU	204																								
WE	205																								
TH	206																								
FR	207																								
SA	208																								
SU	209																								
MO	210																								
TU	211																								
WE	212																								
TH	213																								
FR	214																								
SA	215																								
SU	216																								
MO	217																								
TU	218																								
WE	219																								
TH	220																								
FR	221																								
SA	222																								
SU	223																								
MO	224																								
TU	225								2778																
WE	226								2778																
TH	227																								
FR	228								2736									2789							
SA	229																								
SU	230																								
MO	231								2829																
TU	232								2838																
WE	233								2741																
TH	234								2723									2745							
FR	235																	2847							
SA	236																								
SU	237																								
MO	238								2803																
TU	239								2797																
WE	240								2826																
TH	241																								
FR	242																	2919							
SA	243																								
SU	244																								
MO	245																								
TU	246								2898									2771							
WE	247								2991									2729							
TH	248								2950									2795							
FR	249								2870									2933	2739						
SA	250																								
SU	251																								
MO	252								2892									2763							
TU	253								2891									2781							
WE	254								2886																
TH	255								2730									2751	2765						
FR	256								2901									3023	2910						
SA	257																								
SU	258																								
MO	259								3025									2788	2768						
TU	260								2938										2740						
WE	261								2779																
TH	262								2909										2772						
FR	263								2833									2965	2981						
SA	264																								
SU	265																								
MO	266								2929										2821						
TU	267								2855										2740						
WE	268								2926									2746	2729						
TH	269								2947									2800	2922						
FR	270								3000									3101	2974						
SA	271																								
SU	272																								
MO	273								2908	2751								2817	2881						
TU	274								3014									2834	2911						
WE	275								3076									2872	2856						
TH	276								2789									2796	2896						
FR	277								2931									2863	2886						
SA	278																								
SU	279																								
MO	280								3019										2827						
TU	281								3061									2860	2761						
WE	282								3077									2898	2807						
TH	283								2957										2876						
FR	284								2968									3199	3264						
SA	285																								
SU	286																								
MO	287																								
TU	288								3027									2817	2812						
WE	289								2977									2741	2851						
TH	290								2929									2725	2838						
FR	291								2918									2960	2969						
SA	292																								
SU	293																								
MO	294								2995									2766	2876						
TU	295								2988									2730	2750						
WE	296								2957									2820	2777						
TH	297								2998									2744	2750						
FR	298								2964									2994	2901						
SA	299																								
SU	300																								
MO	301								3006									2938	2794						
TU	302								3062									2797	2757						
WE	303								3091	2757								2820	2778						
TH	304								3056									2741	2876						
FR	305								3051									3017	2891						

FIGURE 3 Calendar of actual hourly volumes for PCS 22 at Brampton.

CALENDAR OF COUNTS FOR TOP 300 HOURLY VOLUMES IN 1980
LOCATION: 91 KIRBY HWY 115 - N of Kirby 2 Lanes DIRECTION: C

DAY	NUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SA	187											1355	1487	1466	1304										
SU	188																		1382	1456	1758	1686	1527		
MO	189																								
TU	190																								
WE	191																								
TH	192																								
FR	193																1309	1484	1388	1299	1455	1369			
SA	194										1312	1665	1667	1524	1437										
SU	195																	1305	1420	1514	1775	1758	1588	1282	
MO	196																								
TU	197																								
WE	198																								
TH	199																								
FR	200															1313	1347	1362	1415	1437	1622	1463			
SA	201										1344	1737	1758	1610	1440										
SU	202														1433	1393	1387	1354	1365	1422	1438	1531	1254		
MO	203																								
TU	204																								
WE	205																								
TH	206																								
FR	207																1378	1497	1408	1458	1468	1527			
SA	208											1638	1778	1669	1438	1323									
SU	209														1334	1316	1289	1300	1431	1290	1460	1530	1432		
MO	210																								
TU	211																								
WE	212																								
TH	213																								
FR	214															1447	1469	1393	1455	1439	1428	1367			
SA	215										1492	1655	1920	1759	1663	1572									
SU	216												1374												
MO	217														1259	1382	1408	1491	1352	1344	1356	1302			
TU	218																								
WE	219																								
TH	220																								
FR	221																	1370	1326	1402	1416	1284			
SA	222											1606	1730	1493	1388	1379									
SU	223																	1329	1387	1510	1724	1665	1499		
MO	224																								
TU	225																								
WE	226																								
TH	227																								
FR	228															1273	1495	1424	1357	1535	1604	1437			
SA	229										1355	1628	1729	1507	1293										
SU	230																1333	1382	1614	1630	1746	1616	1642		
MO	231																								
TU	232																								
WE	233																								
TH	234																								
FR	235																1436	1605	1425	1471	1542	1436			
SA	236										1297	1616	1657	1421											
SU	237																	1308		1328	1566	1577	1598		
MO	238																								
TU	239																								
WE	240																								
TH	241																								
FR	242														1253	1517	1567	1555	1456	1354					
SA	243										1326	1531	1309												
SU	244																	1289	1355	1436	1644	1611	1519		
MO	245												1289	1600	1593	1523	1543	1558	1536	1408	1428				
TU	246																								
WE	247																								
TH	248																								
FR	249																								
SA	250																								
SU	251																	1389	1558	1575	1698	1547			
MO	252																								
TU	253																								
WE	254																								
TH	255																								
FR	256																	1381	1305						
SA	257																								
SU	258														1266	1413	1358	1407	1351	1334	1305				
MO	259																								
TU	260																								
WE	261																								
TH	262																								
FR	263																	1359	1267		1300				
SA	264																								
SU	265															1258	1354	1491	1559	1574	1473	1286			
MO	266																								
TU	267																								
WE	268																								
TH	269																								
FR	270																	1383	1338		1340				
SA	271																								
SU	272																1357	1504	1519	1344	1444				
MO	273																								
TU	274																								
WE	275																								
TH	276																								
FR	277																								
SA	278											1448	1498	1482	1502	1264									
SU	279														1419	1429	1463	1373	1308						
MO	280																								
TU	281																								
WE	282																								
TH	283																								
FR	284																	1325	1355						
SA	285																								
SU	286																								
MO	287													1304	1453	1587	1789	1897	1658		1373				
TU	288																								
WE	289																								
TH	290																								
FR	291																								
SA	292																								
SU	293																		1274						
MO	294																								
TU	295																								
WE	296																								
TH	297																								
FR	298																								
SA	299																								
SU	300																								
MO	301																								
TU	302																								
WE	303																								
TH	304																								
FR	305																								

FIGURE 4 Calendar of actual hourly volumes for PCS 91 at Kirby.

CALENDAR OF COUNTS FOR TOP 300 HOURLY VOLUMES IN 1980
LOCATION: 2 HOMER QEW - E of Hwy 405 4 Lanes DIRECTION: C

DAY	NUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
FR	200																2809	3016	2804						
EAST	200												1461				1530	1504	1490						
WEST	200															1311		1512	1314						
SA	201												3272	3347	3248	3076	2748		2795						
EAST	201											1491	2169	2307	2194	1940	1525								
WEST	201																		1665	1321					
SU	202												2950	3152	3159	3040	2996	2886	2865	2938					
EAST	202											1530	1961	2080	2002	1682	1522								
WEST	202															1358	1474	1595	1835	1952	1725	1603			
MO	203																2758	2923							
EAST	203												1648	1688			1494	1460							
WEST	203																	1463	1518						
TU	204																	2753							
EAST	204												1509				1548								
WEST	204																	1349	1323						
WE	205												3171	2824			2851	3226	2938						
EAST	205											1679	2018	1809			1466	1453							
WEST	205															1330	1385	1773	1636	1380					
TH	206												2950				2777	2927							
EAST	206											1498	1796	1579			1474								
WEST	206																	1577	1483						
FR	207												2886				2998	3022	2879						
EAST	207												1649	1541			1580	1500							
WEST	207															1320	1418	1522	1449						
SA	208											3026	3264	3205	3088	3281	2950	2838							
EAST	208											1756	2028	2117	1913	2033	1688								
WEST	208																	1457	1497	1361					
SU	209												2910	3164	3110	3102	2909	2907	2929	2885	2805				
EAST	209												1778	2128	1960	1735	1590								
WEST	209															1367	1319	1636	1760	1828	1834	1602			
MO	210																								
EAST	210													1596			1489								
WEST	210																		1374						
TU	211												3099	2885			2923	3069	2768						
EAST	211											1702	2045	1887	1538		1489								
WEST	211																1434	1668	1521						
WE	212											2990	3199	3180			2936	3245	3255						
EAST	212											1813	2123	2146	1631		1489								
WEST	212																1447	1860	1943	1606					
TH	213												3072	2874			2843	3240	2940						
EAST	213												1899	1845	1460		1480								
WEST	213																1363	1842	1719						
FR	214												3152	3538		3004	3372	3308	3235						
EAST	214												1844	2305		1553	1791	1580	1515		1527				
WEST	214												1308		1329	1451	1581	1728	1720						
SA	215											3317	3415	3620	3457	3131	3328	3080	3121	3692					
EAST	215										1598	2059	2214	2487	2272	1991	2088	1573							
WEST	215																	1507	1805	2448	1490				
SU	216											2927	3600	3562	3629	3683	4202	3428	3260	3812	3187	3018			
EAST	216											1941	2479	2468	2435	2385	2710	1678							
WEST	216																1492	1750	2017	2624	2088	2061	1754	1882	1526
MO	217											2867	3472	3759	3213	3104	3221	3248	3117	3441					
EAST	217											1888	2322	2524	1843	1539									
WEST	217														1370	1565	1796	2192	2227	2621	1890	1536	1413		
TU	218																2766	2950							
EAST	218												1631	1576			1466	1448							
WEST	218																	1502	1332						
WE	219											2825	2922	3208	3080		2842	3196	3096						
EAST	219											1727	1869	2140	2014										
WEST	219															1338	1420	1779	1836						
TH	220												2961	2905			2939	3239	2853						
EAST	220												[illegible]	1843			1480								
WEST	220																1459	1814	1630						
FR	221												2848	3068			3085	3211	2912						
EAST	221												1635	1879	1451		1576	1503							
WEST	221															1409	1509	1708	1560						
SA	222											3035	3165	3475	3089	3140	2976	2889	2879	3074					
EAST	222											1814	2052	2408	2018	1840	1695	1456							
WEST	222																	1433	1589	1868					
SU	223												3297	3653	3444	3189	3154	3262	3331	3564	2912				
EAST	223											1762	2230	2496	2282	1789	1568								
WEST	223															1400	1586	1975	2217	2484	1975	1585			
MO	224																2791	2971							
EAST	224												1616	1568			1526	1513							
WEST	224																	1458	1327						
TU	225													2787			2861	3021							
EAST	225											1460	1746	1715			1538								
WEST	225																1323	1579	1402						
WE	226												2941	2841			2915	3141	3094						
EAST	226											1587	1873	1858			1477	1469							
WEST	226															1334	1438	1672	1840						
TH	227																2771	3122							
EAST	227												1487	1667											
WEST	227															1344	1344	1697	1464						
FR	228												2983	2984			3224	3407	3139						
EAST	228												1755	1760	1479		1702	1583				1484			
WEST	228															1319	1522	1824	1721						
SA	229											3065	3324	3541	3692	3155	3141	2931	2999	3002					
EAST	229											1810	1992	2382	2474	1936	1860								

FIGURE 5 Multidirectional calendar for PCS 02 at Homer.

CALENDAR OF COUNTS FOR TOP 300 HOURLY VOLUMES IN 1980
LOCATION: 91 KIRBY HWY 115 - N of Kirby 2 Lanes DIRECTION: C

DAY	NUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
FR	200															1313	1347	1362	1415	1437	1622	1463			
NOR	200															848	919	987	967	1065	1230	1108	756		
SOU	200																								
SA	201										1344	1737	1758	1610	1440										
NOR	201									736	957	1141	1111	1060	950	721									
SOU	201																								
SU	202														1433	1393	1387	1354	1365	1422	1438	1531	1254		
NOR	202																								
SOU	202														908	955	983	1072	1122	1195	1221	1285	1087	738	
MO	203																								
NOR	203																								
SOU	203																								
TU	204																								
NOR	204																								
SOU	204																								
WE	205																								
NOR	205																								
SOU	205																								
TH	206																								
NOR	206																								
SOU	206																								
FR	207																1378	1497	1408	1458	1468	1527			
NOR	207															772	924	1082	970	1028	1071	991	786		
SOU	207																								
SA	208											1638	1778	1669	1438	1323									
NOR	208										816	1024	1054	1029	877	802									
SOU	208												724												
SU	209														1334	1316	1289	1300	1431	1290	1460	1530	1432		
NOR	209																								
SOU	209														800	872	873	984	1111	1027	1214	1317	1213		
MO	210																								
NOR	210																								
SOU	210																								
TU	211																								
NOR	211																								
SOU	211																								
WE	212																								
NOR	212																								
SOU	212																								
TH	213																								
NOR	213																								
SOU	213																								
FR	214															1447	1469	1393	1455	1439	1428	1367			
NOR	214													702	749	926	990	980	1013	1018	1072	1068	979	882	
SOU	214																								
SA	215										1492	1655	1920	1759	1663	1572									
NOR	215									756	1042	1069	1226	1186	1110	1077	791				697				
SOU	215												694												
SU	216												1374												
NOR	216											677	898	816											
SOU	216																				737	937	887		
MO	217														1259	1382	1408	1491	1352	1344	1356	1302			
NOR	217																								
SOU	217												700	864	955	1088	1118	1221	1131	1127	1147	1126	1046	858	
TU	218																								
NOR	218																								
SOU	218																								
WE	219																								
NOR	219																								
SOU	219																								
TH	220																								
NOR	220																								
SOU	220																								
FR	221																	1370	1326	1402	1416	1284			
NOR	221															656	707	900	893	915	1080	959	677		
SOU	221																								
SA	222											1606	1730	1493	1388	1379									
NOR	222										770	981	1049	884	816	794									
SOU	222																								
SU	223																	1329	1387	1510	1724	1665	1499		
NOR	223																								
SOU	223															760	830	975	1129	1263	1476	1463	1283	831	
MO	224																								
NOR	224																								
SOU	224																								
TU	225																								
NOR	225																								
SOU	225																								
WE	226																								
NOR	226																								
SOU	226																								
TH	227																								
NOR	227																								
SOU	227																								
FR	228															1273	1495	1424	1357	1535	1604	1437			
NOR	228												706		692	757	1000	993	913	1127	1241	1079	689		
SOU	228																								
SA	229										1355	1628	1729	1507	1293										
NOR	229									721	920	1052	1088	876	687										

FIGURE 6 Multidirectional calendar for PCS 91 at Kirby.

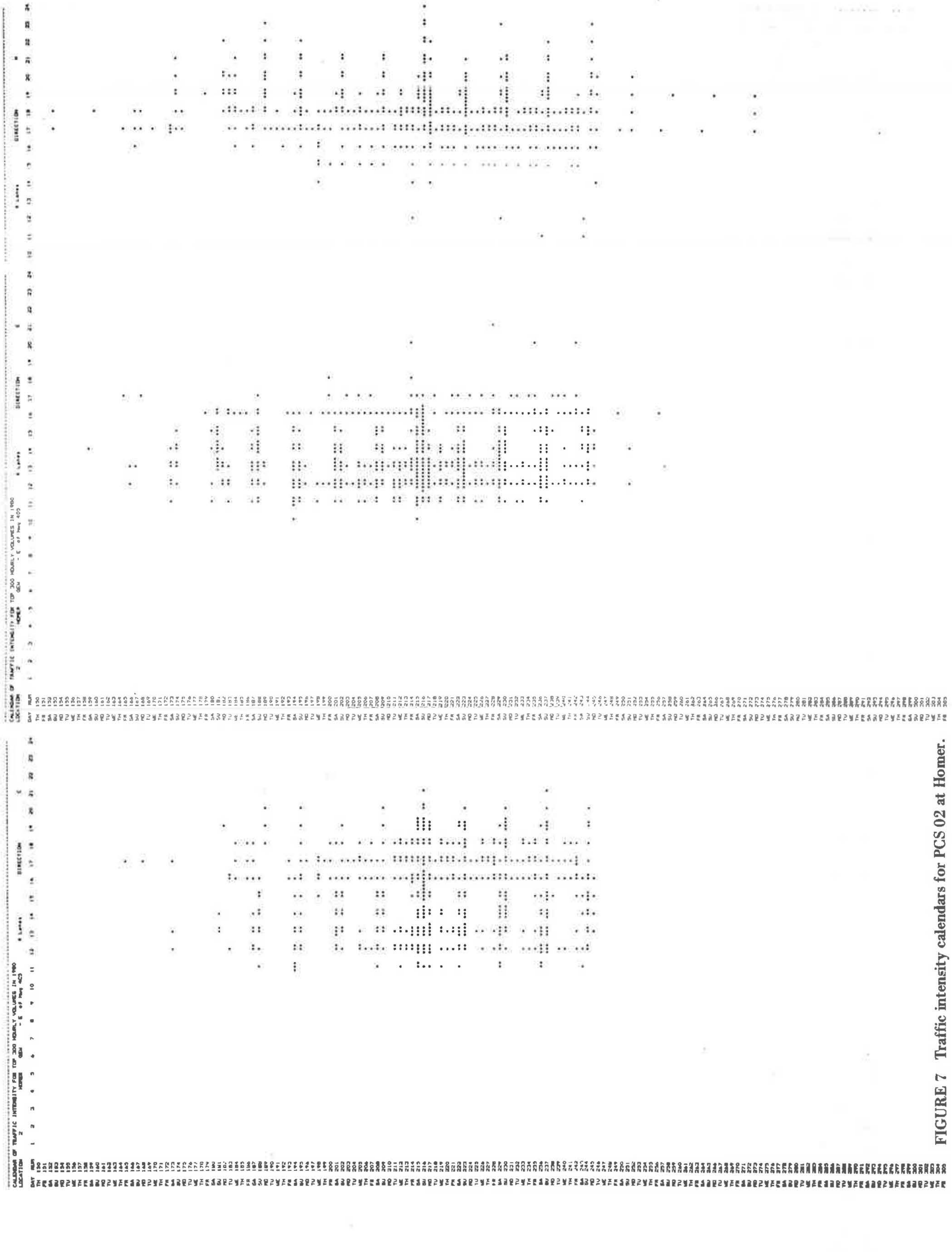


FIGURE 7 Traffic intensity calendars for PCS 02 at Homer.

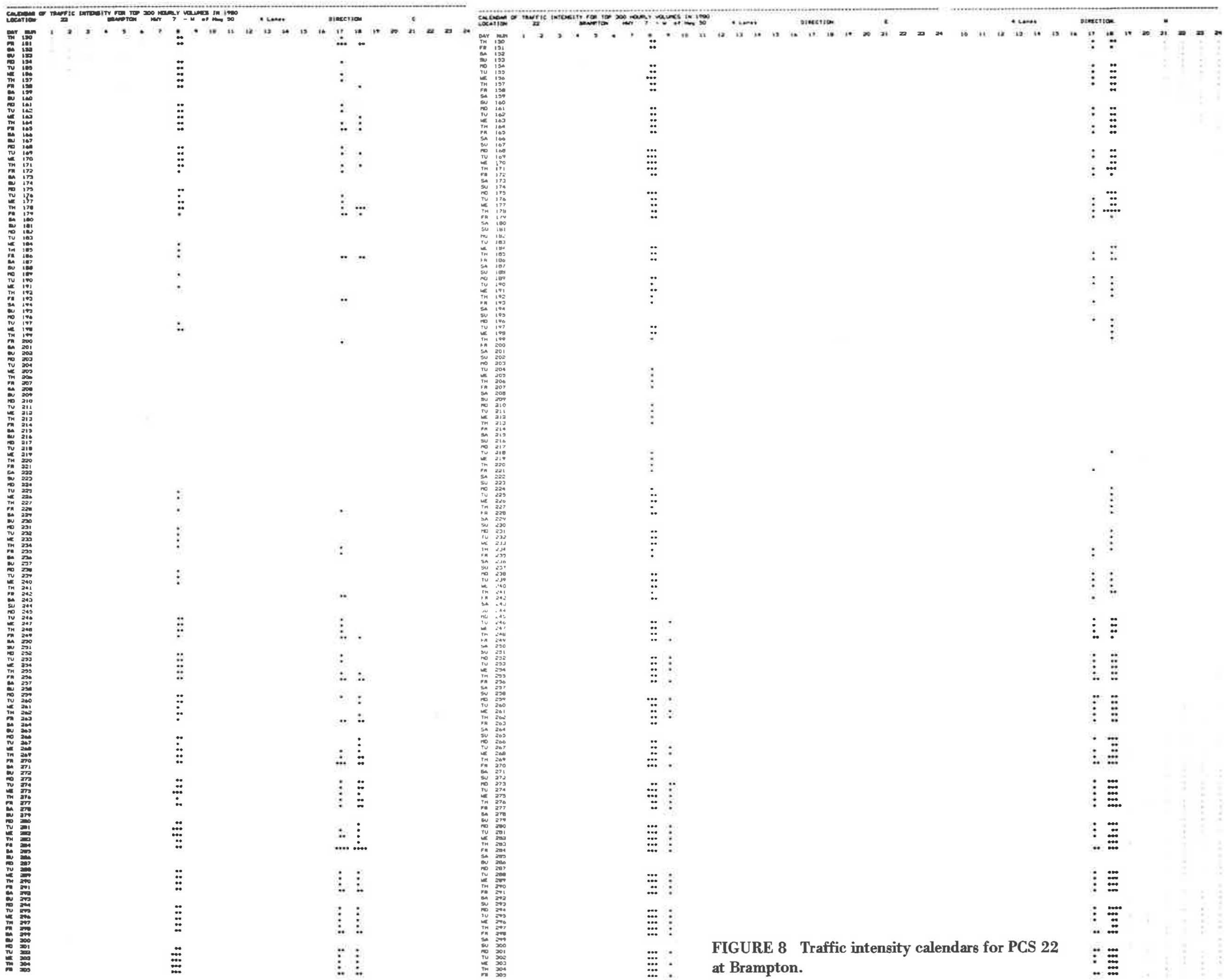


FIGURE 8 Traffic intensity calendars for PCS 22 at Brampton.

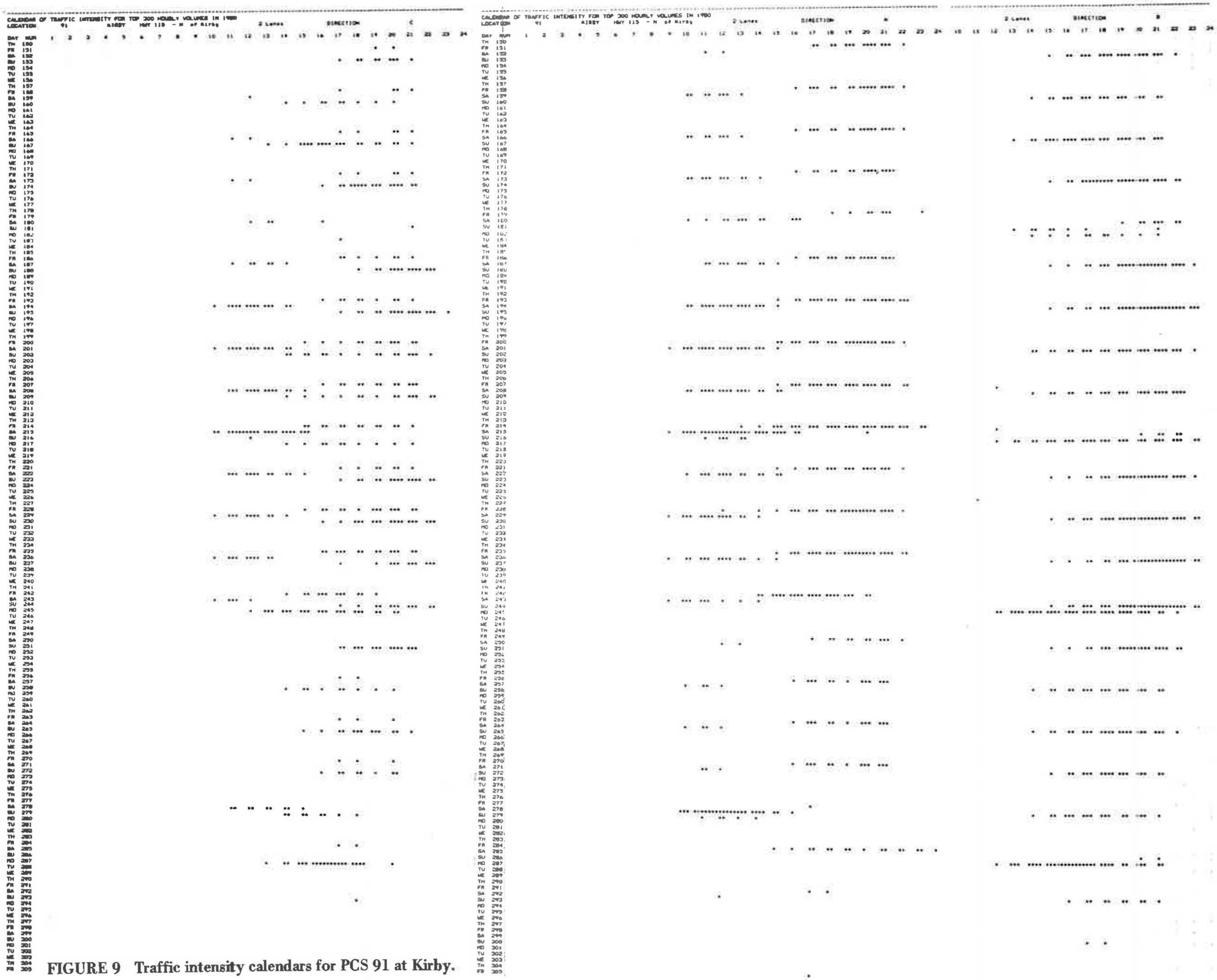
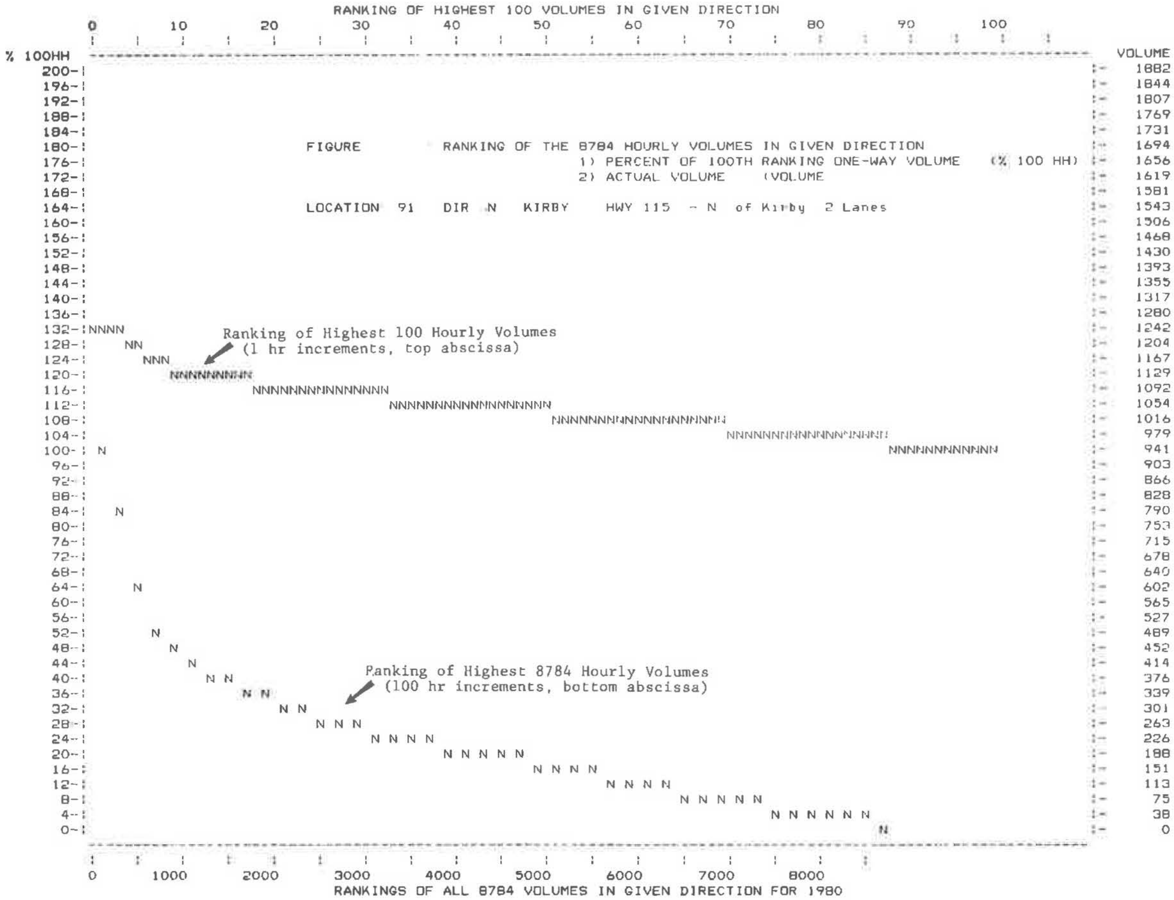


FIGURE 9 Traffic intensity calendars for PCS 91 at Kirby.



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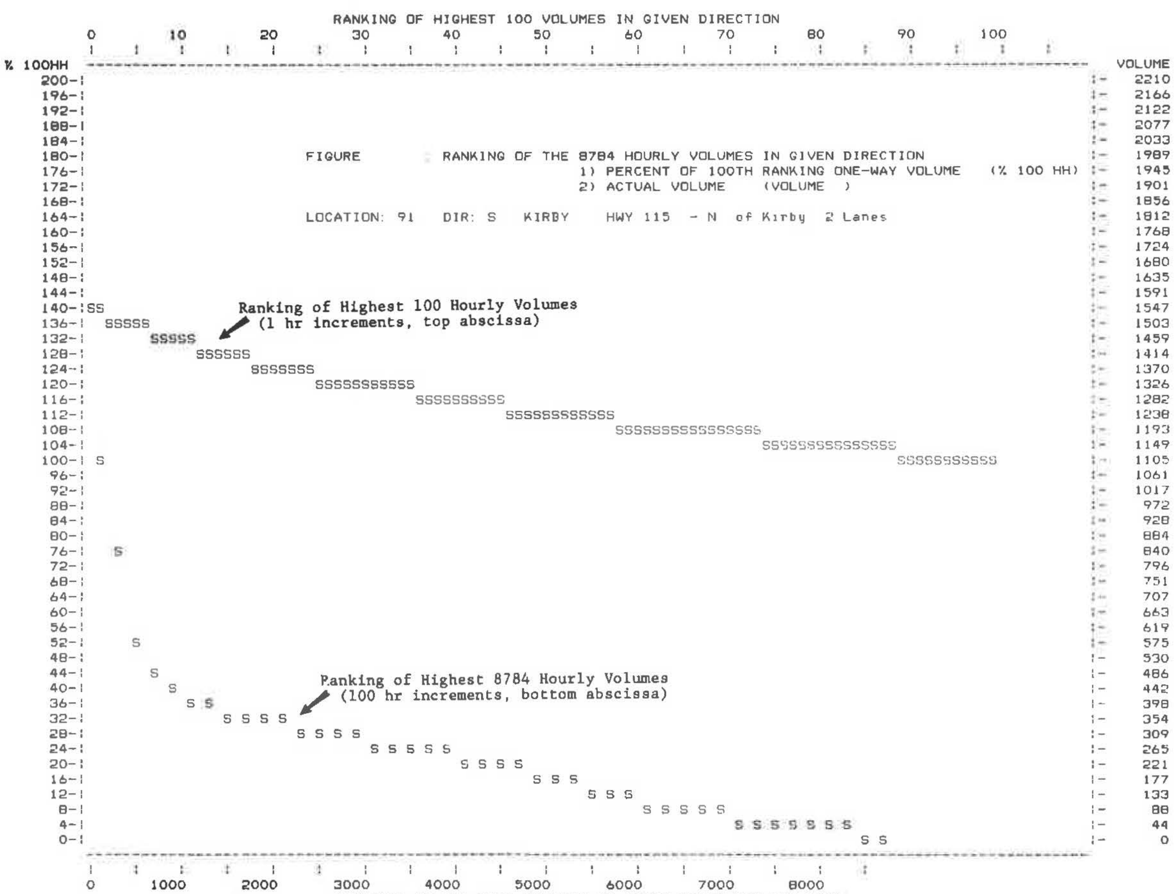
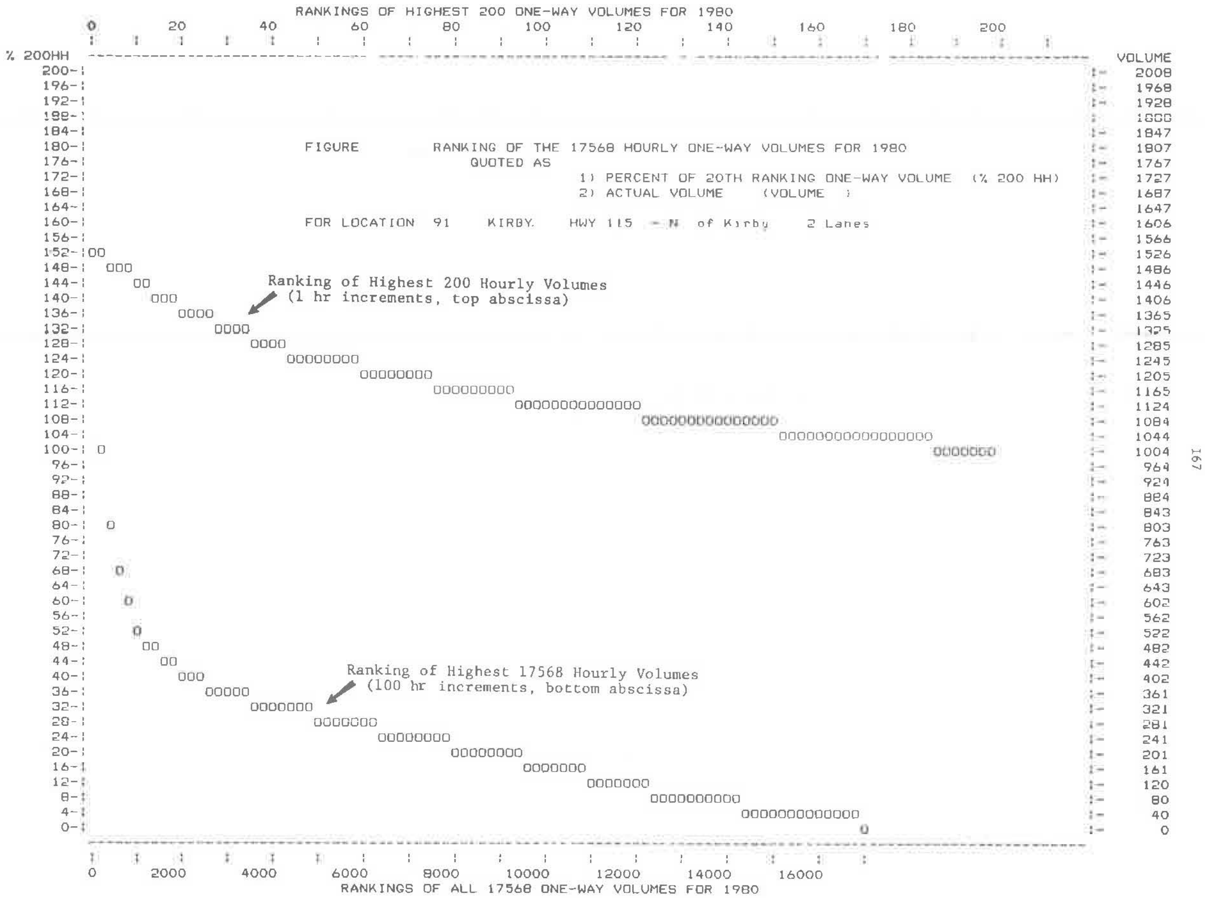


168

FIGURE 10 Ranking of directional volumes for PCS 91 at Kirby.



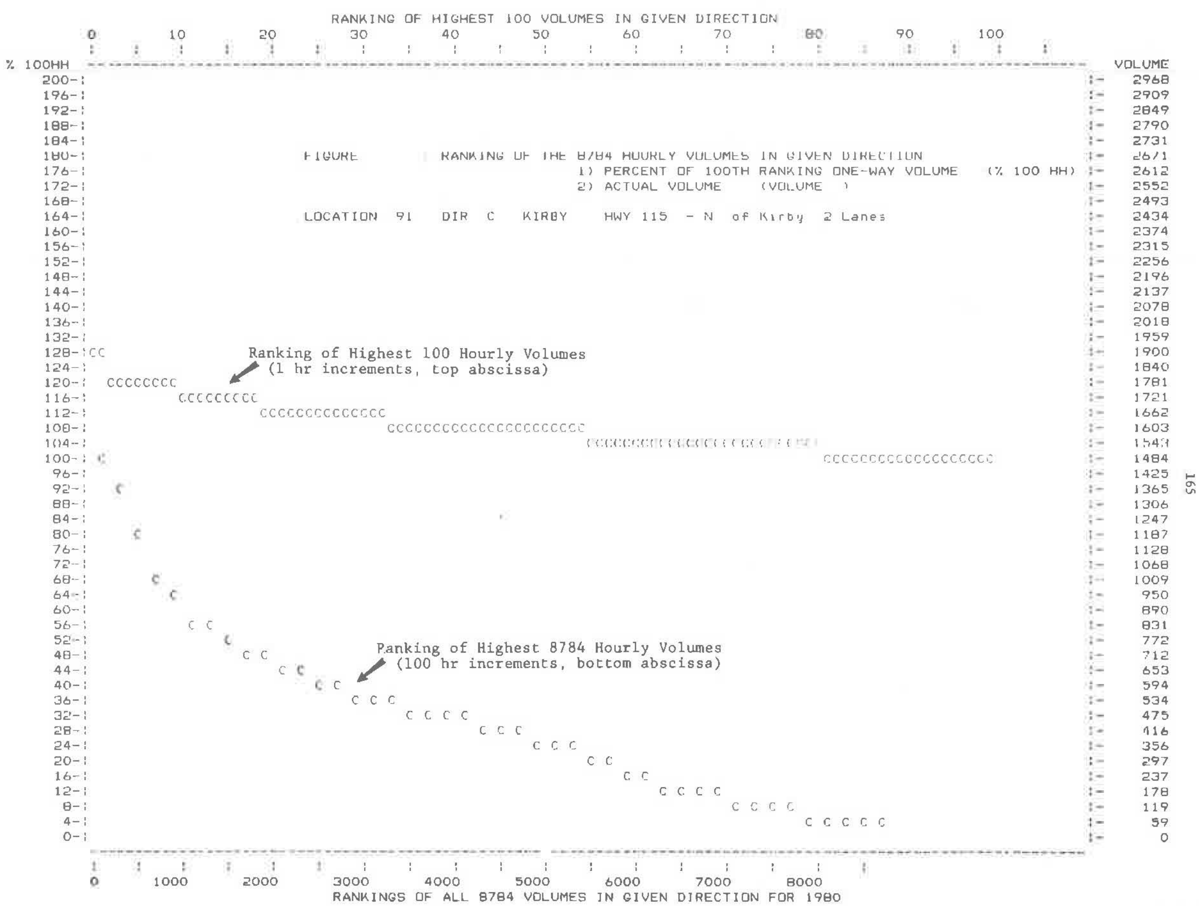


FIGURE 11 Ranking of combined two-way and one-way volumes for PCS 91 at Kirby.

cates the rank position of the total 8,784 (or 17,568) hourly volumes in the year. The ordinates of these graphs have dual labels, which simultaneously indicate the absolute demands and the relative demand distribution as a percentage. Both ordinates can be used with either the top or the bottom curve. The right ordinate indicates the magnitude of the hourly demand, expressed in vehicles per hour. The absolute scale is provided as a reference to indicate the absolute shape of the distribution and allow comparison with data from other sources. The ordinate on the left expresses the demand as a percentage of either the 100th or the 200th highest hourly volume. It is intended to emphasize relative peaking characteristics when comparing highways with either different designs or different traffic volumes. The graphs are labeled using the following plotting conventions for rank hour distributions:

C = Combined two-way volumes,
O = One-way volumes (independent of direction),
S = Southbound directional volume,
N = Northbound directional volume,
W = Westbound directional volume, and
E = Eastbound directional volume.

Directional Volumes

Because traffic capacity is, in general, virtually independent of volumes in the opposing direction, unidirectional peaks in traffic volume are of prime interest. Figure 10 shows northbound (N) and southbound (S) unidirectional plots for station 91 at Kirby. The figure shows some directional variation in peaking characteristics: southbound has a higher ultimate peak, and the northbound direction maintains its peaking over a greater range of volumes.

Combined Two-Way Volumes

Traditionally, the ranked combined two-way hourly demand volumes have been plotted. Although this approach has been discouraged by several authors (1,2), these traditional plots are nevertheless provided herein to allow for comparison of the Ontario demand data with other sources. Station 91, at Kirby, is used to illustrate the combined two-way volume plot. The 100th highest combined hourly volume for this location in 1980 was 1,357. The right ordinate continues with the absolute demands and the scale on the left is quoted as a percentage of 1,357, which represents the 100th highest hour.

Ranking of All One-Way Volumes Independent of Direction

The directional peaking characteristics of opposing directions can be simultaneously illustrated on a single graph by ranking the year's 17,564 one-way volumes, independent of direction. This represents 17,564 intensities of demand, which are generally best related to one-way volumes even for two-way, two-lane roads such as that at station 91 at Kirby. If both directions peak during the same hour, they are represented individually in the rankings. Relative peaking characteristics are expressed as a percentage of the 200th highest hour (HH) for equitable comparisons with directional and two-way graphs. Figure 11 shows such a one-way volume ranking for PCS 91 at Kirby.

INTERPRETATION OF DIFFERENT TYPES OF PLOTS

In general, highways have a balanced design and each direction of travel has the same directional capacity. In this case a ranking of the 17,568 hourly one-way volumes (top of Figure 11) would indicate for how many hours throughout the year a given directional traffic volume was exceeded. Conversely, this figure can be used to estimate a directional one-way traffic volume that will be exceeded during a prespecified number of hours.

Some highways, however, have different directional capacities. Examples of these are uphill stretches, places where one direction has an additional passing lane or paved shoulder, or conditions where only one direction has a severe lateral obstruction. In this case comparable intensities of traffic would correspond to different one-way volumes for each direction. Analysis by direction would therefore be required and the directional plots in Figure 10 would be more appropriate.

FREQUENCY DISTRIBUTIONS FOR VOLUME LEVELS

The distribution of a year's demand is often presented as a frequency distribution. Two types of frequency distributions are discussed herein, and each is presented in both absolute and relative terms. The first distribution indicates how many hours of the year the highway operates at a given volume level, and the second indicates how many users operate at a given intensity of demand.

Frequency Distribution for Hours

The conventional method of presenting frequency distributions consists of tabulating the number of hours that the highway operates at a given volume level or in a given volume range. This type of frequency distribution is facility oriented in that it expresses the number of hours the facility is exposed to a given demand level or demand load.

The use of such a facility-oriented technique is somewhat limited as was pointed out by Crabtree and Deacon (3) and Yagar and Van Aerde (4). It is true that these distributions can be used to calculate the wear and tear on the facility. However, because wear and tear are a function of the total number of vehicles and their size and generally not a function of the time distribution, it is more efficient to use a simple annual or seasonal total expressed as such or in terms of annual average daily traffic (AADT) for this purpose.

Frequency distributions by hour have been provided here because their use is still part of traditional highway design thinking. Sample distributions are shown in Figure 12 for station 91. The distributions by hour are provided for each direction and the combined two-way volume in terms of both hourly frequencies and percentages of the total 8,784 hours in 1980.

Frequency Distribution for Drivers

Tabulating the number of drivers (or vehicles) that operate at a given volume level is perhaps a more appropriate method of presenting a station's frequency distribution. This type of frequency distribution is more user oriented because it expresses the number of drivers that will be exposed to a given demand intensity (volume) throughout the year. These user-oriented statistics are more convenient and direct and allow costs to be directly computed by multiplying the unit cost per vehicle at each volume level by the number of drivers or vehicles in the volume interval or cell. This allows highway up-

LOC: 91 KIRBY HWY 115 - N. of Kirby 2 Lanes

VOLUME RANGE	FOR BOTH DIRECTIONS HOURS		DRIVERS		FOR NORTHBOUND DIRECTION HOURS		DRIVERS		FOR SOUTHBOUND DIRECTION HOURS		DRIVERS	
	FREQ.	PERCENT	FREQ.	PERCENT	FREQ.	PERCENT	FREQ.	PERCENT	FREQ.	PERCENT	FREQ.	PERCENT
0- 50	324	3.69	8100	0.21	1259	14.33	31475	1.66	1604	18.26	40100	1.95
50- 100	935	10.64	70125	1.78	1325	15.08	99375	5.24	1052	11.98	78900	3.84
100- 150	650	7.40	81250	2.06	1160	13.21	145000	7.65	740	8.42	92500	4.51
150- 200	633	7.21	110775	2.80	1090	12.41	190750	10.07	631	7.18	110425	5.38
200- 250	457	5.20	102825	2.60	1084	12.34	243900	12.87	877	9.98	197325	9.61
250- 300	327	3.72	89925	2.28	729	8.30	200475	10.58	1180	13.43	324500	15.81
300- 350	350	3.98	113750	2.88	549	6.25	178425	9.41	1000	11.38	325000	15.84
350- 400	520	5.92	195000	4.94	455	5.18	170625	9.00	640	7.29	240000	11.69
400- 450	566	6.44	240550	6.09	326	3.71	138550	7.31	315	3.59	133875	6.52
450- 500	572	6.51	271700	6.88	225	2.56	106875	5.64	165	1.88	78375	3.82
500- 550	560	6.38	294000	7.44	118	1.34	61950	3.27	109	1.24	57225	2.79
550- 600	430	4.90	247250	6.26	82	0.93	47150	2.49	77	0.88	44275	2.16
600- 650	360	4.10	225000	5.70	74	0.84	46250	2.44	57	0.65	35625	1.74
650- 700	332	3.78	224100	5.67	49	0.56	33075	1.75	50	0.57	33750	1.64
700- 750	274	3.12	198650	5.03	41	0.47	29725	1.57	38	0.43	27550	1.34
750- 800	258	2.94	199950	5.06	31	0.35	24025	1.27	20	0.23	15500	0.76
800- 850	199	2.27	164175	4.16	34	0.39	28050	1.48	29	0.33	23925	1.17
850- 900	166	1.89	145250	3.68	28	0.32	24500	1.29	27	0.31	23625	1.15
900- 950	134	1.53	123950	3.14	28	0.32	25900	1.37	14	0.16	12950	0.63
950- 1000	105	1.20	102375	2.59	27	0.31	26325	1.39	25	0.28	24375	1.19
1000- 1050	78	0.89	79950	2.02	24	0.27	24600	1.30	18	0.20	18450	0.90
1050- 1100	70	0.80	75250	1.91	25	0.28	26875	1.42	16	0.18	17200	0.84
1100- 1150	69	0.79	77625	1.97	12	0.14	13500	0.71	17	0.19	19125	0.93
1150- 1200	58	0.66	68150	1.73	4	0.05	4700	0.25	18	0.20	21150	1.03
1200- 1250	54	0.61	66150	1.67	5	0.06	6125	0.32	16	0.18	19600	0.96
1250- 1300	44	0.50	56100	1.42	0	0.00	0	0.00	12	0.14	15300	0.75
1300- 1350	46	0.52	60950	1.54	0	0.00	0	0.00	12	0.14	15900	0.77
1350- 1400	51	0.58	70125	1.78	0	0.00	0	0.00	9	0.10	12375	0.60
1400- 1450	41	0.47	58425	1.48	0	0.00	0	0.00	4	0.05	5700	0.28
1450- 1500	34	0.39	50150	1.27	0	0.00	0	0.00	6	0.07	8850	0.43
1500- 1550	24	0.27	36600	0.93	0	0.00	0	0.00	6	0.07	9150	0.45
1550- 1600	16	0.18	25200	0.64	0	0.00	0	0.00	0	0.00	0	0.00
1600- 1650	18	0.20	29250	0.74	0	0.00	0	0.00	0	0.00	0	0.00
1650- 1700	11	0.13	18425	0.47	0	0.00	0	0.00	0	0.00	0	0.00
1700- 1750	8	0.09	13800	0.35	0	0.00	0	0.00	0	0.00	0	0.00
1750- 1800	7	0.08	12425	0.31	0	0.00	0	0.00	0	0.00	0	0.00
1800- 1850	1	0.01	1825	0.05	0	0.00	0	0.00	0	0.00	0	0.00
1850- 1900	1	0.01	1875	0.05	0	0.00	0	0.00	0	0.00	0	0.00
1900- 1950	1	0.01	1925	0.05	0	0.00	0	0.00	0	0.00	0	0.00
1950- 2000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2000- 2050	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2050- 2100	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2100- 2150	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2150- 2200	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2200- 2250	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2250- 2300	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2300- 2350	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2350- 2400	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2400- 2450	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2450- 2500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
TOTALS	8784	100.00	3949700	100.00	8784	100.00	1895140	100.00	8784	100.00	2052320	100.00

FIGURE 12 Frequency distribution for hours and users.

grading strategies to be easily evaluated in terms of user benefits. The frequencies and percentages for drivers (vehicles) in each volume range are indicated in Figure 12 for 1980 at PCS 91. Estimates of user benefits could be further enhanced if for each vehicle (or each hour) the average vehicle occupancy were known. This would allow the total number of people (drivers and passengers) exposed to a given intensity of demand to be estimated.

Comparison of Hour and User Frequency Distributions

The hour and user frequency distribution are similar in nature but their interpretation can be quite different. Hour distributions tend to favor the large number of off-peak hours in which the traffic volume is below average. User distributions tend to correct for this by weighting each hour by the number of users in that hour. Figure 13 shows the relative and absolute frequencies of users and hours for station 91.

The costs incurred at a given traffic demand are experienced by the facility, the vehicle and driver, or the passengers in the vehicle. Although the first two items can be determined from the distribution for hours and vehicles or drivers, the latter must account for occupancy and becomes important when costs of delay and safety are considered.

CONCLUSIONS

A number of different methods for analyzing and comparing the time distribution, the peaking characteristics, and the magnitude of traffic demand were illustrated for a number of sample highways.

Summary tables are the simplest means of presenting the annual traffic demands at a given counting station. Daily averages, peak hour volume counts, and peaking ratios can be compared most easily, but the oversimplification of the traffic summaries results in the loss of some of the more detailed features and characteristics of annual traffic demand.

The calendar provides a structured visual presentation of the distribution of peak demands throughout the year and within each day. Patterns can be identified and the nature of the traffic demand is more easily understood. Plots of ranked hourly distributions provide a clear description of the peaking characteristics of traffic demands because such

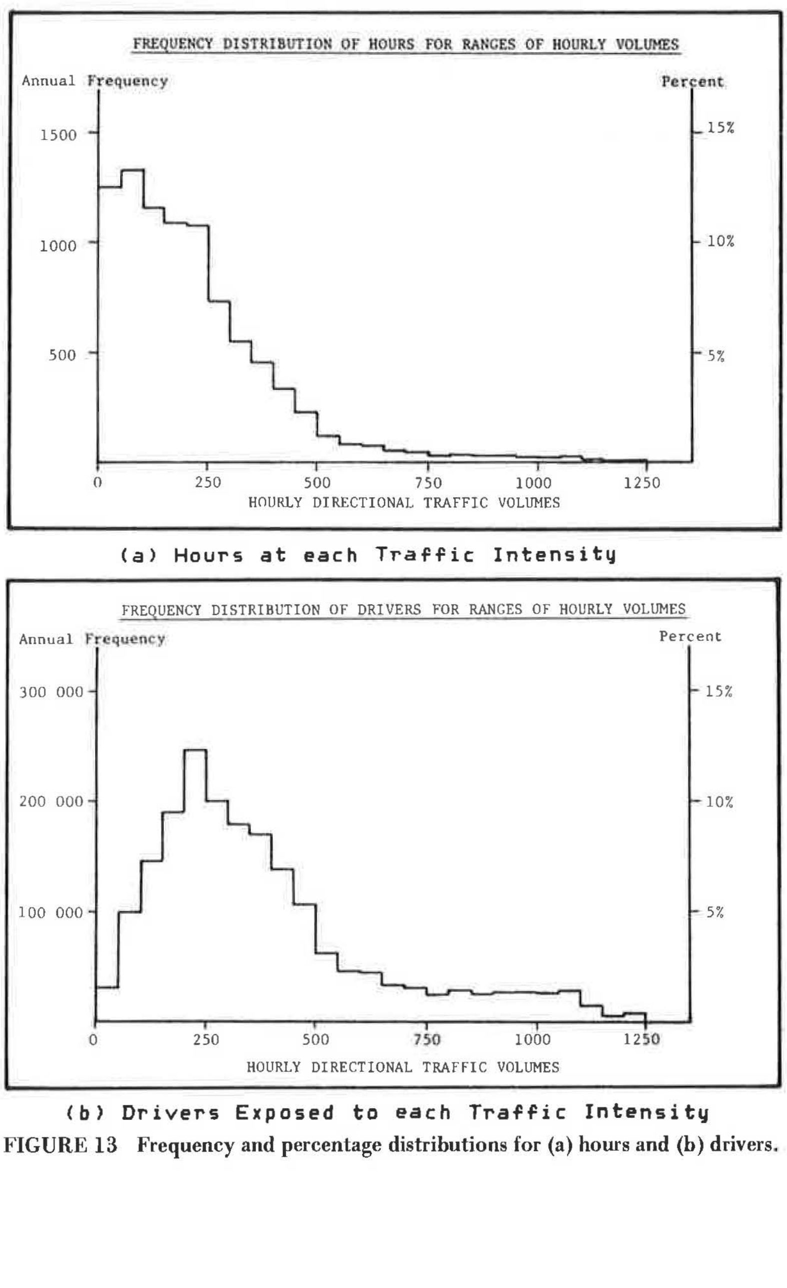


FIGURE 13 Frequency and percentage distributions for (a) hours and (b) drivers.

plots present a clear comparison of the magnitude of traffic volumes during the top hours.

Histograms of numbers of hours and vehicles in each range of traffic volumes are useful indicators of which conditions are most prevalent throughout the year. Because costs are calculated as a function of them, they identify those conditions that should be improved to yield the most significant cost savings.

As previously indicated, each of the methods is particularly useful in illustrating a specific aspect of the annual traffic demand, but each lacks some other type of information that might be desired. A highway agency should therefore use a combination of some or all of the techniques when carrying out a complete analysis of annualized traffic volumes.

RECOMMENDATIONS

Most current analysis is based on simple vehicle counts that do not account for vehicle type distribution. Because capacities tend to vary with the type of vehicle mix, it would be more appropriate to plot rankings, calendars, and histograms in terms of equivalent number of passenger cars. The maximum load, expressed in terms of passenger car units, would occur at times when there is a combination of large traffic volumes and a lot of heavy vehicles. This maximum load condition would not necessarily occur at the highest volume or the highest percentage of heavy vehicles. Specifically, percentage of recreational vehicles tends to be a maximum at times of maximum vehicle counts on recreational routes, but truck percentage tends to be lower during commuter peaks because truckers tend to avoid peak conditions.

Conventional analysis is based on a ranking of traffic volumes as an indication of the times when capacity is most likely to be exceeded. This assumes capacity to be constant and makes peak volume counts concurrent with peak volume-to-capacity ratios. However, capacity can vary considerably and highway users are subjected to the lowest levels of service during times when combinations of large volumes and small capacity exist. This condition does not necessarily occur at either periods of highest volume or lowest capacity. Analysis of actual traffic volumes divided by prevailing capacity might perhaps indicate that the most critical service level conditions occur during winter holidays when traffic volumes are moderate but capacity is severely reduced.

The combined use of traffic volume, expressed in passenger car units, and capacity, matched for corresponding conditions, would provide a more accurate indication of when traffic demands are most critical.

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Microcomputer Training for Transit Managers

MARK ABKOWITZ

ABSTRACT

The introduction of microcomputers to the transit environment is creating much excitement as managers recognize the tremendous potential of these machines to improve transit decision making at many levels of operation. However, the majority of transit agencies has been cautious about procuring and using microcomputers. This is often due to lack of direct experience with microcomputer systems and to concern about the information furnished by computer vendors who are more interested in sales than in the configuration that is best suited to the transit property. In response to this situation, Rensselaer Polytechnic Institute staff have developed and are administering a microcomputer training course to familiarize transit managers with many functional areas where microcomputer capabilities can be harnessed. The course emphasizes hands-on experience and provides considerable exposure to decision making using microcomputers. System selection issues and procedures for conducting a needs assessment are also included in the course content. The development of the course and reactions of class participants are described. The course is being expanded to a regional offering through coordination with several universities.

Microcomputer systems have introduced the potential to significantly alter the management and operations practices of transit properties in the United States. The capabilities and the accessibility of these machines at an affordable price have stimulated and will continue to stimulate the development and implementation of policies and procedures directed at computer-assisted decision making at many levels of transit operation, including administration, budget analysis, routing and scheduling, maintenance, and marketing activities. This should directly and indirectly enhance transit efficiency and productivity.

In response to the microcomputer age, the UMTA Office of Planning Methods and Support established a Transit Industry Microcomputer Exchange (TIME) Support Center to serve as a clearinghouse for transit-related microcomputer activities. Operated by Rensselaer Polytechnic Institute (RPI), the support center has three primary functions:

1. Publish a quarterly newsletter containing information about microcomputer applications in the transit industry, advances in hardware, availability of software, and so forth to increase communication among users;
2. Serve as a clearinghouse for microcomputer software developed by members of the transit community to facilitate a direct exchange of information and software; and
3. Serve in an advisory capacity to address questions or problems relating to microcomputer systems and software.

The support center went into full operation in November 1982. In the first few months of operation, more than 700 transit professionals indicated their interest in being members of the user group, several software programs were submitted for testing and dissemination, and hundreds of programs were distributed and advisory telephone calls fielded. The initial response has been overwhelming because service-oriented projects generally have a lag time associated with them while the target market becomes more fully identified. The response clearly indicates a high level of interest in microcomputers in the transit industry.

In addition to those operators who have already purchased mircocomputers, the center received comments from several others who were in the process of making a commitment to microcomputers but were limited by their lack of on-site experience with microcomputer systems and their application. On the basis of comments received at several professional meetings, this latent demand appeared to be significant, perhaps even larger than the number of operators presently using microcomputers. A survey subsequently taken by the support center of its users substantiated this conclusion: only 33 percent of the user group members reported owning a microcomputer at the time. It is rather unusual to have such a large share of a user audience with little or no experience with the subject in which they have indicated such an active interest.

It was concluded that the latent market was so large because many transit managers were reluctant to request microcomputer procurement without having more direct experience with microcomputer capability. Furthermore, it appeared that many managers were not comfortable with the information they were receiving from computer vendors, because this advice was not always objective and vendors did not have the manager's interests in mind.

In response to this situation, RPI, with UMTA support, developed a training course to provide personnel with the basic skills necessary to procure and effectively use microcomputer systems. The primary objectives of the course are for participants to

- Understand how to select hardware and software,
- Develop an operational familiarity with a small computer,
- Learn about selected programs of immediate use, and
- Gain an awareness of the range of work-related uses of the microcomputer.

COURSE DESCRIPTION

The overall emphasis of the course is on exposing participants to a variety of microcomputer functions, which may be useful in their profession, through hands-on experience. Participants work at microcomputer terminals under the supervision of workshop instructors and staff and receive a workbook and software templates they may keep at the end of the training session. Attendees are exposed to the following microcomputer functions:

- File management,
- Word processing,
- Spreadsheets,
- Graphics,
- Data-base management, and
- Custom software.

Case studies are formulated to demonstrate these functions. These case studies use problems common to transit professionals involved in service planning, scheduling, finance, administration, and maintenance. In addition to specific microcomputer functions, three other topics are covered in the course: (a) system selection issues, (b) conducting a needs assessment, and (c) organizational issues of managing microcomputers. Each course module is described in more detail in the following discussion.

File Management

File management is perhaps the most basic capability of a microcomputer system. This segment focuses on learning how to create files, modify them, and sort information for analysis and distribution. The applications example concerns maintaining personnel records of transit employees. File management software is also used to demonstrate production of a telephone directory of employees and preparation of mailing labels for letters.

Word Processing

The text-editing function of a microcomputer, including formatting, entry, and production, is covered in this segment. This material is interfaced with the file manager to demonstrate how renewal letters are prepared and sent to drivers whose licenses are scheduled to expire in the next 60 days.

Spreadsheets

This is perhaps the most versatile and widespread use of a microcomputer in the transit environment. The course covers formatting, entry, and manipulation of spreadsheets to perform a number of transit analyses. Spreadsheet programs are used to illustrate several applications relevant to the transit industry. These include cash flow forecasting, operator wage budgeting, performance analysis using data collected as part of Section 15 ride checks, and timetable construction. Each of the applications uses progressively more sophisticated features of spreadsheets, and collectively the applications demonstrate nearly all capabilities of spreadsheet software.

Graphics

The graphics module is interfaced with the spreadsheet segment. Output from the spreadsheet programs serves as input to the graphics software, resulting in the production of tables, figures, and plots illustrating analysis results. Applications include graphic representation of cash flow forecasts and ride check data, and peer comparisons based on performance measures derived from Section 15 data.

Data-Base Management

The data-base management and custom software modules of the course are treated as advanced microcomputer subjects. The important objectives here are to alert the transit manager to

- Applications for which this capability should be used,
- Situations in which outside contracting should be considered, and
- How to contract with a software programmer.

Data-base management is the most complex subject covered in the course. It is introduced after the attendee has become familiar with file management, spreadsheets, and related capabilities. The primary emphasis in this module is on showing how multiple files can be structured and manipulated to perform a comprehensive analysis. The applications example focuses on maintenance tracking using records of shop activities and vehicle on-the-road performance. Attendees are also asked to formulate their own data-base management design for the transit payroll problem.

Custom Software

This segment addresses the need to personally develop software for a specific transit problem when "off-the-shelf" programs are not suitable. The participant is introduced to the complexities of writing and testing code and managing contracts for custom software development. Applications examples include a route-monitoring package and a technique for planning data-collection activities using statistical sampling designs.

Simulation Game

The climax to the hands-on environment is a simulation game scheduled after the instruction modules. A hypothetical transit problem is defined in which microcomputer analysis is needed at several departmental levels. Having gained a familiarity with various microcomputer functions and programs, attendees must conduct the analysis, work with other departments, and make a presentation to the board of directors at the end of the day. The purpose of the simulation game is to provide participants with an opportunity to gain additional confidence in formulating problems, using the microcomputer system, and using the results in the decision-making process.

System Selection

The system-selection module of the course focuses on disseminating all the information necessary to understand various system options and introducing criteria for selecting among the feasible alternatives. The introduction to this module focuses on the state-of-the-art in microcomputer applications at transit agencies. Subsequent material is divided into understanding microcomputer terminology, describing hardware options and costs, evaluating software options and costs, issues of system integration, and a priority ranking of selection criteria. The system integration discussion is particularly important because success in using microcomputer systems hinges to a large extent on compatibility of hardware and software, transferability of programs from one microcomputer system to another, and potential micro-mainframe linkages.

Needs Assessment

Although needs assessment precedes system selection chronologically, the order is reversed in the training session so that attendees are familiar with system attributes before they learn the procedure for identifying whether these attributes are relevant to their agency needs.

At the conclusion of this module, some attendees may be self-sufficient to conduct their own internal needs assessment, and others may recognize the need to obtain outside assistance for conducting an assessment. The principal objective is to convince each participant of the importance of conducting a needs assessment in order to proceed rationally and logically, rather than impulsively, in developing a microcomputer system.

The module begins with a general description of the two key elements in a needs assessment procedure: (a) conducting an analysis of current procedures and (b) performing a requirements analysis. The remainder of the session is devoted to an actual case study of a microcomputer needs assessment.

Organizational Issues of Managing Microcomputers

An important aspect of implementing a microcomputer system that is often overlooked is the management of the system when it is in operation. It is common for different departments or individuals to have difficulty about who has priority access to the machine. Potential misuse of the hardware and software and protecting personal files are also important security considerations.

Another potential problem is the human-machine interface within the agency and the resulting impact on job productivity. Although microcomputers have significant potential to improve productivity, there is a practical limit to their value and, in fact, the implementation of a microcomputer system can be counterproductive if personnel do not accept its arrival in the agency.

COURSE IMPLEMENTATION

The training activity at RPI was divided into two phases. The first phase involved course development and the offering of a pilot course at Rensselaer Polytechnic Institute in August 1983. The pilot course was monitored and evaluated to make improvements to the course content before making it available to other institutions interested in using the material for instruction.

The second phase of the project is focusing on RPI coordination with three UMTA University Centers that will be offering this course in their regions. The university center concept was developed by UMTA in response to expressed congressional concern for (a) the transit industry's vital need for middle management training and (b) identifying focal points for transit research and training activities. The centers' activities include development of continuing education courses in management and operations issues for transit officials.

The pilot course was held at the RPI microcomputer laboratory, which houses 12 personal computers. Enrollment was limited to 36 people per session (3 per microcomputer), with reservations accepted on a first come, first served basis. Class size was restricted to permit individual instruction and limit to a manageable size the number of people per microcomputer.

The response to this offering was extremely good. Despite the fact that UMTA Section 10 reimbursement was not available, enrollment reached capacity within 3 weeks. Registrants were mostly transit personnel (with a few academics and consultants) representing a diverse set of job responsibilities including finance, administration, scheduling, and maintenance.

The nature of the course and the backgrounds of attendees resulted in the identification of several key issues that are likely to affect the success of microcomputer training. Many of these issues were raised by attendees in completing evaluation forms distributed near the end of the session. The ensuing discussion focuses on the major issues that were identified.

Keyboard Eagerness

From the moment they arrive in class, attendees are anxious to "play with the machine." It is imperative to encourage this attitude by starting off immediately with keyboard exercises and games designed to establish a familiarity with the machine. The danger of deferring this activity in favor of introductory lectures is the loss of enthusiasm that is important to starting a training session off on the right foot.

Class Size

There is an important distinction between the theoretic and the practical limit of attendance for hands-on training. Initially, it was believed that three persons to a microcomputer was a reasonable solution to this problem. It became apparent during the pilot course that two persons to a microcomputer is the practical limit to ensure retention and participation without losing group interaction.

Previous Microcomputer Experience

The class was split nearly in half between those with previous microcomputer experience and those with no prior experience. The strategy used in the pilot course was to establish groups, consisting of a mix of experienced and novice users, at each computer station. In this fashion the experienced members of the class also served as tutors for their group. In this way a consistent instructional pace was maintained because all groups progressed at a similar rate.

The alternative arrangement, placing novices with novices and experienced users with one another, would have been counterproductive. In fact, a more reasonable approach would be to hold separate training sessions for novices and experienced users.

Occupational Responsibilities

This is one of the important distinctions between microcomputer training and other training courses offered to the transit community. The market for microcomputer use cuts across department lines within the transit agency, resulting in a large market for this type of training. The challenge of meeting the training needs of each individual is also more difficult. No explicit attempt should be made to assign individuals to work stations according to their job descriptions. Rather, the course should be structured to demonstrate a wide variety of microcomputer applications within transit operations. The intent of this approach is to reach every attendee with at least some applications of personal interest and provide exposure to other applications that the attendee can absorb as a representative of other departments within the agency that might also benefit from microcomputer implementation.

Hands-On Instruction

Hands-on instruction is a more dynamic forum for training than courses that do not require technological interaction. The participant must be able to grasp the material quickly and retain it because learning microcomputer capabilities and applications is an incremental process. It is rather easy for students to fall behind, so a primary emphasis must be placed on organized instruction and effective learning aids. A detailed course workbook should be prepared, including "cheat sheets" on how to operate the system, load software, file programs, and print hard copies. The applications should also be documented in the workbook along with copies of typical screens if the program is being run successfully. Instructors should also make reference to the workbook, whenever possible, to effectively coordinate their presentation with the written instructional material.

The course structure has been modified to reflect the lessons learned from the pilot course. Additional offerings were subsequently held at Texas Southern University and at Indiana University. Reactions to these courses were extremely positive, and attendance continued to meet enrollment capacity. As a result, additional offerings of the course have been scheduled to serve transit training needs in this area.

CONCLUSION

The introduction of microcomputer technology to the transit environment has been a slow and gradual process. The majority of transit professionals has been reluctant to procure microcomputer systems without first obtaining sound, objective advice on functional requirements, system capabilities, alternative hardware and software options, and present uses of the microcomputer in the transit industry. Training is an important element in providing this information and also serves as an avenue for exposing participants to the wide range of uses and benefits of microcomputer technology, particularly if hands-on opportunities are provided.

The course described in this paper provides a good, fundamental exposure to the uninitiated and many additional insights to those with limited previous experience. It is seen as the basic unit of microcomputer training for transit managers from which other more specialized courses can be developed based on market needs.

ACKNOWLEDGMENTS

The author would like to acknowledge the advice and support provided by the UMTA Office of Methods and Support, particularly Ronald Jensen-Fisher. Contributions made by Jack Reilly, Amir Eiger, and Daniel Bower are also greatly appreciated. Finally, the author would like to thank Betty Alix for her efforts in preparing this text.

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Interactive Decision Process for Public-Private Cooperative Projects

G. ROBERT ADAMS, TERRY L. GOTTS, and JON M. WESA

ABSTRACT

Both the public and the private sector can often benefit from the cooperative financing of essential transportation services that neither would undertake alone. In Michigan the question often revolves around jobs--jobs that would be lost if a rail subsidy were discontinued, or jobs that would not be created if a service road to a plant expansion could not be built. Opportunities for cooperative involvement between the public and private sectors have often had to be considered with less information available than decision makers might desire. The calculations of benefits and costs have been so lengthy and time consuming that only a narrow range of alternatives could be considered if the relevant information was to be timely. The model described permits timely and understandable evaluations of the personal income and tax impacts resulting from employment changes that are outcomes of transportation improvement projects. The model has been designed to be simpler to operate than a multifunction hand calculator. The intent is to allow a decision maker, who knows or cares little about a computer, the opportunity to test a variety of "what if?" questions very rapidly, calculating the balance between public costs and benefits and generating reports and business graphics at will.

Transportation departments in many states face an imminent drop in real revenues. The overall decline in travel, coupled with a general trend toward lighter, more fuel-efficient vehicles, gives ample warning that the widespread tax restructurings of the last few years serve more as survival packages than as cure-alls. For example, the Michigan Department of Transportation (MDOT) estimates that the tax package passed in December 1982 will only postpone (from FY 1985 to FY 1990) the date at which revenues from the State Trunkline Fund will fall short of the department's fixed costs for debt service, routine maintenance, and administration.

Private industries have not been immune to hard times. Industries with critical transportation requirements have been doubly hurt both by the impact of the recent economic recession and by the inability of state departments of transportation to fund former levels of system upkeep and carrier subsidies. Some service abandonments have resulted.

In such an economic climate, both the public and the private sector can often benefit from the cooperative financing of essential transportation services that neither would undertake alone. In Michigan, the question often revolves around jobs--jobs that would be lost if a rail subsidy were discontinued or jobs that would not be created if a service road to a plant expansion could not be built.

Opportunities for cooperative involvement between the public and private sectors have often had to be considered with less information than decision makers might desire. The calculations of benefits and costs have been so lengthy and time consuming that only a narrow range of alternatives could be considered if the relevant information was to be timely.

Clearly, some uniform mechanism was needed for providing the MDOT management and the Michigan Transportation Commission with accurate and timely information about a variety of requests for funds. The method should also allow for the rapid evaluation of a wide range of state funding alternatives and for an analysis of the sensitivity of results to the underlying employment impact estimates and assumptions reflected in model parameters. That rather complex challenge, posed by Commissioner Rodger D. Young, led to the formulation of the model presented in this paper.

The model has been designed to be simpler to operate than a multifunction hand calculator. The intent is to allow a decision maker who knows or cares little about a computer the opportunity to test a variety of "what if?" questions very rapidly, calculating the balance between public costs and benefits and generating reports and business graphics at will.

ECONOMIC FOUNDATIONS

The measures and evaluations used in the model are presented in terms of a benefit-cost analysis. The objective of a benefit-cost analysis is to determine whether a specific project or reallocation of resources will result in an increase in the value of goods and services produced in the economy. Where transportation projects are to be implemented in conjunction with the construction of a new plant or major economic development, only the costs and benefits attributable to the transportation improvement are considered.

The benefit and cost measures used in this model were developed with specific policy concerns in mind. The economic climate in Michigan, and its degree of dependence on the automobile industry, focused policy interest on economic development and employment issues. Accordingly, benefits are measured and reported in terms of the value of inputs to production, of which employment and wage impacts are a significant part.

The economic climate in Michigan has resulted in declining revenues and increased demands on the state's fiscal resources. To address the policy interest in the state budget impact of a project, the wage component of benefits is reported in terms of both taxes and net income. The state single business tax on business activity is also estimated.

Benefits

The model is based on the premise that public investment in a partnership should yield direct, tangible benefits to the public sector. The change in value added to output in the economy is taken as a measure of total benefits, where value added is defined as the sum of wages, interest, rent, and profits. To reflect the tax impact of employment changes, the wage component of value added is measured as the sum of net personal income, state and federal taxes on personal income, and state taxes on sales. For the nonwage components of value added, only the state tax on business activity is estimated. The estimation of total value added to include all nonwage components is considered an essential extension of the model.

Wage impact calculations are based on estimates of direct employment changes. Employment changes are the principal input to the program and specify the number of jobs directly affected along with corresponding average wage levels by industry. Annual gross income per employee is based on a 2,080-hour full-time work year. The current federal and state income tax tables are maintained as parameters in the program for the calculation of income tax impacts. At present, the model calculations are based on the assumption of a family of four and use the standard deduction to calculate federal income tax estimates. The model does not address the complications introduced by the consideration of two-income families. State sales taxes are calculated using the table values for federal sales tax deductions for Michigan, which are also based on individual income.

The calculation of benefits also includes estimates of secondary impacts. For example, if the project is expected to increase the number of jobs in an automobile manufacturing plant (primary employment), a portion of the additional income will be spent locally on goods and services. These additional expenditures have a secondary job-creating effect. When jobs are lost, the same type of chain reaction occurs in reverse.

Secondary employment impacts are based on total primary income (net of taxes). Net primary personal income is aggregated over individuals to determine total net primary income. An expenditure multiplier is then applied to determine the total secondary income impact. The number of secondary jobs is determined by dividing individual secondary income into total secondary income. Individual secondary income is equivalent to full-time employment at the average secondary wage, which is taken to be the average wage in service industries adjusted for geographic differentials. The tax calculations for secondary impacts are based on individual secondary income in the manner described.

A particularly interesting feature of the model is the treatment of job preservation benefits. Job preservation benefits result when the implementation of a project will prevent the closing of a plant and the resulting unemployment. The model provides for the employment impact to decline over time to account for the reemployment of displaced workers in other industries. The rates of reemployment are based on duration of unemployment statistics obtained from the Michigan Employment Security Commission.

The single business tax estimates are based on employment factors developed from data obtained from the Michigan Department of Management and Budget, Office of Revenue and Tax Analysis. Industry-specific factors relating payroll data to single business tax payments are used to calculate tax estimates from the employment impact estimates. The extension of the model to estimate all nonwage components of value added will also be based on employment inputs.

Costs

Project costs are determined by engineering estimates as input to the program. To permit the evaluation of alternative levels of public sector involvement in a project, the model was developed to be sensitive to alternative methods of financing. The model can accommodate costs in terms of grants, annual subsidies, and low-interest loans. It can also take bond financing into account.

In the case of a project funded by a bond sale, the debt service costs are included. Bond rates are selected from a table of current tax exempt bond yields reported biweekly in the First Boston Transportation Financing Newsletter, which stratifies rates by term and credit rating. For low-interest public sector loan financing, the cost to the state is the difference between the opportunity cost on funds loaned out and interest payments received.

Evaluation

The evaluation of benefits and costs compares the discounted present value of benefits to the discounted present value of costs. The discount rate, taken as a measure of the opportunity cost of public sector resources, is the bond interest rate appropriate to the life of the project.

Information on the distribution of impacts is a by-product of the measures used in developing the benefit and cost calculations. For example, the distribution of impacts between primary and secondary effects, the distribution between net income and tax effects, and specific information on the number of jobs affected are available from output reports. Of particular policy interest is information on the net tax impact on the state budget. The net fiscal effect on the state is determined by comparing project costs with the sum of single business tax estimates, state income tax estimates, and state sales tax estimates that are developed in the benefit calculations.

MODEL INPUTS

The inputs for the model are entered and stored in a disk file and are treated as default environment parameters during a model run. The format of the input and parameter file is shown in Figure 1.

In the model the benefit calculations are job dependent. Therefore, either the private developer or the department must be able to estimate the number of jobs affected, the industries in which the jobs are found, and the skill levels (as reflected in average salaries) of each job group. Each group of jobs must also be identified as transient or stable; that is, short term or long term. For example, a job related to the construction of a rail siding would be considered transient; a manufacturing job at a company that locates on the siding would be considered stable. These original job estimates may be varied during the model run to test their effect on the evaluation.

To determine a discount rate for the calculation of present values, and to calculate the interest cost of a bond issue, the state's bond rating and project life are necessary inputs to the parameter file. An appropriate interest rate is then selected by consulting the aforementioned First Boston Corporation table, which is also maintained in the parameter file.

```
* PARAMETER SET FOR PUBLIC/PRIVATE COOPERATION MODEL
*        1         2         3         4         5         6         7
*234567890123456789012345678901234567890123456789012345678901234567890
*TTTTTTxxxxxxxxxxxxx
*
 BOND RATING        AAA
*
* SINGLE-BUSINESS TAX F-FACTORS & G-FACTORS
*
*                       SECTOR .. F-FACT .. G-FACT ..INDUSTRY NAME
 SBT FACTORS                 1   .02608    1.365   AGRICULTURE,FOREST
                             2   .02293    1.403   METAL MANUFACTURING
                             3   .03736    1.480   CRUDE PETROLEUM
                             5   .01664    1.304   CONSTRUCTION
                             6   .01755    1.403   ORDNANCE
                             ...
                             ...


                             ...
                             ...
                            49   .02088    1.310   PROFESSIONAL SERVICES
                            50   .01730    1.387   UNCLASSIFIED
*--END OF SBT FACTORS-----------------------------------------------
*                   RTG 01-YR 05-YR 10-YR 15-YR 20-YR 30-YR
 BOND YIELDS        AAA  5.50  7.25  8.25  9.00  9.25  9.40
                    AA   5.75  7.50  8.50  9.35  9.50  9.70
                    A    6.00  8.00  9.20  9.70 10.00 10.25
                    BAA  6.50  8.75  9.75 10.25 10.50 10.70
 BOND DATE          03/02/84
 AVG. SECONDARY WAGE 5.00
 EMPLOYMENT MULTIPL. 2.00
*   JOBS -- FULLER-KINNEY SPUR
*TTTTTT.............SEC D C NJOBS AVGWG
*                       U S
*                       R D
*                         R
*JOBS                23 2 R    40 12.93
*   END OF JOBS TEST DATA
```

FIGURE 1 Environment parameters.

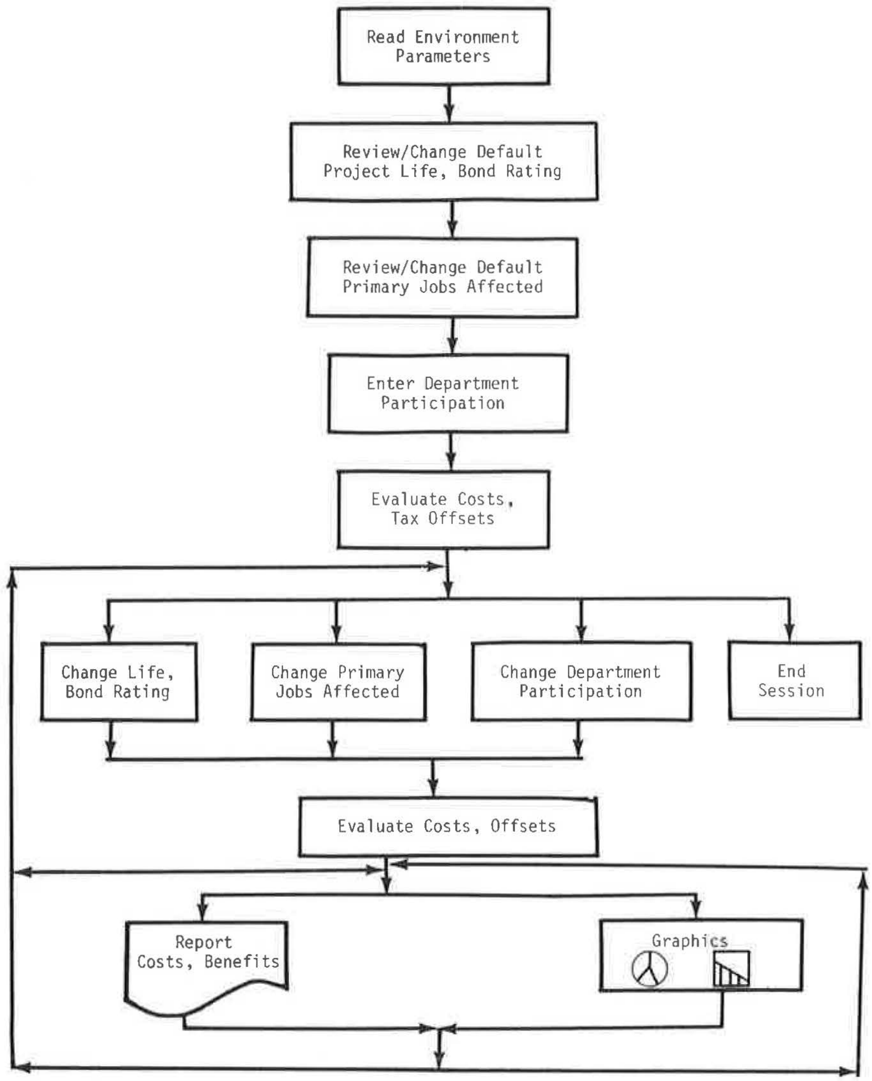

FIGURE 2 Logical path of model session.

Other inputs are the values for the average secondary industry wage level and the secondary impact multiplier. The single business tax factors in the parameter file are industry specific for Michigan's business tax structure and would not be applicable elsewhere.

MODEL OPERATION

The computer model, written in FORTRAN-IV for the Burroughs B-7700, has been designed to be run by a person with little or no computer expertise. Decision makers, in particular, often have little time or patience for learning complicated run instructions or memorizing acronyms that direct the program's flow. With this model, when the user is logged on to the time-sharing system and has started the program, he or she needs only to select an action by pressing a function key. The user then has the option to fill in or change the information on a form displayed on the screen. A flow diagram of the process is shown in Figure 2.

The first task of the program is to read in the environment parameters from a disk file. After the parameters are read in, the menu of available functions is displayed (Figure 3).

PUBLIC/PRIVATE COOPERATION PROJECT ANALYSIS

M E N U

FUNCTION KEY	ACTION DESIRED
F1	REVIEW/CHANGE DEPARTMENT'S BOND RATING
F2	REVIEW/CHANGE PRIMARY JOBS CREATED
F3	REVIEW/CHANGE DEPARTMENT PARTICIPATION
F4	CALCULATE COSTS AND BENEFITS
F5	MAKE PRINTER REPORT OF PRESENT STATE
F6	MAKE EASY-GRAPH FILE OF PRESENT STATE
F7	END SESSION

. . . Please press appropriate FUNCTION key (FUNCTION keys are the brown row of keys located above the numbers row on the EECO's typewriter keyboard.)

FIGURE 3 Function menu.

The function keys are a row of sixteen special keys located above the regular keyboard on the EECO forms terminal used for program control. Only seven of the keys are presently meaningful to this program; the rest could be used for future enhancements.

By pressing function key F1, the user indicates a desire to review or change the project life, the department's expected bond rating, or both (see Figure 4). This feature may be used to test how sensitive a particular project's viability might be to the department's ability to sell bonds.

The project life and bond rating are easily changed by typing their desired values. (The matrix of interest rates at the bottom of the form comes from the parameter set and is assumed to be constant for the session. It is, therefore, protected from change during the run.) When the project life and bond rating are satisfactory to the user, pressing the XMIT ("transmit") key inputs the values to the program and returns the user to the menu.

By pressing function key F2, one can edit the number and type of jobs to be used in the evaluation. The first time F2 is pressed, a worksheet is presented that contains any information present in the parameter set. Subsequent returns to this form display the current state of the estimates of jobs affected. All that is necessary to add, delete, or change any of the information is to retype and press XMIT.

Function key F3 allows the user to specify the form and degree of the department's participation in the project. As stated previously, participation can take the form of a one-time grant, which could represent the capital outlay necessary for a major infrastructure reinvestment; a low-interest loan; direct annual operating assistance to one or more companies; or any combination of the three. If the department would need to issue bonds to fund the project, this is specified on this form by entering their size and term. Pressing XMIT inputs the contents of the worksheet to the system.

When all information necessary for the cost and benefit calculations is present, pressing F4 displays the first comparison of state cost to state tax offsets for the assumed life of the project (Figure 5). The response time is very good. A wait of more than 3 seconds usually means that the whole computer system is running slowly on that particular day. It should be emphasized that this display does not include the entire spectrum of benefits; for example, no mention is made of change in personal income or federal income tax. These will be addressed in the discussion on system outputs. The current comparison is designed to give the user a sense of the state fiscal impact of a project.

With the information from the cost-offsets display, the user is now free to test alternatives. One might compare a low-interest loan with a grant. Alternatively, one could change the original estimate of the number of jobs affected until a break-even point is found, or increase state participation until the fiscal impact becomes negative. Or one could test the alternatives of a concrete service road versus its bituminous equivalent by comparing the capital cost of concrete using a 25-year life with the capital cost of a bituminous surface using a 15-year life. A few minutes spent changing the project parameters using F1-F3, and evaluating the change with F4, can give a wealth of information about both the preferred nature of the solution and the recommended boundaries of his or her bargaining position to a decision maker preparing for a meeting or negotiating session.

MODEL OUTPUTS

For any combination of state participation, jobs, bond rating, and project life yielding results of interest, the user may request a printed report by pressing function key F5. The program first asks for identifying data for the report heading and then prints the one-page report shown in Figure 6. At MDOT, the report is printed on a Burroughs page-printer, which allows multiple-character fonts and "portrait" printing (meaning that the short side of a sheet of paper is at the bottom, as it is in most books, instead of at the side, as it is in most computer output). This makes for a very readable report that can be inserted in a briefing paper without retyping or artwork.

By using function key F6, the results of the calculations can be displayed in eleven optional ways using business graphics. Figure 7 shows the menu of graphics choices as it is displayed to the user.

Because no graphics package is known to exist for the EECO terminal, all graphics are accomplished by writing a file of commands for the Tektronix Easy-Graph program. The graphics are then displayed on a

B O N D   Y I E L D S & P R O J E C T   L I F E

Project Life : [ ] years

Department Bond Rating : [ ]

YIELDS	1-YR.	5-YR.	10-YR.	15-YR.	20-YR.	30-YR.
Aaa	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%
Aa	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%
A	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%
Baa	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%	XX.XX%

Source: First Boston Transportation Financing Newsletter, mm/dd/yy

. . .Press XMIT key when ready.

FIGURE 4 Bond interest worksheet.

RESULTS OF COST & BENEFIT CALCULATIONS

COSTS:	AMOUNT OF GRANT	:$500,000
	COST OF LOAN	: 24,289
	COST OF OPERATING ASSISTANCE:	71,825
	COST OF BOND ISSUE	: 355,532
	TOTAL COST TO STATE	:$ 951,646

BENEFITS OVER PROJECT LIFE OF YEARS:

PRIMARY JOBS

0 SHIFTED
0 CREATED
0 DESTROYED
40 RETAINED

SECONDARY JOB IMPACT 131

TOTAL INCREASED TAXES:

	(PRIMARY)	(SECONDARY)
INCOME	$ 73,570	$50,894
SALES	$ 19,063	34,702
SINGLE BUSINESS	$ 268,109	

TOTAL TAX OFFSET: $ 446,338 PRESS XMIT TO CONTINUE.

FIGURE 5 Costs and tax offsets.

PUBLIC/PRIVATE COOPERATIVE PROJECT ANALYSIS

Project: EXAMPLE OF SYSTEM ANALYSIS
Prepared for: TERRY GOTTS
Date: 04/05/84
Time: 10:44

DEPARTMENT PARTICIPATION

ASSISTANCE TYPE	AMOUNT	INTEREST	TERM	REAL COST
Grant	$ 500,000			$ 500,000
Loan	100,000	@ 3.00 %	for 10 Yrs.	24,289
Operating Asst.	10,000		for 10 Yrs.	71,825
Bond Issue	600,000	@ 8.25 %	for 10 Yrs.	355,532
		Total Public Cost(in 1982 $)		$ 951,646

Assumed Project Life =10 years
Discount Rate =8.250%

Assumed Department bond rating =AAA.
Bond yields from First Boston Transportation Financing Newsletter, 03/02/84.

PUBLIC BENEFITS

Job Impact: 40 Primary jobs
131 Secondary jobs

Change in Personal Income(Net of Taxes) = $3,732,415.

Increment in Federal Income Tax = $371,424.

State Tax Increment (in 1982 $) over 10 years:

State Income Tax	$ 124,464
Sales Tax	53,765
Single Business Tax	268,109
Total State Tax Increment	$ 446,338

Total Benefits $4,550,177.

FIGURE 6 Report.

PUBLIC/PRIVATE PROJECT ANALYSIS

GRAPHICS SELECTION

Title of project:

Put an X in the box beside the graphics you want:

☐ 1. Loan interest/cost stream

☐ 2. Present value of stream of subsidy payments

☐ 3. Present value of bond interest stream

☐ 4. Change in personal income

☐ 5. Change in Federal Income Tax

☐ 6. Change in State Income Tax

☐ 7. Change in State Sales Tax

☐ 8. Change in Single Business Tax

☐ 9. Total costs vs. State tax offsets

☐ 10. Pie chart of present worth of costs

☐ 11. Pie chart of present worth of benefits

. . . press XMIT when ready.

FIGURE 7 Graphics options menu.

nearby Tektronix 4014 terminal with hardcopy capability. It should be noted that some forms terminals, such as the Tektronix 4020 series, support both business graphics and raster-scan hardcopy, so that the use of two terminals is not necessary.

A sample of graphic output is shown in Figure 8. This is a graphic representation of the time series that was used to derive the output report in Figure 6. It is a cumulative representation of the cost versus tax offset curves so that the break-even year, if there is one, is clearly evident. Note that, in the example, the costs start out high because of a $500,000 grant in year 1. Figure 9 shows the change in the cost versus tax offset relationship resulting from conversion of a significant portion of the grant to a low-interest loan of a lesser amount. This example represents an increase in private sector participation in the sample project.

CONCLUSION

The environment that motivated the development of the model described is characterized by increased

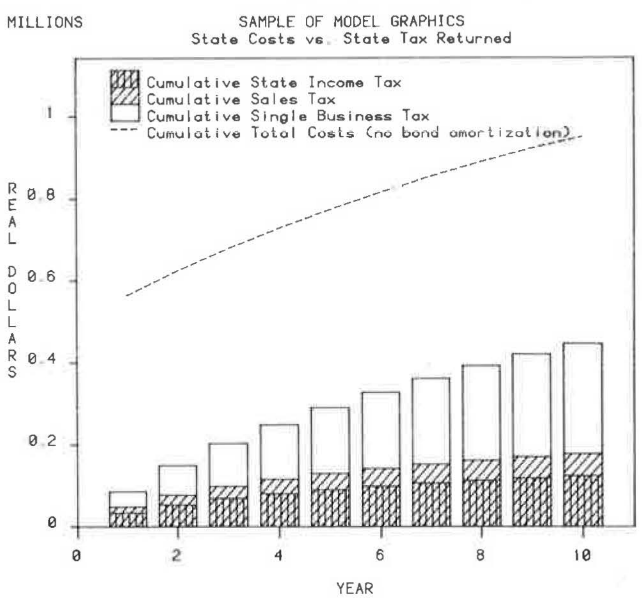

FIGURE 8 Costs versus offsets.

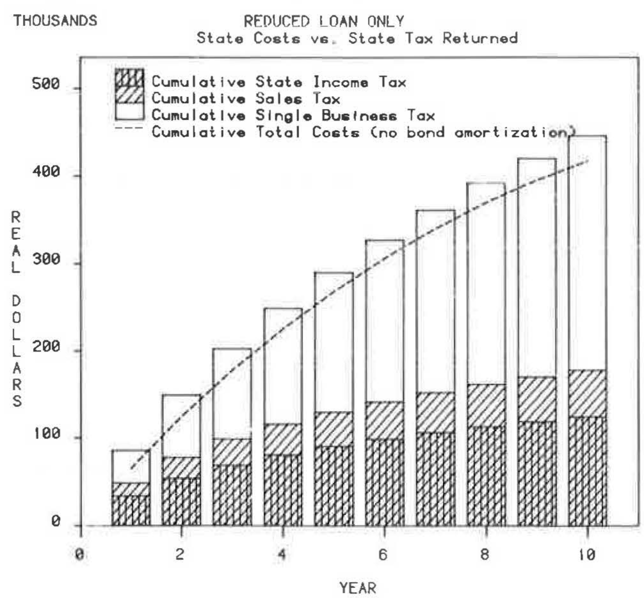

FIGURE 9 Comparison after shift.

concern for the fiscal impact of transportation projects and a high degree of policy sensitivity to the level of employment and economic welfare in Michigan. The model accordingly provides a means of rapidly evaluating the income and fiscal effects of employment changes that are the outcomes or by-products of transportation improvement projects. The model is also quite easy to run and is therefore accessible to those whose responsibilities will not permit the luxury of becoming acquainted with complicated run instructions or computer jargon.

Publication of this paper sponsored by Committee on Computer Graphics and Interactive Computing.

Microcomputer Decision Support System

F. MICHAEL TELLER and STUART L. MYERS

ABSTRACT

In the past 2 years the Maryland Department of Transportation has developed a decision support system that provides financial advice to the Secretary of Transportation and to other policy-making officials within Maryland state government. The components and techniques used in developing this system are described. To place the system in perspective, there is a brief comparison of the process before implementation of the system with current practice. General guidelines are given to assist the reader in identifying issues and criteria for development of decision support systems. These criteria are general in nature and may be applied to a wide variety of situations, not just financial planning or transportation-related analysis. Comments, conclusions, and specific hardware and software evaluations based on experience to date are offered.

The purpose of this paper is to inform other professionals in the transportation field about the experiences of the Maryland Department of Transportation (MDOT) in developing and implementing a microcomputer-based decision support system. In order that the reader may better appreciate the nature of work performed by the Financial Planning and Analysis Section at MDOT, a brief description of the department and its funding sources is included. In the balance of the paper, concentration is on the components of the financial decision support system at MDOT, guidelines for developing a decision support system and financial modeling, and conclusions and comments regarding the MDOT experience to date.

BACKGROUND

MDOT is responsible for all state-owned transportation facilities and programs. This responsibility includes the planning, financing, construction, operation, and maintenance of various modes of transportation. In addition, the department carries out various related licensing and administrative functions.

The department is supported by the Transportation Trust Fund, which consists of revenues from motor fuel taxes, motor vehicle taxes, a portion of the state corporation income tax, operating revenues generated from MDOT-owned facilities, transit fares, federal aid, and bonds and notes supported by the trust fund.

The Financial Planning and Analysis Section is part of the Secretary's staff. This section is charged with the responsibility for providing the Secretary with impartial advice on the financial impact of policy-level, program-level, and project-level decisions.

MAJOR ISSUES

The Financial Planning and Analysis Section performs three distinct types of analyses. The first type of analysis is focused on providing revenue and expense forecasts covering 5-year and 20-year planning horizons. The second major area of analysis is the determination of upper and lower limits of the department's bonding capacity given projected levels of revenues, operating expenditures, and capital program spending. The final area of analysis deals with special projects and detailed analyses of a nonroutine nature.

Before the department purchased a microcomputer and financial spreadsheet software package, these analyses were performed using a time-sharing service for the revenue projections and bonding capacity. Special projects were analyzed using hand-held calculators, paper, and pencils. Each of these analyses required a substantial investment in time just to produce the initial results. Any sort of "what if?" or sensitivity analysis required a similar amount of time.

As an example of the amount of effort then required, the 5-year financial projection required about 1 month to complete with the aid of the time-sharing service and two mainframe computers. The output generated was a one-page report focused on a dozen or so key variables and linked to one national economic forecast.

Beginning with the purchase of the first microcomputer in the fall of 1981, the Financial Planning and Analysis Section refined the procedures and methods used in their analyses. For example, the same 5-year projection now includes about 100 variables that are validated against four separate national economic forecasts. The MDOT 5-year financial projection now usually requires only 1 week from start to finish and is produced without any increase in the number of personnel in the Financial Planning and Analysis Section.

This dramatic increase in productivity has been a result of the development of a decision support system based on a microcomputer and VisiCalc spreadsheet software. A decision support system is an interactive computer-based system that allows decision makers to analyze and solve complex, unstructured problems. Interactive is used to mean the ability to directly enter any changes in the base model and to review results immediately. In the following section the components of the decision support system now being used at MDOT by the Financial Planning and Analysis Section are described.

COMPONENTS OF THE DECISION SUPPORT SYSTEM

The first component of the decision support system is a series of models used to project revenues and expenditures. By using the spreadsheet software a number of techniques may be combined into a single model. For example, MDOT operating expenditures are extrapolated from budget figures using an inflation rate adjustment derived from national economic forecasts. For each year of the projection, the previous year's expenditure is multiplied by the inflation factor to derive the expense in that year. In addition to this capability, certain variables within the forecast may be held constant from year to year.

Another technique used to make long-term projections is regression analysis. Again, the spreadsheet package makes it possible to incorporate the regression coefficients into a formula to calculate receipts for a given year.

To determine the department's bonding capability, a model incorporating information about the department's past bond issues, characteristics of proposed issues, desired capital program, and projected revenues was developed. This model was adapted from an earlier linear programming model written in FORTRAN and run on a mainframe. The current model is much quicker to revise and has the added advantage of allowing the user to immediately see the impact of changes in any of the input variables.

Models developed for special project analyses all have a number of common features. Wherever possible, constants used within the models are referenced separately from outputs. For example, calculations involving the use of a constant interest rate are modeled in such a manner that the user can perform "what if?" or sensitivity analysis by changing the desired input only once as opposed to having to change the value of the constant at each occurrence within the model. In addition, each model contains documentation about what disk the model is located on, the developer's name, and any special instructions regarding print formats or other aspects.

One important point should be stressed regarding the development of these models: All of the models were developed by the Financial Planning and Analysis Section staff without the aid of data processing personnel. This was made possible by the purchase of spreadsheet software in addition to the microcomputers.

The current decision support system allows the Financial Planning and Analysis Section to produce a greater quantity of work of higher quality than was possible previously.

GUIDELINES FOR DEVELOPING A DECISION SUPPORT SYSTEM

The following list and the associated comments should assist in the development of a decision support system. Bear in mind that not all items will apply to any specific situation and that possibly not all relevant considerations are included. The list is intended as a general guide to assist in identifying the key elements required to develop an effective decision support system.

1. Determine the types of answers desired. Are they one number, a range, or a conclusion? As an example, the system used at MDOT for revenue and expense forecasts results in a single number for each item for each year. On the other hand, special project analyses performed for the purpose of establishing rates at state-owned facilities usually result in an acceptable-range-type of answer. An example of where a conclusion-type answer is required is the analysis of past performance of specific units within the organization.
2. Establish standards for acceptable levels of error permitted for each of the various types of answers. For example, multiple-year forecasts may have an acceptable error of plus or minus millions of dollars. For analyses of past performance of specific units, the results generated should have a minimal level of error because actual data are available.
3. Determine what types and amounts of data are required to develop and use the system. One key question to be answered is whether the required data are available or can be acquired at a reasonable cost.
4. Document all assumptions caused by lack of information or unreliable information.
5. Determine how often the system will be used. In general terms, the more frequently a support system is called on to generate a specific result, the more detailed the required analysis becomes. Detailed financial models require a longer setup time.
6. Standardize formats for the output generated by each part of the system. Summarizing the results of a quarterly forecast in the same format each time makes it easier for the decision maker to find needed information.
7. In financial analyses, graphs should be included in the summary of results only as supporting information. Limit the number of graphs included in the analysis to the bare minimum required to emphasize major points. However, graphic techniques can be extremely useful in assisting in the developmental phases of model building. Many hours of analytic work can be eliminated by using graphs to clarify the relationships between variables.
8. The organizational unit that undertakes the development of a decision support system is alone. That unit and only that unit is responsible for seeing that the work gets done--no more blaming the data center because the computer is "down."
9. There is a real difference of opinion in the community about whether hardware or software is more important. The most important aspect seems to be dealer support for both hardware and software. When something does not work, fast, reliable, and affordable hardware support is required. Even more important, software support and training are needed.

The dealer should have knowledgeable people who can help you make the software you purchased function more effectively. This goes beyond selling the latest fad. It means that the dealer should have hands-on experience with daily applications. The dealer can then make realistic recommendations and will be able to answer specific questions from actual experience, rather than from reading manuals.

10. Even with the best support and training it is unreasonable to expect anyone else to truly understand your exact needs or problems. Do not accept anyone's word that a given product or combination of products will meet your needs. Insist on trying products out, either at the dealer's store or, for large purchases, in your own office. Reputable dealers will allow 15 days or more to test a product.

11. Avoid dependence on any other organizational branch of government for microcomputer purchase and support. Find a system that meets your immediate needs and that is understandable and usable by your employees. The most efficient way to send information from one computer to another is to take the disk out of one computer and place it in the next. Keep things simple: find the least expensive and most straightforward method of completing the task at hand. Later, if requirements grow or become too involved for the original approach, upgrade to a more powerful configuration.

12. It is a mistake to attempt to start off with the "optimal system." Start small and grow in manageable steps. This will allow hedging bets and keeping mistakes to a minimum.

In the next section the experiences of the Financial Planning and Analysis Section with hardware, software, and dealer support are related. In the last section capsule evaluations of each item are presented.

MDOT EXPERIENCE TO DATE

In the fall of 1981 MDOT purchased a TRS-80 Model II microcomputer with 2 disk drives, 64K memory, and a Daisy Wheel II printer through a statewide procurement contract. Scriptsit word processing software, the VisiCalc spreadsheet program, a Profile database package, and a Radio Shack Statistical Analysis Package were also included.

In hindsight, this particular configuration was and remains marginally acceptable compared with less expensive and more powerful systems that were then available. This is especially true of any comparison with systems available today. However, having even a marginally acceptable system is infinitely better than having no system at all, being dependent on a mainframe system, or paying time-sharing charges.

Increased dependence on the microcomputer-based decision support system and growing reliability problems required the purchase of another TRS-80 Model II with 128K of RAM and a Dot Matrix 400 printer. This and the simultaneous upgrading of the original Model II to 128K and the purchase of Enhanced VisiCalc took place in the spring of 1983.

Increased responsibilities assigned to the Financial Planning and Analysis Section combined with growing dissatisfaction with Radio Shack equipment's reliability and limited capabilities justified the procurement of an Apple II with 128K RAM and an Okidata 93 Dot Matrix printer in the fall of 1983. Also purchased at that time were VisiCalc, Advanced VisiCalc, Apple Writer IIe, VisiPlot/VisiTrend, and Ascii Express Professional. (Data compatibility between spreadsheets was not an issue because of the use of VisiCalc. The VisiCalc models are 100 percent transferable between the two systems. Any future purchases would also require similar compatability.) Although this system is not up to the latest state of the art (for example, an IBM system), it was about one-third the price and currently meets the real needs of the user. Naturally, an IBM XT with Lotus 123 and so forth would be a superior configuration, but it was estimated not to be three times as valuable for current or foreseeable needs.

The experience of MDOT with these various systems has been mixed to date. The TRS-80 Model II computer system was an expensive investment that did not perform up to the standards promised by the manufacturer. The TRSDOS operating system is slow and cumbersome and the Radio Shack manuals are poor. The software received from Radio Shack was always several versions behind the same software made by competitors. Profile and the Statistical Analysis packages have received little use because they are so limited and hard to use. Scripsit, although it seems to be a reasonable word-processing package, is so poorly documented and so unfriendly that secretaries took almost a year to learn to use it.

Experiences with the Apple IIe system have been entirely different. This is attributable to two factors. First and foremost is the reliable and professional dealer support provided by the Apple retailer. The employees are professionals and there is a stable core of senior management to train the junior salespeople, technicians, and software specialists. Equally important is the extensive competition among third-party vendors for Apple software and peripherals. This forces prices to be competitive, and at the same time focuses vendor efforts on developing quality products.

CONCLUDING REMARKS

For substantially less than the annual cost of a clerical position, MDOT was able to obtain a microcomputer and a single first-generation spreadsheet program. This allowed two professionals to routinely perform the various analyses described. It is believed that the Financial Planning and Analysis Section has just begun to scratch the surface of the potential of the state of the art in microcomputing. The stand-alone microcomputer freed the section from dependence on time-sharing services and mainframe computers. It is true that the processing time for certain types of problems is longer on the microcomputer, but output is received for review much faster.

The key to the present decision support system was the purchase of the spreadsheet software. This software has enabled the section to develop fairly complex financial models without the use of programmers and data processing facilities. As a result, the section has a much greater degree of control over the scheduling of workflow. In addition, the decision support system is capable of the fast turnaround times that are achieved in large part because of these very factors.

Although the current decision support system is still evolving, when compared with the methods used before its development the section is far ahead. The rewards in both improved product quality and increased quantity of output are well worth the effort required to develop the system.

PRODUCT EVALUATIONS

The following equipment, as well as items from Radio Shack, was used:

Manufacturer	Registered Trademark
Apple Computer Co.	Apple IIe, Apple Writer IIe

Manufacturer	Registered Trademark
Tandy Corporation	TRS-80 Model II
	TRSDOS
	Dot Matrix Printer 400
	Daisy Wheel Printer II
	Scriptsit, Profile
	Statistical Analysis
VisiCorps	VisiCalc
	VisiPlot/VisiTrend
	Advanced Visicalc
	Enhanced VisiCalc
Southwestern Data Systems	Ascii Express Professional
IBM	IBM XT
Lotus	Lotus 123

Hardware

Radio Shack Model II Computer

The strong points of the Model II computer are

- Large disk storage capacity,
- Detachable keyboard, and
- Separate number keys.

The weak points of the Model II computer are

- Black and white display,
- Complicated operating system,
- Inefficient use of memory (see VisiCalc description),
- Expensive service calls,
- High frequency of maintenance,
- Lack of a high-resolution display,
- Highly limited software selection, and
- Expensive peripherals.

Radio Shack Daisy Wheel Printer II

The strong points of the Daisy Wheel Printer II are

- Relatively fast (40-50 cps) and
- High reliability.

The weak points of the Daisy Wheel Printer II are

- High repair costs and
- High ribbon-replacement costs.

Radio Shack Dot Matrix Printer 400

The strong point of the Dot Matrix Printer 400 is its reliability. The weak points are

- High cost,
- Poor print quality,
- Short ribbon life, and
- High ribbon-replacement cost.

Apple IIe

The strong points of Apple IIe are

- Low initial cost,
- Modular construction (if one part goes to the shop the rest of the system can still be used),
- Efficient use of memory (see VisiCalc description),
- Ease of upgrading from a wide selection of peripherals, and
- High-resolution graphics and color capability.

The weak points of the Apple IIe are

- Limited disk storage capacity and
- Wide variety of accessories can lead to compatibility problems if proper care is not taken.

Okidata 93 Dot Matrix Printer

The strong points of the Okidata 93 are

- High print quality,
- Large variety of print styles,
- High through-put (160 cps), and
- Low ribbon-replacement cost.

The weak points of the Okidata 93 are

- Changing ribbons can be messy and
- Printer noise may require the purchase of a sound enclosure

Software

Original VisiCalc

The strong points of original VisiCalc are its ease of use and flexibility. Its weak points are

- Small model size (25K on a 64K computer);
- No logic functions (if, then, else);
- No entry editing; and
- Limited display capability (no commas in numbers).

Enhanced VisiCalc

The strong points of Enhanced VisiCalc are

- Ease of use,
- Flexibility,
- Logic functions, and
- Edit capability.

Its weak points are limited model size (18K on a 64K computer, 50K on a 128K computer) and limited display capability (no commas in numbers).

Scriptsit

The strong points of Scriptsit are its large number of features and its ability to handle very large documents.

The weak points of Scriptsit are the facts that it is very poorly documented and hard to learn.

Profile

The strong points of Profile are unknown because of lack of use.

Its weak points are

- Poor documentation,
- Highly limited display capacity, and
- Difficulty of use.

Statistical Analysis

The strong points of Statistical Analysis are unknown.

It weak points are

- Poor documentation,
- Limited capacity, and
- Poor data handling routines.

VisiCalc to Run on Apple IIe

The strong points of VisiCalc are

- Ease of use,
- Flexibility,
- Efficient use of memory (96K available for the model), and
- Logic and editing functions.

Its weak point is its poor display capabilities (no commas in numbers).

Advanced VisiCalc

The strong points of Advanced VisiCalc are

- Ease of use;
- Powerful financial routines (e.g., time, IRR); and
- Powerful display capabilities (e.g., commas, negative numbers in parentheses).

The weak points of Advanced VisiCalc are that it uses a lot of memory (only 70K available for the model) and is slower than VisiCalc.

Apple Writer IIe

The strong points of Apple Writer IIe are that it is easy to learn and relatively powerful.

Its weak points are that it does not handle very large documents without splitting them into separate chapters and requires memorizing control codes.

VisiPlot/VisiTrend

The strong points of VisiPlot/VisiTrend are

- Ease of use,
- Excellent documentation,
- Adequate statistical functions,
- Outstanding data manipulation capabilities, and
- Powerful graphics capabilities.

The weak points are that it operates relatively slowly and is not a full statistics package.

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Applications of Computer Graphics to Chicago Area Transportation Planning and Programming

ELIZABETH A. HARPER and DONALD P. KOPEC

ABSTRACT

In the last few years computer graphics has become an important analytic tool. This tool exceeds the individual capabilities of both rapid computing and graphic illustrations in providing insightful perspectives and understanding of planning data. While the field of computer graphics has been rapidly developing as a general business aid, transportation professionals have been developing interactive computer graphic programs designed for specialized modeling functions. The use of existing software packages to supplement transportation planning and programming has lagged. Instances in which current planning and programming techniques can be enhanced by integrating existing software graphics packages with transportation models and functions are described. The tailoring of existing software packages for use by transportation planners who are inexperienced in system analysis is also discussed.

That graphics is an important tool for understanding and communicating information is not new. There are many instances in which a visual image of a phenomenon raises new questions or produces insight into the meaning of the data being displayed. There also is no doubt that the speed and flexibility of computers have vastly expanded and enhanced the potential scope of any analysis. Planners now have access to a vast amount of information from which to infer relationships and project future effects of various alternatives.

Computer graphics, a combination of these two important techniques, is a tool for analysis that goes beyond either graphics or rapid calculations. The speed and accuracy with which a computer can manipulate, modify, and visually represent data make computer graphics a valuable new tool for both analysis and presentation.

In the past, planners spent long hours studying numbers to determine relationships. Then those numbers were sent to graphics departments for visual representation. Anywhere from 2 days to 2 weeks later visual aids were returned to be used for presentation or publication. Now planners can use the computer to quickly produce graphics, which often illustrate relationships or anomalies worthy of study or attention. When analysis has been completed to the planner's satisfaction, the graphics generated are of good enough quality for presentation or publication.

In the last decade the importance of computer graphics has been evolving and numerous people have been experimenting with its applications. Spearheading the movement in the transportation field was Jerry Schneider of the University of Washington who in 1973 organized and reported on a seminar on "Interactive Graphics in Transportation Systems Planning and Design" (1). The seminar explored capabilities of interactive computer graphics and brainstormed potential applications. Since then computer graphics in transportation planning has received attention and support from numerous individuals and organizations, including the U.S. Department of Transportation, the Transportation Research Board, the Transportation Systems Center (Warren, Michigan), and the University of Washington Department of Civil Engineering (2).

Efforts so far have emphasized interactive applications especially developed for operations planning, and many practical uses of computer graphics in the transportation planning field have been left unexplored. There are two reasons why there is a need for developments in this area:

1. Interactive computing usually requires programming expertise, which is beyond the majority of planners (3). Attempts at producing interactive graphics by an inexperienced programmer will be more frustrating than productive.
2. Large amounts of planning data are not operations related. This wealth of information, including socioeconomic data, time series data, and capital programming data, is still pertinent to transportation planning and policy decisions and should be subjected to computer graphic analysis techniques in order to make the best use of all available resources.

Although interactive computing enhances all computer-aided tasks, including graphics, the assets of computer graphics are not dependent on being interactive. Interactive packages are usually designed for narrow, specific, operations analysis tasks and do not allow for applications to, and use of, the numerous other planning functions and existing data bases.

Through use of the Statistical Analysis System Graphics (SAS) (4) and the IBM Graphic Data Display Manager (GDDM) (5) at the Chicago Area Transportation Study (CATS), it has become apparent that existing, commercially available graphics software packages can be applied to almost any of the numerous existing data bases to greatly enhance the many-faceted transportation planning functions. Because computer graphics packages are general in scope, they can be easily adapted to standard computer-aided analyses and projects, including capital development, system management, demand modeling, socioeconomic data-base maintenance, and operations planning. Examples of such applications follow.

POSSIBLE APPLICATIONS

In every case the graphic presentation provides a different perspective on the information produced than was previously available. Also, in each case, the graphic output could be easily incorporated into jobs that are already run as standard procedure in a transportation planning function. It is hoped that these examples will lead to further application of computer graphics, both batch and interactive, to planning functions.

Preliminary Data Analysis

In many cases graphics can indicate characteristics of data that are critical to the initial study design. The following two examples show (a) a way in which planners can use graphics to check for accuracy and completeness of a network and (b) a way in which planners can understand trends in initial socioeconomic data before applying travel demand models.

A standard, traditional network data set contains various characteristics of links, including the nodes they connect and their capabilities, in a tedious list format. Before beginning a regional or subregional analysis the planner may want to focus on the configurations of a particular area of concern to look for errors in coding and for consequential characteristics of the particular area.

The series of network maps shown in Figures 1-5 represents a portion of the Du Page County, Illinois, highway network. When the network of Du Page County (Figure 1) was first processed, it was obvious that a particular link had been miscoded. This link was corrected and the county map rerun. The corrected network is shown in Figure 2. It was then decided to take a closer look at a 36-square-mile township in the center of the county. Figure 3 shows this enlargement. Following a detailed examination of the network, concern was expressed about the capacity of some links in a particular area of the township. The links of the township were factored by the capacity found in the network data base and displayed (Figure 4). An alternative representation of the link capacity is shown in Figure 5.

These graphics were produced in an interactive session, and could have displayed any characteristic of the link such as volume or speed. Although the interactive aspects of this particular application greatly add to its usefulness, the same information could be gleaned from a few iterations of batch jobs

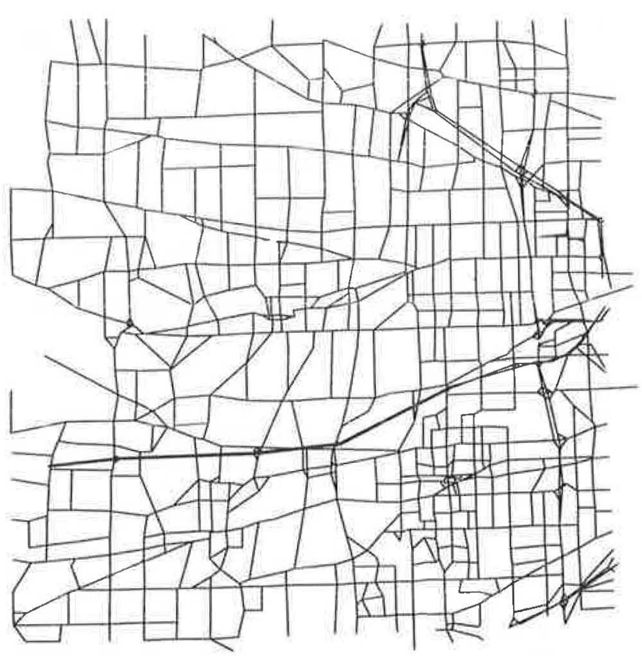

FIGURE 1 Highway network of Du Page County, Illinois.

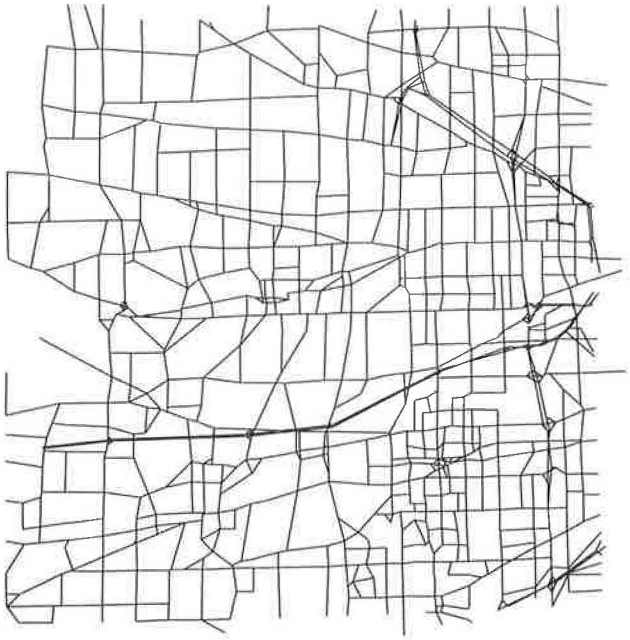

FIGURE 2 Corrected highway network of Du Page County, Illinois.

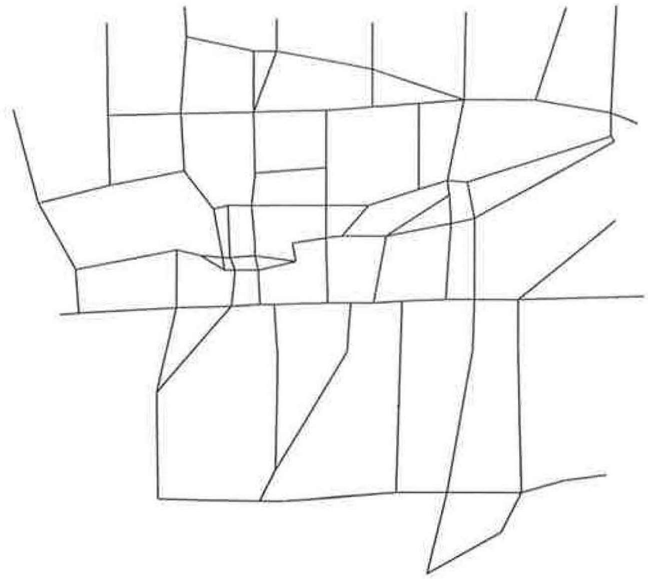

FIGURE 3 Highway network of Milton Township, Du Page County, Illinois.

designed to zero in on areas of concern. The planner inexperienced in programming merely needs to select for input the zones to be examined.

Before beginning the regional analysis the planner may be interested in attributes of the data such as changes in socioeconomic characteristics. Listings are usually provided of all relevant data available such as changes in population. Figure 6 shows decreases in population that occurred in southern Cook County. This graphic, produced as part of the usual processing of socioeconomic data, facilitates analysis of trends in the region. Subsections of this information could also be enlarged by specifying the townships of special interest.

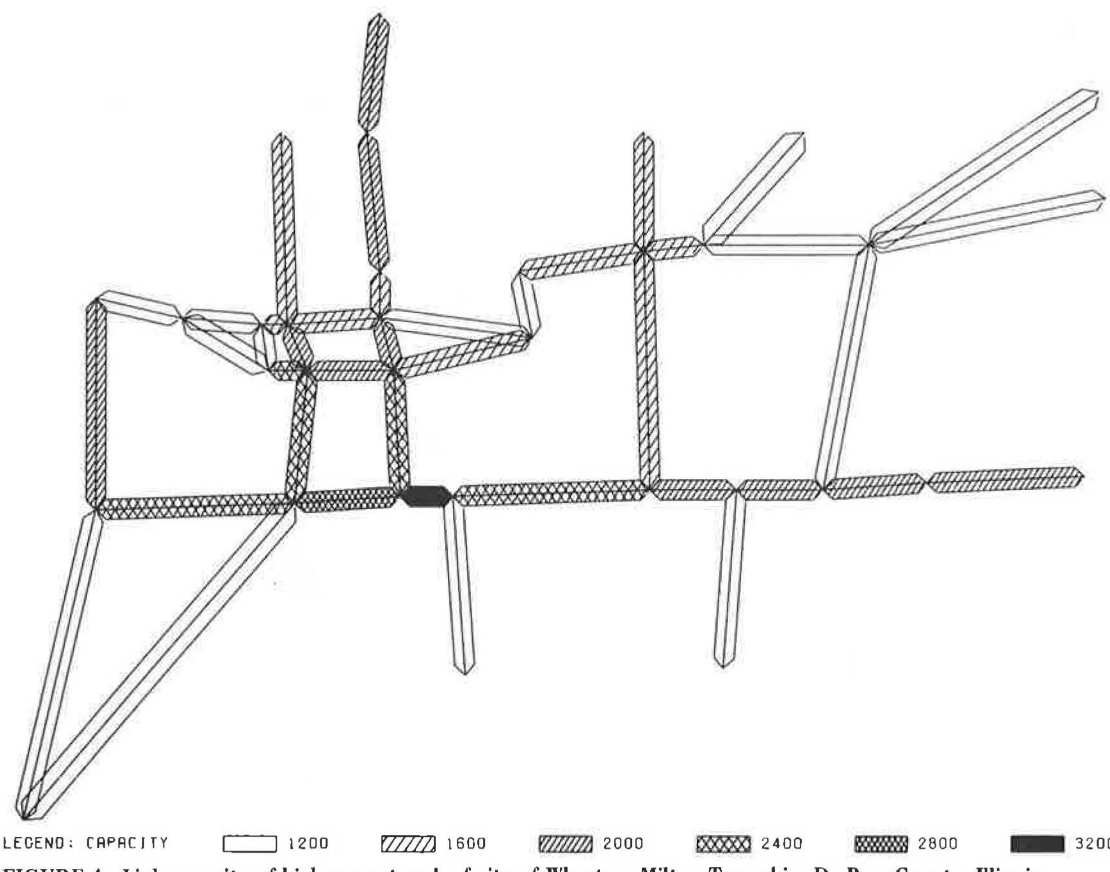

FIGURE 4 Link capacity of highway network of city of Wheaton, Milton Township, Du Page County, Illinois.

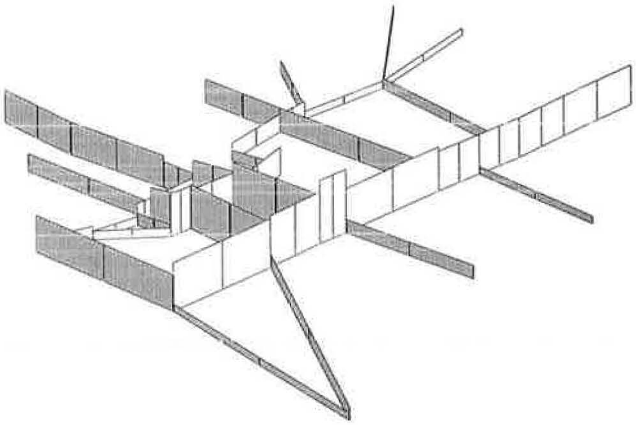

FIGURE 5 Alternative representation of link capacity of highway network of city of Wheaton, Milton Township, Du Page County, Illinois.

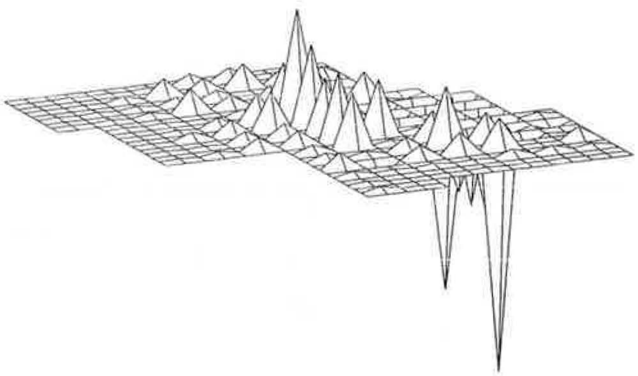

FIGURE 6 Changes in population in southern Cook County, Illinois.

Implementation

Implementation is an area where comprehensive analysis has been lacking in the past. As more efficient means of maintaining information, monitoring programs, and forecasting fiscal needs are being developed, the uses of computer graphics in understanding and communicating developing trends to policy makers are becoming apparent. In the past policy makers had endless lists of capital projects as their main input to the comprehensive decision-making process. Figures 7 and 8 show an easier way to comprehend CATS' 5-year capital program. The bar charts show, at a glance, the relative magnitude of investments in geographic, investment, and temporal categories. These charts could be modified in numerous ways to show most aspects of the program that are of interest to policy makers. These graphics can be produced by the same jobs that provide listings and summary tables. Therefore, when developing the new transportation improvement plan (TIP), alternative investment scenarios could be quickly and easily developed, illustrated, and compared.

Computer graphics can also supplement the implementation process by helping in the analysis of programming issues and trends. Figure 9 shows one way of examining information about the progress of the TIP in implementing transportation system development (TSD). Charts like the one in Figure 8 can be produced at any time during the TSD or TIP effective period and could, with a series of options, be factored for changing inflation rates, project awards, and funding scenarios.

An important factor in plan implementation is the impact of awards on the profile of the programmed investment. Although lists of numbers and percentages can be used to illustrate the impact of awards on the program's investment characteristics, the magnitude of the impact of varying award rates can be more clearly shown graphically (Figures 10 and 11). These charts and similar charts showing numerous other issues affected by awards could be produced as a standard procedure when the summary of awards is generated.

Long-Range Plan

Long-range planning techniques are easily adapted to computer graphic analyses because of the wealth of data available to, and generated by, the travel demand models. An integral part of the process is the estimation of the demand for travel on any link compared to the capacity of the existing system. Various reports are produced by an evaluation routine as part of the standard planning models. The planner is to examine this output for information that would be useful in developing alternatives for evaluation and to gain an understanding of the general characteristics of the system. Figure 12 shows volume on links with a volume-to-capacity ratio greater than one.

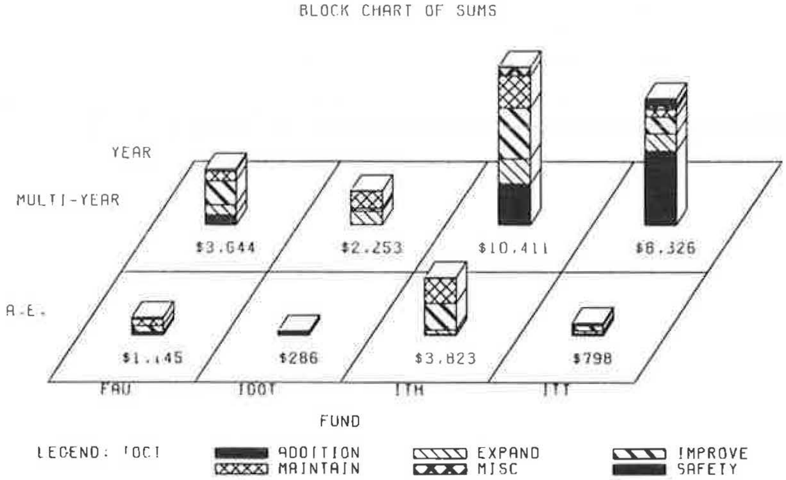

FIGURE 7 FY 1983-1987 TIP investment by year and fund category ($000,000).

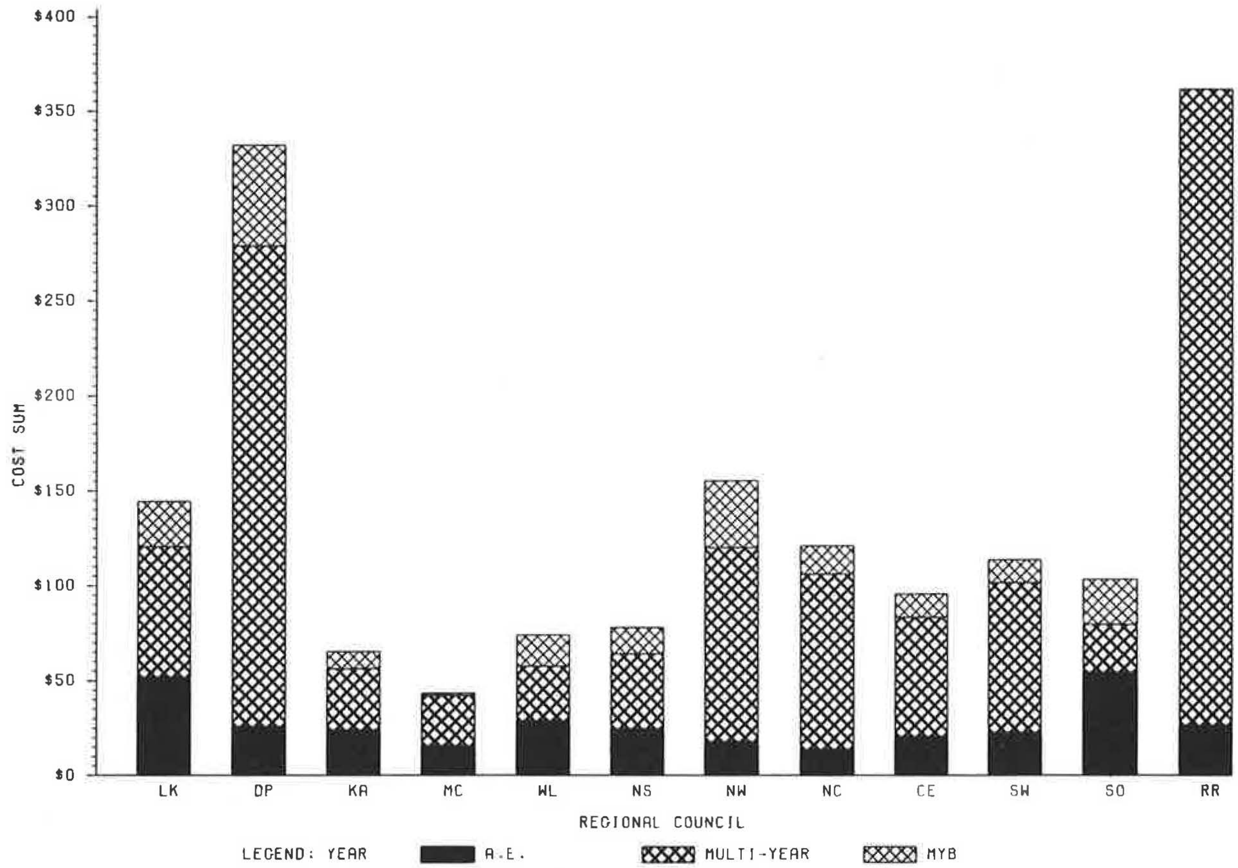

FIGURE 8 TIP investment by regional council and year ($000,000).

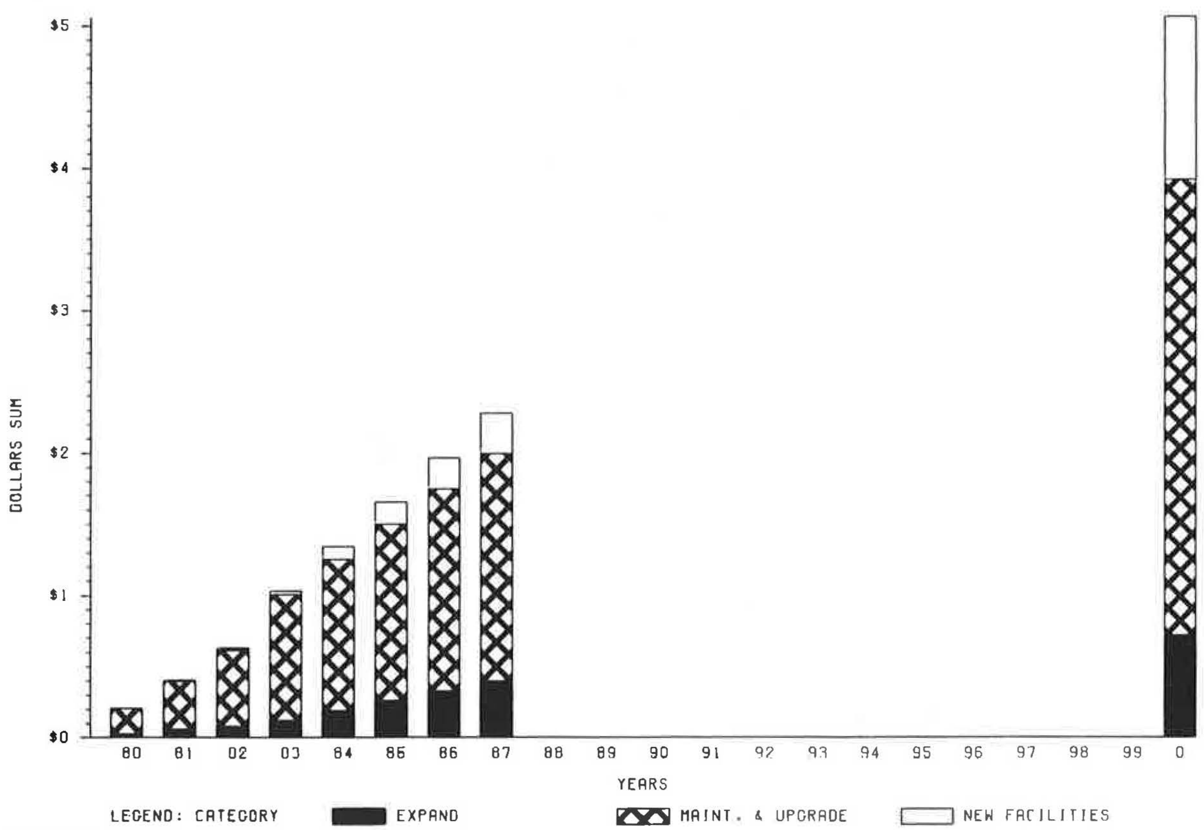

FIGURE 9 Cumulative TSD implementation progress ($000,000,000).

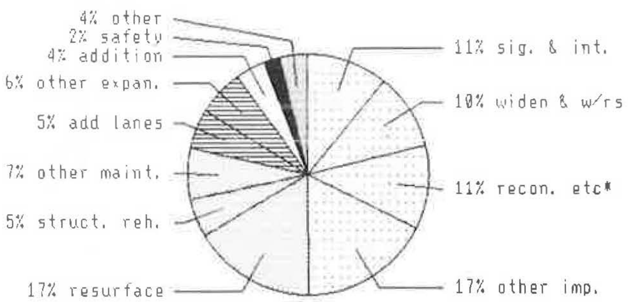

FIGURE 10 Original investment by category.

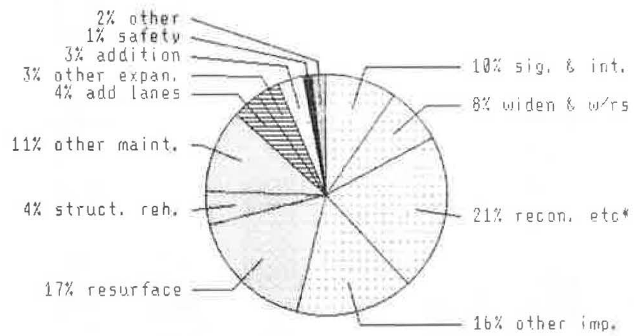

FIGURE 11 Awarded investment by category.

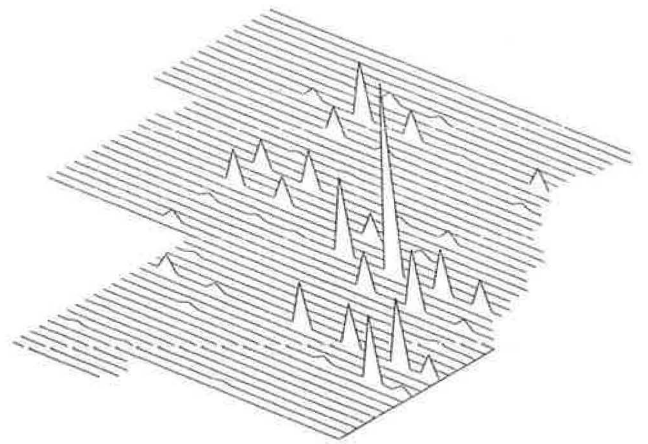

FIGURE 12 Excess volumes by township.

This map can be applied to any of the variables available in the evaluation routine, or to any other available data that can be aggregated to townships, zones, or links. (When standard levels and scope of analysis are known, simple software can be included in the evaluation program to produce similar maps along with the batch run.)

One of the steps in the CATS travel demand estimation process is to distribute trips by zone. The result of this step is a table of trips into and out of each zone. The output of this program is not one of the standard reports, but selected parts of it can be printed, compressed, or generated onto an active computer file for examination by a batch or interactive compilation of charts. The graph in Figure 13 shows, by the height of each block, the number of home-to-work trips between each possible pair of counties in the region.

Another step in the CATS travel demand estimation system is to make an estimation of the split of trips between transit and automobile. The result of this program is a printout of percentages of trips that are estimated to occur between zones by automobile and transit.

In this example, trends in the data, which are not easily seen in the numbers generated by the standard report, are observed in the computer graphic illustrations shown in Figures 14 and 15. For example, notice that work trips to the central business district (CBD) are predominantly on transit in the zones that are 30 or more miles from the CBD (Figure 14). Also notice that zones that are 5-10 miles from the CBD are almost exclusively in the 60 percent transit bracket. A very low percentage of work trips to the CBD from 1 to 3 miles away are on transit. But in zones that are 10-50 miles from the CBD the mode of transportation to work in the CBD is seemingly unrelated to distance.

For non-CBD-bound work trips there is a natural break point beyond which the principal mode of travel to work is not transit but automobile (Figure 15). This break point, 15 miles, is approximately the market area of the Chicago Transit Authority.

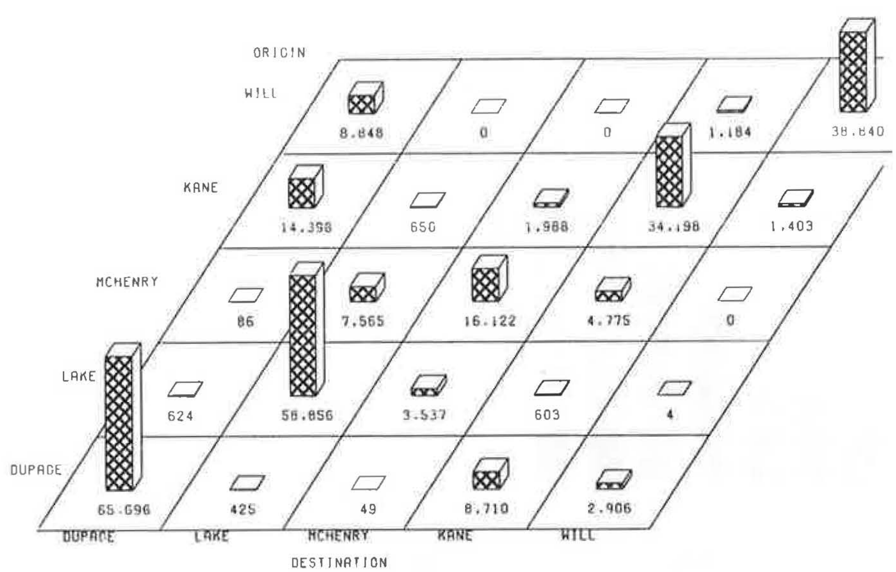

FIGURE 13 Work trips between suburban counties.

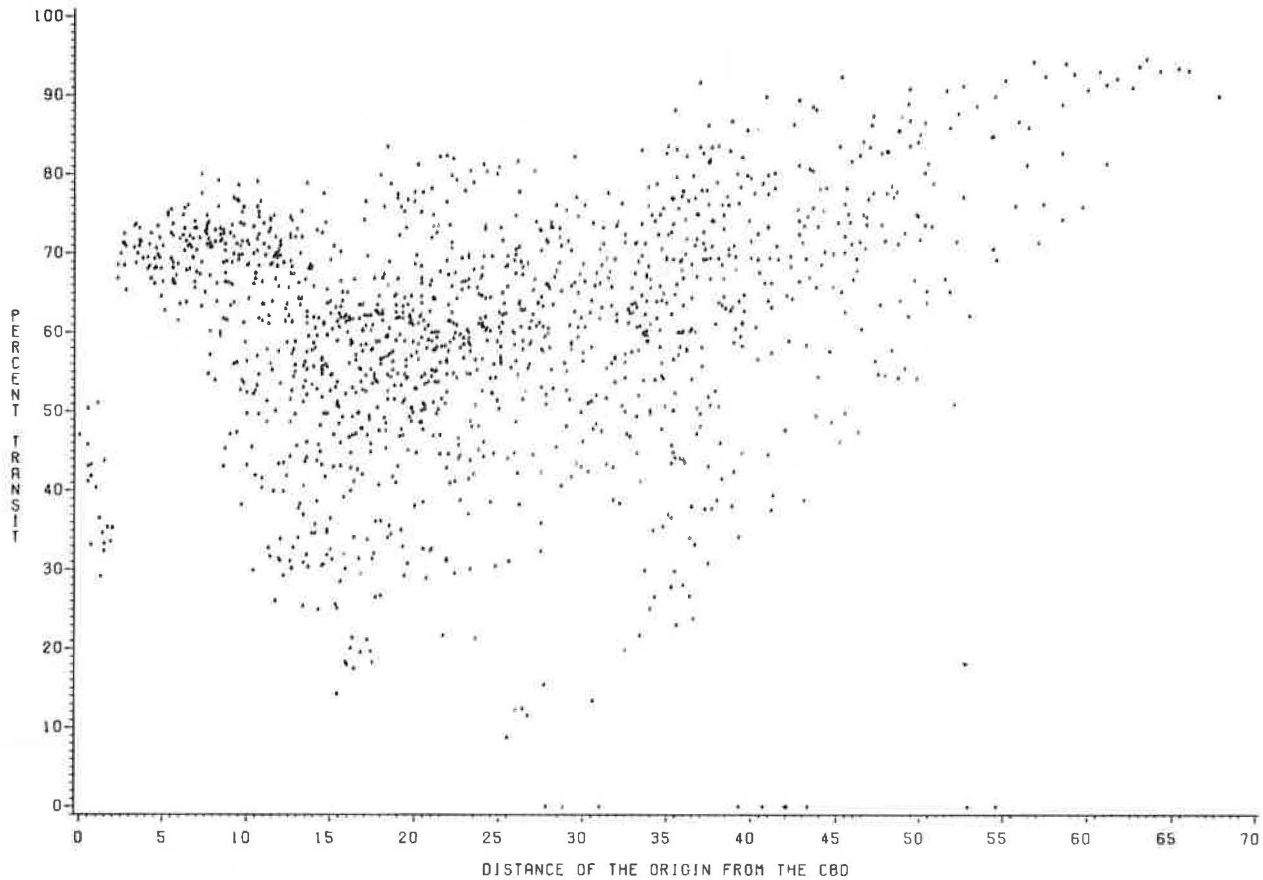

FIGURE 14 Mode split of CBD-bound work trips.

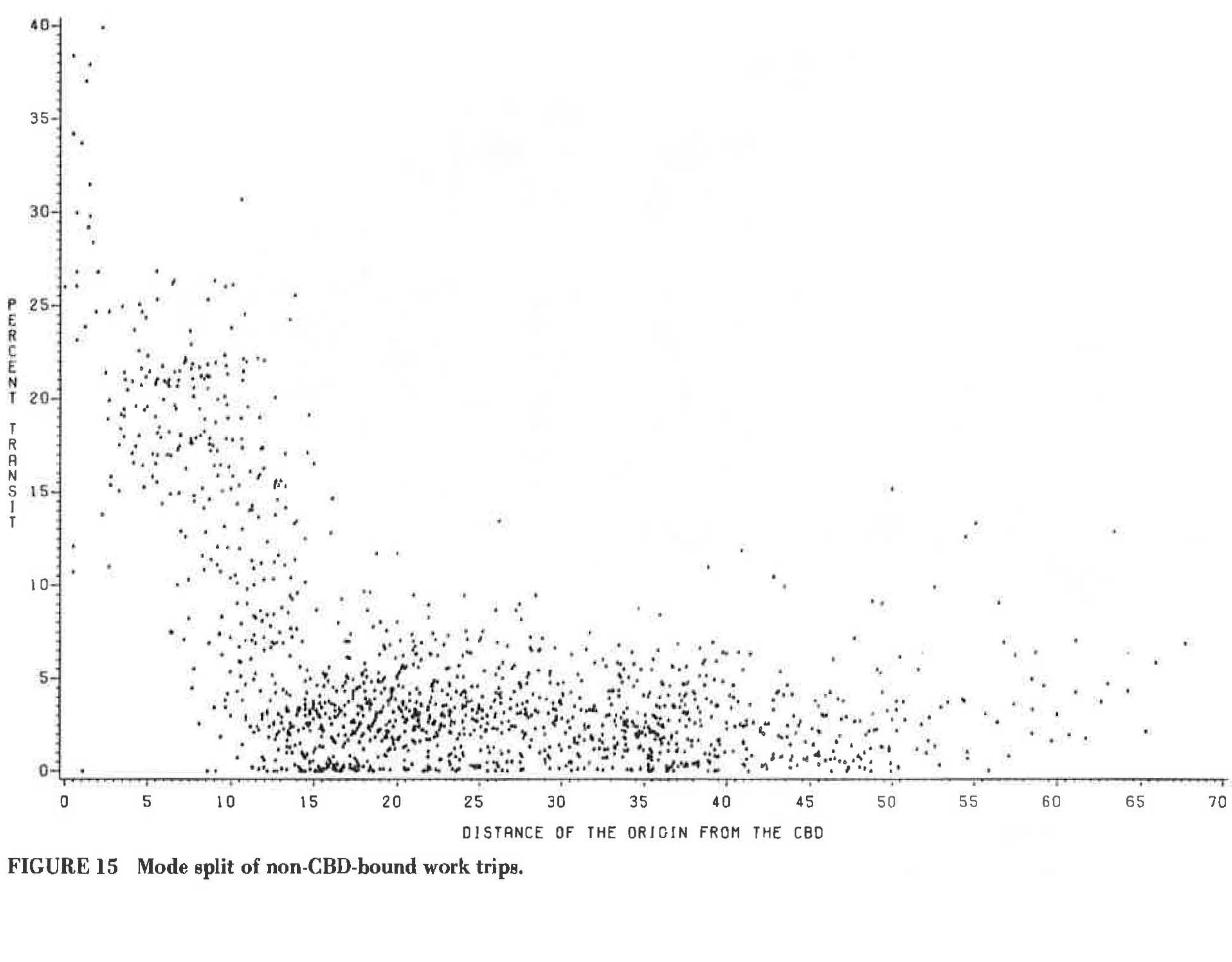

FIGURE 15 Mode split of non-CBD-bound work trips.

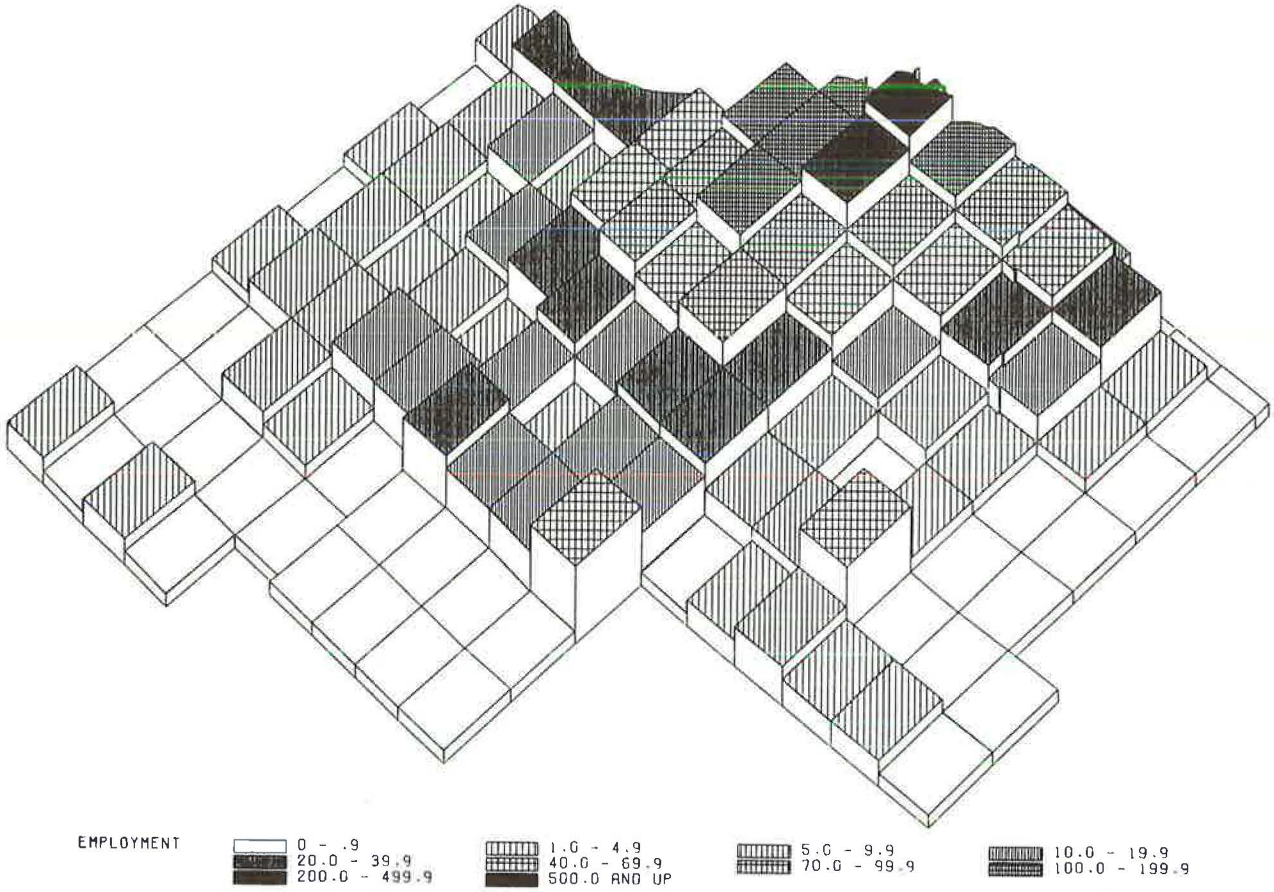

FIGURE 16 1980 employment by township.

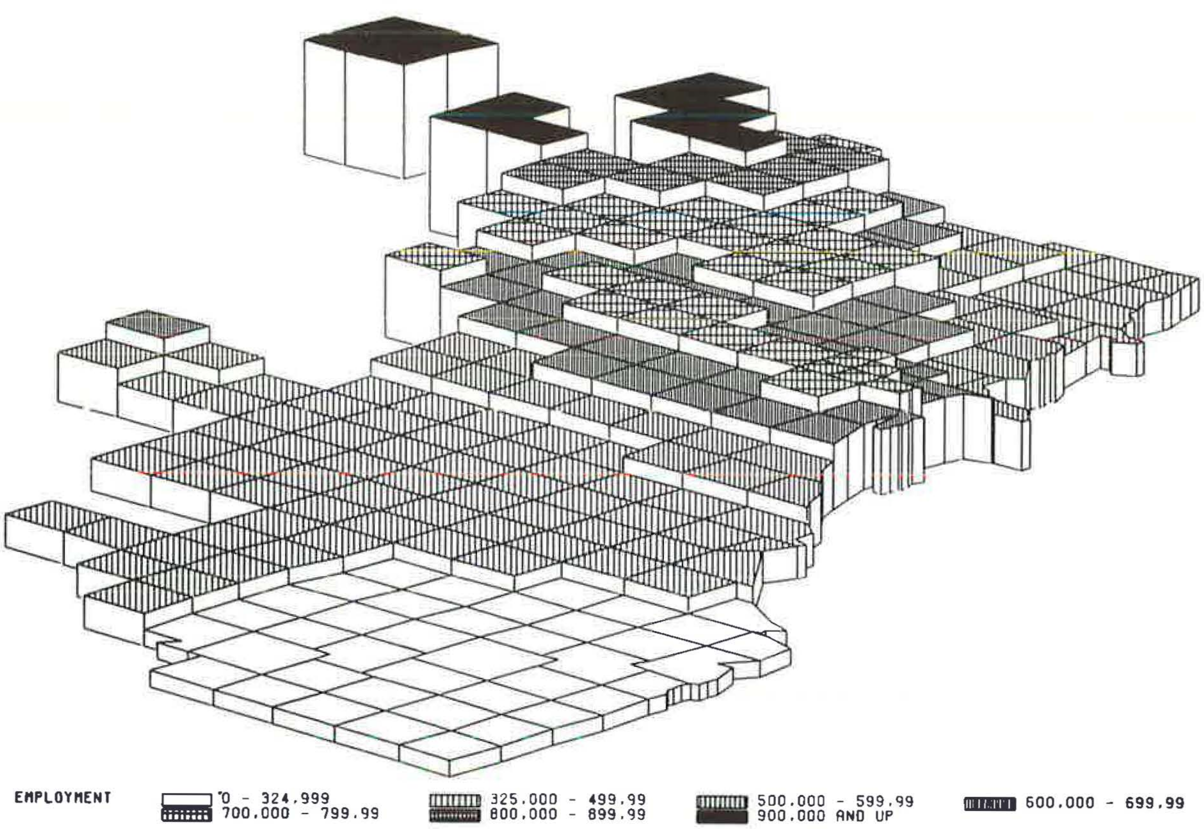

FIGURE 17 Suburban employment within 45 min. of each Chicago analysis zone using the highway system.

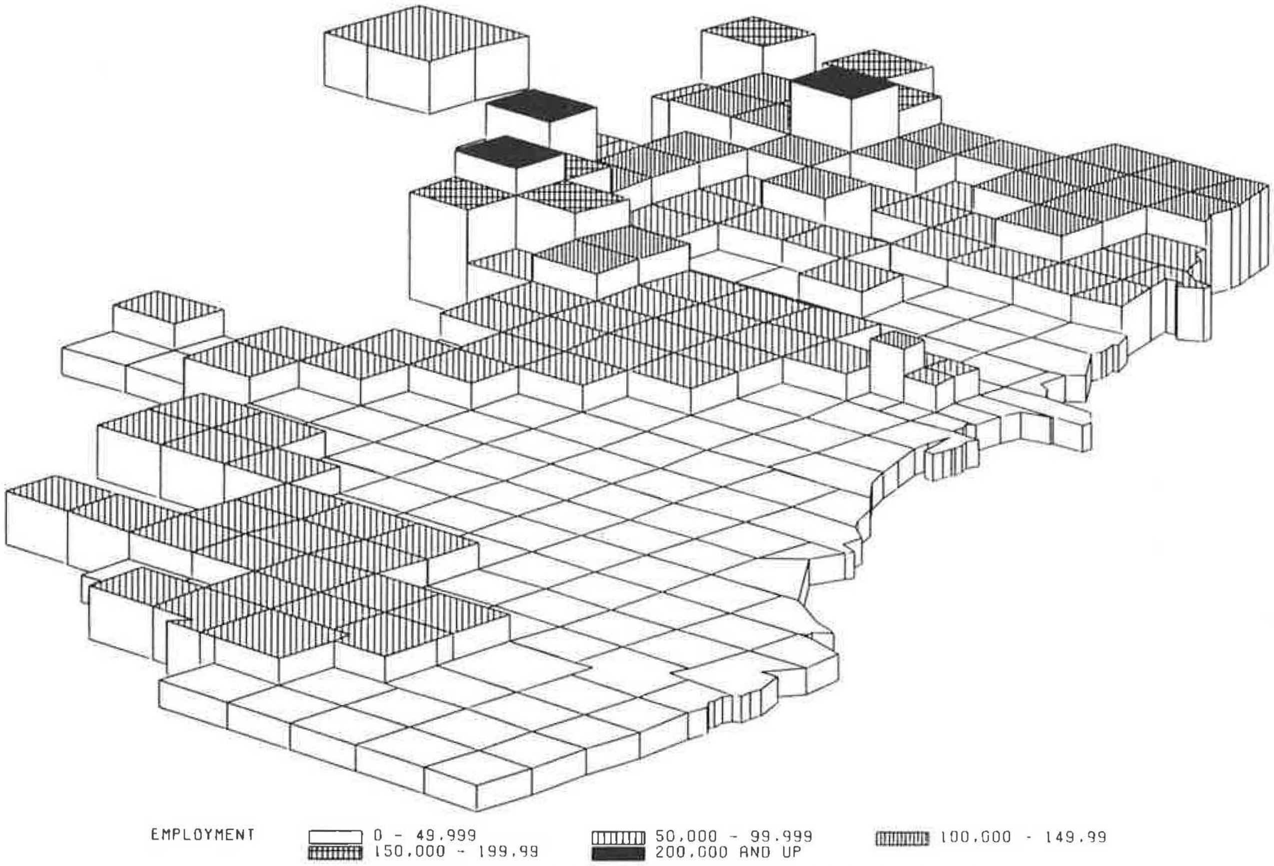

FIGURE 18 Suburban employment within 45 min. of each Chicago analysis zone using the transit system.

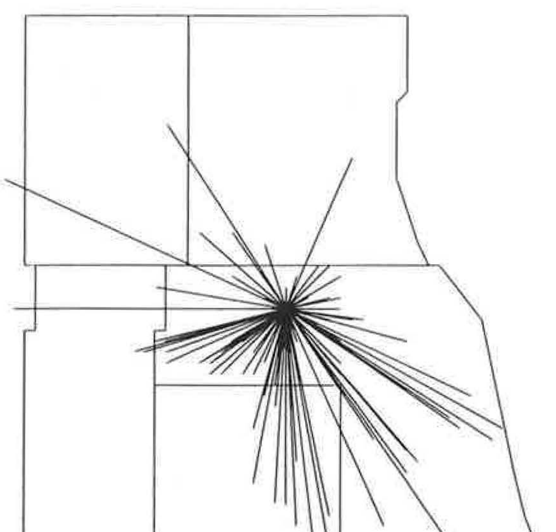

FIGURE 19 Carpool participants for a Schaumburg, Illinois, employer.

In addition to supplementing the products already produced by the planning functions, computer graphics can aid in evaluating results in new ways. For example, a project recently completed at CATS required the evaluation of Chicago residents' accessibility to suburban employment. Figure 16 shows the employment in the region by township. The three-dimensional maps shown in Figures 17 and 18 illustrate the amount of suburban employment (number of jobs in the suburbs) that is within 45 minutes of each Chicago analysis zone on the highway and transit networks, respectively. Other such analyses might include per capita expenditures on maintenance, travel time to the CBD under various proposed alternatives, or many other combinations of pertinent data.

Transportation System Management

The best example of using computer graphic analysis in transportation system management is in the ridesharing program. An important part of the CATS ridesharing program is the determination of desire lines; that is, where the demand for a ridesharing program might exist. The match program produces a listing of information about employees, their home and work grid coordinates, start and work times, and ridesharing or driving preference. Some minimal additional software could produce graphic displays of these desire lines as a result of a run of this program (Figure 19). This graph shows one line for each trip to work at a suburban employer. Corridors for potential carpools are evident.

CONCLUSIONS

A variety of applications of computer graphics to the field of transportation planning has been presented. The benefits realized through the work illustrated here include the ability to have traditional transportation planning programs produce graphics for analytic purposes; the capability for non-computer-oriented planners to select from a menu list and generate graphics for varied and specialized purposes; the potential for the experienced system analyst to interactively manipulate and analyze information in a manner not addressed by the standard models; and, finally, the production of graphics that are used for analysis and that may also be used in presentations and publications.

Even though there is a definite need for the development of specialized interactive graphics tools, especially for operations analysis, it is thought that low-cost, commercially available graphics packages can be effectively used to enhance the knowledge of transportation planners and their audience. The planning field is characterized by the complexity of its data sources and structures. The professional should make use of all tools available in order to realize the full potential of personnel, data, and models.

In conclusion, it is recommended that every effort be made to explore potential applications of existing software packages. In addition, efforts should be made to train transportation professionals in basic uses of computer graphics, both batch and interactive, in order to take the best advantage of the enormous potential.

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Design of a Single-Route Ridership Forecasting Model

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ABSTRACT

The transit ridership forecasting model (TRFM) has been designed to overcome many of the serious obstacles to implementation presented by previous methods of forecasting ridership on a single route. TRFM simplifies, optimizes, and repackages conventional ridership forecasting techniques to make the job of the planner as easy as possible. The model exploits the advantages of a popular, modest-sized microcomputer (e.g., animated color graphics), but it also deals effectively with inherent limitations of microcomputers (e.g., small memory and slow calculation speed).

Travel demand estimation is considered an integral part of transportation planning. However, despite two decades of model development, few transit planning agencies use the best available methods for ridership estimation. Transit planners instead often substitute rules-of-thumb or intuition in determining the impacts of service changes. There are many reasons for this gap between theory and practice, but one major reason is that virtually all available computer packages for ridership estimation require more data, more computer expertise, more equipment, and more time than planners generally possess.

The transit ridership forecasting model (TRFM) attempts to put sophisticated forecasting methodology into the hands of transit planners. TRFM greatly simplifies ridership estimation from the planner's viewpoint and attempts to retain the accuracy of mainframe models. In TRFM, simplification takes three forms: (a) eliminating mathematical procedures that are unnecessary to its sole objective of single-route ridership estimation; (b) designing the input procedures to remove, as much as possible, the burden of data preparation; and (c) organizing the program so that planners may easily customize the model to their needs.

TRFM is a fully interactive, color graphics program that just estimates ridership on a single route. The design of TRFM retains the salient parts of mainframe models such as the urban transportation planning system (UTPS) but exploits the advantages of microcomputers, specifically the Apple II+/IIe.

However, the limitations of the Apple II and similar computers (limited memory, slow computation speed, long disk access time, and limits to the resolution of color graphics) have resulted in several compromises. TRFM serves as a good reference point for what may and may not be accomplished on a modest-sized microcomputer and indicates the types of trade-offs that must be made.

The research project that generated TRFM had two purposes: the first was to design a microcomputer program that would overcome the implementation obstacles of previous models; the second was to determine whether planners would adopt the methodology when it was made available. The first purpose has been satisfied, but the second is only now being pursued.

MINIMUM DESIGN STANDARDS

A list of "musts" was developed at the beginning of the project to develop TRFM. It was believed that if the model failed to accomplish any one of these points, its applicability would be so seriously limited that few planning agencies would want to use it. For TRFM to be a useful tool rather than merely an academic exercise, the following had to be accomplished:

1. Sensitivity to service changes on the route of interest, with the implication that ridership estimates would be based on a mode-choice model of sufficient breadth to reflect virtually all service changes contemplated by planners.
2. Familiarity to quantitatively oriented planners; it was believed that if TRFM were too experimental it would not become widely accepted as a planning tool.
3. Compatibility with the 1980 Census because few transit planning agencies have the resources to collect and analyze vast amounts of travel and demographic data; TRFM needed to efficiently use existing data sources.
4. Quick computation with an outside limit of 30 minutes. Any program running longer than that could hardly be called interactive.
5. Easy-to-understand structure, so that even a planner with only passing knowledge of ridership forecasting could produce reasonably good results.
6. Enough sophistication to satisfy planners who possess extensive knowledge of the principles of ridership estimation; the model could not insult their intelligence by making too many assumptions nor by being overly restrictive in how calculations were handled.
7. Attractive packaging--TRFM had to measure up to other software products in terms of user friendliness and polish. Much of the commercial software now available is so well written that expectations of owners of microcomputers are rapidly rising. Line-by-line input procedures that once were acceptable on multiple-user systems are now unacceptable on single-user systems.
8. Performance of the preceding seven items entirely within the restrictions of a modest-sized microcomputer, because this is what is most readily available to transit planners.

These were the minimum requirements; all of them were met. There was also an additional list of goals, many of which could not be fully realized:

1. Color graphics to support all data input. Proper use of color graphics can make the tedious and boring process of data entry more enjoyable. This goal was fully achieved.
2. Parameters that are readily understood, so that they can be grasped by people not familiar with ridership estimation. This would be necessary if the model were to be trusted by users or explained to others. This goal was achieved for all but two parameters, which ended up with units of "utils/minute."
3. Applicability to cities of every size and geography. Although a microcomputer model might be most helpful to transit agencies in small cities, it probably would be first adopted by larger systems that had at least one full-time planner. This goal has been met, although systems in large cities are required to provide (proportionally) slightly more data than systems in small cities.
4. Computation time of 5 minutes or less. A short computation time enables planners to adjust default parameters by repeatedly running the model until ridership estimates consistently match current levels. Formal, statistical calibration can thereby be avoided. This goal was achieved only for shorter-than-average routes.
5. Accuracy of results to within 1 percent of those obtained from mainframe models. This goal was surpassed; in many planning situations TRFM is just as accurate as mainframe models.

In the following sections how well the minimum requirements were met and the extent to which the additional goals were achieved are discussed more fully. But first it is necessary to describe some of the mathematical portions of TRFM.

ANALYTICAL STRUCTURE OF TRFM

Mathematically, TRFM is an implementation of many of the results from a major investigation of riders' evaluations of the time spent in travel (1,2). Psychological scaling was used to determine the relative values placed on various elements of bus transit, walking, and automobile trips. In addition to providing many default parameters for TRFM, this study identified which elements could be ignored and which must never be ignored in a ridership estimation procedure. Those that can be ignored, resulting in a more simplified model, will be discussed first.

Network Simplifications

Current mainframe models for forecasting ridership evolved from models to estimate highway traffic volumes. But people use transit networks very differently from highway networks. An automobile driver has nearly unlimited freedom to choose a path that minimizes travel time between origin and destination. A transit rider has a very limited choice of paths. It has been established that riders dislike transferring and avoid transfers whenever possible (2,3). If an assumption is made that, by choice, riders make at most one transfer, then there is only one possible path for the vast majority of trips that are known to use one particular route. Consequently, it is necessary to produce only a network containing the route of interest and all immediately connecting routes. Furthermore, in gridded and radial systems these connecting routes almost never intersect the route of interest more than once, so circuits in the network can be avoided. TRFM insists that such circuits are not present, so that over-the-network trip times can be rapidly calculated.

The process of creating a network for TRFM is similar to Dial's (4) windowing and focusing concept. The network focuses on the route of interest, which is shown in considerable detail; connecting routes are shown in far less detail. A good network focusing on a single route can almost always be shown in less than 80 nodes, TRFM's current maximum. Consequently, a TRFM network requires a small fraction (5-10 percent) of the data that would be necessary without windowing and focusing.

TRFM does not require a highway network. It has been repeatedly shown that automobile speeds are a roughly constant multiple of bus speeds, regardless of traffic conditions (5). When it is reasonable to assume that automobile trips follow the path of bus routes, TRFM calculates automobile trip time as a fixed fraction of bus running time. This permits elimination of most highway network data--data that are generally not available to transit planners.

There are two important instances in which automobiles cannot be assumed to follow bus routes: when there are "U's" or large one-way loops. Automobile drivers will generally travel shorter distances than bus riders between two points on a loop or a U. TRFM employs a scale drawing of the network, produced with the assistance of graphics routines, to detect the existence of a loop or a U and then shortens automobile trips by the appropriate amount.

In gridded networks, as opposed to radial networks, a significant number of riders may reach areas around the route of interest without ever going on that route. To allow for this behavior, TRFM discards trips that start at a point on a connecting route and end at the transfer point between that route and the route of interest. TRFM also permits the planner to further discard a fraction of all trips that start or end at a point on a connecting route. This fraction is normally zero in small cities, but it can be as high as 0.5 for systems with closely spaced or perfectly gridded routes. The effect of discarding trips is similar to what would be achieved with stochastic traffic assignment.

In addition to the significant savings in required data, these network simplifications have computational advantages. The description of the network can be compactly stored, preserving memory and disk space. Algorithms for finding node-to-node trip times and link loads can be optimized for a network without circuits. This is important because of the need for quick results.

Trip Distribution

Trip distribution equations vary greatly in complexity but have similar effects on estimates of total route ridership. A doubly constrained gravity equation (e.g., where the trip table must be consistent with trips attracted to every zone as well as trips produced at every zone), which is preferred by highway planners, has more than twice as many parameters as nodes. These parameters must be iteratively determined each time the model is run. A singly constrained gravity equation (i.e., where only trip productions need be consistent with the trip table) does not require iterative recalibration. Consequently, the equation selected for trip distribution was singly constrained.

In addition to speed, singly constrained trip distribution equations have other advantages because total trip production need not agree with total trip attraction, so a planner can adjust trip productions up or down according to the socioeconomic characteristics of the people in each zone. Trip attraction, because it is only a measure of the ability of a zone to attract trips, can be determined by many different methods depending on data availability. An entropy-maximizing form (6) of the gravity equation was selected because more is known about calibrating this particular version than any other method of estimating trip distribution.

Early in the development of TRFM it was found that total route ridership, the most important result, is relatively insensitive to the single parameter of the trip distribution equation. Therefore, it made little sense to have more than one trip purpose (as is the practice in highway volume estimation) just to have a slightly more accurate trip table. Limiting TRFM to a single trip purpose has obvious computational advantages, but it also greatly reduces data requirements at the trip generation step.

Trip Generation

Single purpose trip productions and trip attractions are based on demographic and employment information. The default trip generation equations are patterned after those developed by the Southeastern Wisconsin Regional Planning Commission (7). Trip production is based on numbers of households falling into specified size and automobile availability categories, in a form compatible with 1980 Census data. Trip attraction is derived from the number of service employees, nonservice employees, and students.

Mode Split

TRFM, following standard practice, divides transit riders into two categories: captive and choice. Captive riders are assumed to be insensitive to service variables and constitute a fixed fraction of all trips produced in the service area. Choice riders are divided between transit and automobile by a binary logit equation that has terms for initial waiting time, walking time, transfer time, riding time, fare, automobile excess time, automobile costs at the destination, automobile costs per minute of travel, waiting penalty, and transfer penalty. The selection of terms was based on the previously mentioned study of evaluations of time spent traveling. Because of the availability of transferable parameters (8), the binary logit equation was preferred to other mode-split equations.

INTERACTIVE COLOR GRAPHICS AND OTHER VISUAL DISPLAYS

Graphics has been a positive force in transit route planning, dating back to IGTDS (9) and NOPTS (10). However, extensive use of graphics was impractical until the introduction of the microcomputer because of the specialized hardware that was previously required. Nonetheless, these early efforts demonstrated that an interactive graphic capability could make data preparation and manipulation easier, faster, and more pleasurable. The design of TRFM's graphics routines was heavily influenced by these pioneering efforts.

The original goal of the graphics routines in TRFM was to allow the planner to enter a drawing of portions of the transit network. Then, whenever TRFM needed a piece of data, the program would prompt the user by pointing to the right node or link. Conversely, when the planner wanted to see a piece of previously entered data or a calculated result, he could get it by pointing to the correct link or node on the display. The drawing becomes a communications device, eliminating the need for explicit link and node numbers (or similar identification.)

When the mathematical model steps of TRFM were refined, another important use was found for the graphics information. As previously mentioned, TRFM does not use a highway network; it infers automobile trip times from bus running times. Consequently, it is essential for TRFM to know when automobile trips roughly follow bus routes and when they do not. The graphics display, if the network is drawn to scale, has sufficient information to make this determination and to allow for calculation of any necessary corrections in automobile trip time.

The standard Apple II+ has been chosen for its popularity among transit agencies, not because it has outstanding graphics features. Apple II+ graphics capabilities are the minimum necessary for network display (though the Apple is better in this regard than many other popular brands of microcomputers). The design of the graphics routines had to overcome the limited color resolution (140 horizontal x 192 vertical), the slowness of the BASIC graphics statements, aggravating and unexpected color changes, and the lack of a cursor or cross hairs. In addition, the graphics routines had to work on a monochrome display as well as a color one and make allowances for computers without light pens, paddles, or joysticks.

Figure 1 shows the design of the graphics display. The arrows indicate a position within the display. They can be animated by paddles or keyboard. The strip of symbols along the right side of the display serves as the menu from which various functions can be selected: plotting nodes (square dot), plotting links (vertical line), deleting nodes and links (D), starting a new network (N), continuing to the numerical data input step (C), and printing the display (1 and 2).

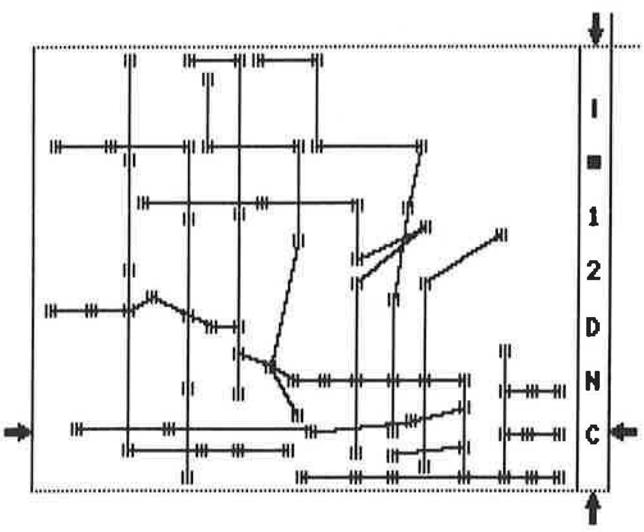

FIGURE 1 Monochrome representation of the TRFM graphics display showing a route in Racine, Wisconsin.

Getting the graphics to work was straightforward; BASIC is a good language for graphics if speed is not important. Getting the graphics to work quickly required substitution of machine language subroutines for BASIC statements plus the use of some little-known tricks (e.g., hiding some of the program from itself) to dramatically improve BASIC's execution time.

When the network has been drawn, data can be entered for each node and link. TRFM prompts the planner for information by pointing to each link with an arrow and highlighting each node in a contrasting color. As the data are assembled, nodes turn different colors depending on their status (route of interest, connecting route, transfer point) and one-way links are marked.

The graphics routines have the feel of an arcade game. Ridership estimation is serious business, but it need not be boring. The use of color, sound effects, and game paddles with a fire button make plotting the network far more enjoyable and no less accurate than it would be if the drawing were produced by inputting screen coordinates onto a quiet, monochrome display.

Other Aids to Data Preparation

TRFM employs 10 on-screen work sheets to aid data preparation. Any time TRFM prompts for a number, a work sheet is available. At the minimum, a work sheet displays the current value and gives the planner an opportunity to change it. All work sheets accept both numbers and arithmetic expressions as inputs. Some work sheets (e.g., those used for calculating trip production and trip attraction) allow the planner to reference statistical equations. When the calculations on a work sheet call for parameters, a "parameter page" is readily available. It displays the necessary parameters and gives the planner an oportunity to change them. TRFM is provided with a complete set of default parameters. Examples of a work sheet and an associated parameter page are shown in Figures 2 and 3.

```
1. # OF 0 AUTO HH'S          10
2. # OF 1 AUTO HH'S          36
3. # OF 2+ AUTO HH'S         53

4. # OF 1 PERSON HH'S        20
5. # OF 2 PERSON HH'S        29
6. # OF 3,4 PERSON HH'S      35
7. # OF 5+ PERSON HH'S       15

8. TOTAL FAMILIES            99

9. % TO MAIN LINE AREA      100

10. TOTAL TRIPS             361

ENTER NUMBER OF CHOICE OR 'C' TO
CONTINUE OR 'P' TO SEE PARAMETERS
?
```

FIGURE 2 Example of a work sheet: trip production.

Some model designers have adopted the attitude that parameters should be difficult or impossible to change. They fear that, if parameters can be easily modified, inexperienced planners will botch forecasts. The philosophy behind TRFM is considerably different. Users are encouraged to adjust default parameters as needed. TRFM remembers any changes and incorporates them in subsequent forecasts. Over time, and without formal calibration, parameters can be refined until highly accurate forecasts are consistently achieved for a given system.

The work sheets and parameter pages were patterned after those of VisiCalc. The popularity of VisiCalc stems largely from two features: the ability to see all numbers as if they were written on a sheet of paper and the instantaneous recalculation that occurs when any number is changed. These capabilities were incorporated into TRFM's work sheets.

```
 1. RATE/0 AUTO HH'S           .71
 2. RATE/1 AUTO HH'S           .06
 3. RATE/2+ AUTO HH'S          -.58

 4. RATE/1 PERSON HH'S         -1.425
 5. RATE/2 PERSON HH'S         -.36
 6. RATE/3,4 PERSON HH'S       .47
 7. RATE/5+ PERSON HH'S        1.315
 8. CONSTANT TRIPS/HH          3.89

 9. % OF 0 AUTO HH'S           10.01
10. % OF 1 AUTO HH'S           36.22
11. % OF 2+ AUTO HH'S          53.77

12. % OF 1 PERSON HH'S         20.57
13. % OF 2 PERSON HH'S         29.54
14. % OF 3,4 PERSON HH'S       34.79
15. % OF 5+ PERSON HH'S        15.1

ENTER NUMBER OF CHOICE
OR 'C' TO CONTINUE
?
```

FIGURE 3 Example of a parameter page: trip production.

When data have been entered, TRFM allows the planner to quickly view the entries, change any value that might have been typed improperly, and modify the network. A network can be saved on disk for later reference.

COMPUTATION TIME

It should be clear from earlier discussions that computation time was of great concern. An initial goal was a computation time of 5 minutes. A substantially longer computation time would inhibit the refinement of parameters and of data preparation techniques by simply running the model repeatedly. When the first draft of TRFM was prepared, calculation for a full-sized network took 3 hours. This greatly exceeded the maximum computation-time standard set at the beginning of the project.

The long computation time was caused by the BASIC interpreter (a slow way to execute any program) and exacerbated by structured programming techniques. Compiling the program produced a sevenfold improvement in speed. Additional time savings were achieved by three measures: extensive rewriting to combine as many steps as possible, substitution of integer arithmetic for floating-point arithmetic, and reduction of the dimensionality of frequently referenced arrays. These actions reduced maximum computation time to 18 minutes. The set of test networks for Racine and Milwaukee, Wisconsin, averaged about 13 minutes. Further improvements in computation time were achieved by installing some additional hardware (a widely available 8088 coprocessor board) in the Apple, which cut average computation time to 8 minutes. Brute-force refinement of parameters was made practical by these improvements in computation time.

Unfortunately, these speed increases carry a price tag. It is now more difficult for a user to customize those portions of the program that have been compressed and compiled.

CALIBRATION ISSUES

All forecasting models need some calibration. In recent years, calibration has become synonymous with statistical estimation, but other methods do exist. Statistical calibration is essential when models become so large that only a portion of parameters can be determined at one time. But if a model has only a few parameters that require minimal adjustment, the model can be run repeatedly until the planner is comfortable with the accuracy of the forecasts.

This brute-force calibration will not work properly unless the program has been specifically designed for that purpose. TRFM includes several features to facilitate brute-force calibration: (a) TRFM runs quickly; (b) TRFM allows for transferable parameters so that the number of truly unknown parameters can be held to a minimum; (c) parameters are easily accessed and well explained, both on screen and in written documentation; (d) where possible, parameters are presented in ways that have physical, economic, or behavioral meanings; (e) default parameters are provided to serve as a reasonable starting point; and (f) results are consistent with the way transit agencies collect ridership data (total ridership, revenue ridership, on-off counts, and check-point loads) to aid comparison between model results and data from the existing system.

ERROR ANALYSIS

TRFM was subjected to extensive error analysis to determine if the simplification assumptions could substantially affect the results. The error analysis (11) will only be summarized here. Tests were performed on three routes in Racine, Wisconsin, to determine if the following four procedures would lead to significant error: (a) adopting a no-multiple-transfer rule, (b) approximating automobile trip times as fractions of bus running times, (c) correcting for loops and U's from the scale drawing of the network, and (d) showing connecting routes in less detail than the route of interest. In each case, errors were less than 0.1 percent in total ridership, or less than one rider.

More worrisome are errors due to misspecification of model parameters. All forecasting models, not just TRFM, are vulnerable to inappropriately selected parameters. However, TRFM confronts this problem directly by presenting parameters in easy-to-understand terms and by giving the planner ample opportunity to study and modify them as necessary.

Another source of error, almost never discussed, is sloppy work. It is only human nature to be more careful in preparing a few pieces of data than in preparing many pieces of data. Consequently, a model that is optimized in its data requirements, like TRFM, may be much more accurate than a complex model, which appears to be better on paper.

COMPARISON WITH OTHER MODELS

The impetus for development of TRFM came from transit operators who were disappointed that the interactive graphics transit design system (IGTDS) could not be implemented on readily available hardware. IGTDS forecasts ridership and other impacts of bus rapid transit. In particular, it handles situations in which there are many origins of trips but only one destination, such as park-and-ride or freeway flyer service. In structure IGTDS is similar to TRFM, employing graphics to facilitate data input and basing ridership on the traditional four-step modeling procedure (trip generation, trip distribution, mode split, trip assignment). TRFM is much broader than IDGTS in the types of routes it can analyze, but TRFM does not provide as comprehensive an evaluation of route performance.

One recently developed computer program that invites comparison with TRFM is the transit operations planning (TOP) model system developed by Turnquist, Meyburg, and Ritchie (12). Like TRFM, TOP is a microcomputer program that can estimate ridership on a single route; it is based on the traditional four-step procedure. TOP is more comprehensive than TRFM, because in addition to ridership estimation it estimates level-of-service variables and performance indicators. In structure, TOP is similar to mainframe models and requires a big microcomputer (an Apple III with 256K bytes of memory and three disk drives).

The most striking difference between TRFM and TOP is the emphasis placed on user needs. TOP assembles several sophisticated mathematical steps (e.g., an optimization procedure for reconciling trip tables with on-off counts, consideration of stochastic variations in bus arrival times, and a procedure for establishing equilibrium between levels of service and ridership) into a complex package. However, less effort was placed on streamlining the process for the planner. TOP appears to be best suited for planners who are well versed in the principles of ridership estimation. In contrast, TRFM dispenses with relatively less-important data and procedures, placing greatest emphasis on helping the planner enter the data and extract the results. In TRFM a highly complex step is permitted only when both theory and existing data indicate the step is required for the specific task at hand.

DISCUSSION

Computers have not fulfilled their early promise in transit planning. They perform calculations quickly and they display intricate drawings, but they cannot collect and cull data or judge whether a particular equation is appropriate. There have been many attempts to create more elaborate mathematical models but relatively few recent attempts to improve the computer-human interface.

The introduction of microcomputers presents a new opportunity for model designers. Costs are now so low that a major percentage of computer resources can be devoted to making the job of the planner easier. Interactive techniques for doing this (e.g., color graphics, menus, and work sheets) are all well developed. They merely require adaptation to the particular needs of transit planners.

It is essential that planners understand any model being used. However, the state of the art has now reached a point where only people well versed in operations research and statistics can properly apply the newest techniques. Transit agencies, weighing the advantages and disadvantages of mathematical models, often will opt to do without forecasting rather than use techniques that few of their people understand. If any model is to be widely adopted, its assumptions need to be made explicit; its rationale for selection of particular equations must be made obvious; and, desirable but less important, complexities should be either scrapped or presented as readily bypassed options. Furthermore, the interactive features of the computer program should serve to illuminate the process, both as data are entered and as alternatives are tested.

The acid test in determining if a program is sufficiently user friendly is its acceptance or rejection by transit operators. For this reason some emphasis has been placed on publicizing and distributing TRFM. Unfortunately, but understandably, there is considerable resistance among managers of transit systems to mathematical models of any sort. Efforts are being made to explain the benefits of ridership forecasting and the ways in which a microcomputer can help. Transit managers, in turn, are now providing valuable feedback on how this and future programs can aid and improve transit planning.

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Professional Development in Transit: Need and Issues

BRENDON HEMILY

ABSTRACT

Interest in the development of human resources has recently increased within the transit industry. Concurrently, the number of professional development programs offered by academic institutions has increased as a result of initiatives by UMTA. Some of the issues relating to professional development, based on the experience of the Institute for Urban Transportation at Indiana University, are discussed. The discussion will successively focus on the general concept of employee development, consider the needs for employee development in the transit industry, and explore five important issues that have emerged from the Institute's experience with professional development programs. Employee development is defined as all activities designed to enhance the personal capabilities of individual employees and involves three types of activities: (a) apprenticeship training, (b) continuing education, and (c) professional development. There is an important need for employee development within the transit industry because transit is labor intensive and suffers from high managerial turnover rates. However, employee development has received little attention for a variety of historical, economic, and political reasons. Recent developments suggest that the situation is changing and have resulted in the creation of numerous professional development programs. Five issues related to the design of such programs are discussed: choice of topic, choice of faculty, student mix, overall balance of program, and program logistics. In spite of attendant difficulties, these programs offer a unique opportunity to stimulate exchange among industry professionals and to improve the dialogue between the academic community and the transit industry.

Interest in the development of human resources has recently increased in the transit industry. Concurrently, the number of professional development programs offered by academic institutions has increased as a result of initiatives by UMTA. Some of the issues relating to professional development, based on the experience of the Institute for Urban Transportation (IUT) at Indiana University, are discussed. The discussion will successively focus on the general concept of employee development, consider the needs for employee development in the transit industry, and explore five important issues that have emerged from IUT's experience with professional development programs.

EMPLOYEE DEVELOPMENT

Employee development can be defined as those activities designed to enhance the personal capabilities of individual employees and maintain and upgrade an organization's human resources. Employee development activities can serve these purposes by

- Upgrading skills needed to solve specific problems;
- Communicating a uniform understanding of responsibilities, managerial expectations, and procedures;
- Enhancing upward mobility potential;
- Broadening the professional's outlook and stimulating creative capabilities;
- Increasing issue awareness; and
- Increasing employee satisfaction.

There are many types of activities that can be defined as employee development and these will be classified in three basic categories: (a) apprenticeship training, (b) continuing education, and (c) professional development. A distinction will be made here between "employee" and "organizational" development; although both serve to enhance an agency's human resources, this discussion will focus on those activities that deal with the individual's capabilities rather than with group dynamics. A description of the three categories of employee development follows.

Apprenticeship Training

Apprenticeship training enables the employee to acquire those fundamental skills that will be required to carry out responsibilities in a given position. In transit, for example, this involves the training received by drivers and mechanics to ensure minimum acceptable standards of professionalism, safety, and dependability. Such apprenticeship training also serves to make employees aware of standard procedures, responsibilities, and expectations. It is above all a mechanism for establishing controls, integrating the employee within the organization, and transforming the employee into a service delivery agent.

Continuing Education

Continuing education enables employees to broaden their intellectual capabilities by pursuing educational programs with the intent of eventually obtaining a degree. This can often increase an employee's potential for career mobility and provides a valuable means of increasing employee satisfaction.

Professional Development

Professional development is intended to improve employee effectiveness and efficiency in managing present or new responsibilities. Unlike apprenticeship training, which is primarily aimed at achieving integration and control and is often best performed by the agency itself, professional development can often be provided outside the agency. For example, an intensive workshop program at a university, isolated from the professional's daily crises, may provide an environment that is more conducive to upgrading skills or enhancing creativity than is that at the agency. Before exploring some of the issues that emerged from IUT's experience offering professional development programs, a brief discussion of the need for employee development in the transit industry is in order.

NEED FOR EMPLOYEE DEVELOPMENT IN THE TRANSIT INDUSTRY

Two characteristics of the transit industry make employee development particularly important. First, the transit industry is a highly labor-intensive industry with 73 percent of the industry's operating expenses represented by labor costs (1). Transit is fundamentally a service provided for people by people. Second, the transit industry experiences a high rate of turnover of managers and professionals. This occurs for a variety of reasons including the special pressures generated by the political environment in which transit service is provided (2-4). The high turnover rate underscores the importance of ensuring employee satisfaction and implies that there will always be a need to train newcomers to the industry.

These two inherent characteristics of the transit industry indicate that considerable attention should be given to the human resources involved in the provision of transit service. Reliable, quality transit service requires continuous investment not only in physical capital but also in human resources. However, examination of the industry shows that little recognition has been given to the importance of employee development. First, little money has been spent on training and professional development, and what has been spent is insignificant compared with yearly investments in capital facilities and vehicles. Second, employee development is an important organizational objective in few transit agencies.

Historical, economic, and political pressures provide an explanation of this neglect. First, historical developments, such as the 1934 Holding Company Act, forced the large electric utility companies to divest themselves of their transit holdings. The indirect impact of this was that the transit industry, already in decline, lost its access to the utilities' highly professional management as well as their ability to attract qualified new employees or develop existing human resources (5,p.424). Second, economic pressures resulted from the industry's decline during the 1950s and 1960s. As companies found it increasingly difficult to be profitable, all forms of investment, both physical and human, were forfeited.

Third, in the 1970s most transit operations became public and this often created a political environment. This has had a detrimental influence on employee development; highly political environments lead to crisis management and "fire fighting" and make it difficult for managers to give any rational thought to the needs of the organization and its employees. Furthermore, political environments tend to focus more attention on physical capital decisions than on human resources because of the implicit distribution of funds and power involved and because of their visibility. "Ribbon-cutting" for new rail construction or new buses provides more political visibility than investment in employee training, creating pressures that affect organizational priorities.

These historical, economic, and political pressures have led management of transit agencies and the providers of financial support (local, state, and federal) to neglect the important need for employee development. This lack of interest has, in turn, been reflected in the low level of involvement of the academic community in employee development activities. However, recent changes in attitudes have brought new interest in employee development.

Several factors indicate a growing recognition of the importance of the issue within the industry itself. Individual transit managers have put forth calls for more emphasis in the area (6,p.39). A large consortium of transit agencies was formed in the West to pool resources and provide training for member employees. The American Public Transit Association (APTA) is increasingly interested in employee development as reflected in the topics covered at its conferences.

There is also a growing interest among government agencies. For example, several state departments of transportation have expanded their technical assistance activities to provide training for managers, staff, and board members of public transportation agencies. These training programs, often organized in conjunction with universities or consultants, have involved a variety of topics, from exploring comprehensive approaches to managerial or board-member effectiveness to the teaching of specific skills such as risk management, scheduling, grants administration, or using microcomputers.

At the federal level, both UMTA and FHWA are increasingly involved in employee development. UMTA has initiated three important actions to promote employee development. It has encouraged the development of several training programs through research grants. It has considerably expanded the number of institutions endorsed for its fellowship support program. It has designated nine Centers for Transit Research and Management Development; one objective of these centers is to expand professional development opportunities. These three initiatives have resulted in a great expansion of employee development opportunities for the transit industry. FHWA has also become increasingly involved and has made training for managers and officials of small and rural transit systems a component of their regional technology transfer program.

This attention by both management and government has coincided with a period when many academic institutions are seeking new directions and has thus resulted in increased involvement of universities in transit employee development, in particular in the area of professional development programs. It is in this light that the experience of the Institute for Urban Transportation at Indiana University may provide a timely overview of the issues related to providing professional development for transit employees.

PROFESSIONAL DEVELOPMENT: EXPERIENCE AND ISSUES

Professional development (PD) programs offer considerable potential for universities to develop a more active relationship with the transit industry, and this has been proven by IUT's experience of the last 2 years. This experience has helped identify five important issues that affect the design of PD programs: choice of topic, choice of faculty, student mix, overall balance of program, and program logistics.

Choice of Topics

In designing a PD program one of the first problems to consider is the choice of a topic that is both relevant and feasible. Topics chosen for PD programs have varied widely. Some PD programs focus on a specific issue or area of study (e.g., financial management, labor relations); others focus on a specific segment of the industry (e.g., policy board members, middle managers) and the skills and knowledge these professionals need to perform effectively and efficiently. The methods by which topics are chosen also vary. For example, topics can be chosen through consultation with an industry-based advisory board, through interaction with specific agencies, through observation of current issues of concern to the industry, or through an assessment of relevant expertise that has been accumulated at the institution through teaching or research.

Given the large variety of academic institutions, it is not surprising to find such a variety of PD programs. This is a healthy development as long as two important criteria are kept in mind: relevance and feasibility. In assessing a potential topic it is important to consider its relevance to the transit industry. The purpose of PD programs is to serve the needs of the industry, and academics must be careful to avoid the pitfall of pursuing interesting but irrelevant paths. It is thus important to be sure proposed topics do in fact correspond to industry concerns. Working with advisory groups or specific agencies is one method of doing this. Another is to derive topics from program evaluations filled out by participants.

A related issue is the use of PD programs for disseminating research results. Although such programs can be effective mechanisms, they must be used carefully: the results of academic research need to be framed in terms that are relevant to program participants. It is thus necessary to step back and assess the purpose of the program and relate the program content to the needs of participants.

The second important consideration in choosing a topic is the feasibility of the proposed program. This essentially requires a realistic assessment of the expertise already present at the academic institution (e.g., faculty, staff, existing research, experience, knowledge of topic, previous experience with industry) as well as potential complementary outside sources of expertise. One must be realistic; if the topics chosen are not relevant or cannot be properly taught, the program is a waste of time and energy for all involved.

Choice of Faculty

When a program topic has been chosen and broken down into potential sessions, the next problem is to choose faculty for the program. This is a complex process of matching potential session topics to potential speakers. Potential speakers may include the faculty directly linked to the transportation-related academic institution, qualified professional staff of the institution, other faculty from the university who teach relevant topics, and outside speakers from the industry, government, or other academic institutions.

Ideally, one would want faculty who are interested in a relevant topic, who are familiar enough with transit to relate their expertise to the experience of participants, and who are challenging educators. Such persons are rare and one is often faced with a choice between having qualified faculty who may not be very familiar with the peculiarities of the transit industry and professionals from the industry who may not be very good educators. Establishing a balance is difficult: relating the program directly to the specific concerns of the transit industry is paramount, but creating a true developmental experience requires qualified educators. It is important to remember that a PD program is not just an industry conference; it should be an educational experience.

Student Mix

In choosing a topic to be developed into a PD program one also needs to determine which segment or segments of the transit industry are most likely to need, and be attracted to, such a program. One important but difficult issue is determining what type of student mix to seek. There is a definite trade-off between having a diversified but perhaps disparate group of participants and one that is uniform but more cohesive. In the first case one will try to attract participants from a wide range of locations, size of properties, and backgrounds. This may help broaden intellectual horizons, stimulate interaction, and enrich discussions but at the same time may make it more difficult to discuss specific skills and tools because the students' experience with them is so varied. In the second case, one will try to make the group more uniform by screening participant applications more thoroughly and thus avoiding the "odd" persons who stand out or are unable to follow the technical discussions. This trade-off is difficult to make and must be based on program topic, intent, and philosophy of the academic institution.

Overall Balance of Program

In designing and implementing a PD program one must be sensitive to the overall balance of that program. This is a somewhat complex issue of how participants perceive the program as an educational experience. Two dimensions seem to be particularly important in this delicate equation, methodological focus and pedagogical medium. Each of these dimensions involves a trade-off, and by considering these two elements simultaneously one can assess the overall balance of the program. This can be useful in differentiating PD programs and in evaluating their effectiveness.

Methodological focus ranges from a narrow focus on skills and tools to a broad exploration of perspective and processes. In its narrowest form, a PD program may focus on teaching specific skills and describing tools that help professionals solve the problems they face. The educational question being answered through such programs is "how?" Training courses exploring established planning methodologies (Urban Transportation Planning System), managerial tools (management performance audits), or the adaptation of new technology (computer applications) provide examples of focused activities. In such programs hands-on and nuts-and-bolts attitudes are essential because the intent is to provide practical tools to participants.

At the other end of the methodological spectrum, one finds PD activities that are intended to broaden intellectual perspectives and provoke thought rather than merely upgrade skills. The methodological focus is on the process rather than on the tools, and the educational question being answered is "why?" Executive development programs that explore the issues of decision making are fine examples. Comprehensive courses that outline all the aspects of the provision of transit service might also be considered process-oriented programs. In such programs it is important to avoid being either trivial or overwhelming.

A second dimension that can be used to assess a PD program is the predominant pedagogical medium. The content of a course can be conveyed by two methods: in a didactic mode, expertise and knowledge are conveyed in a primarily unidirectional process from expert to participant; in an interactive mode, learning by participants is accomplished by a multitude of communications and exchange among participants. In a more simplistic image this dimension represents the relative balance of lectures and case studies. There is of course no right or wrong position but a trade-off to assess; lectures are more efficient in a certain sense because they convey more information, are easier to develop, and correspond better to the usual style of faculty. On the other hand, in case studies, although less information can be covered, learning is more complete as is the developmental process for the individual.

The balance of a program should depend on the topics, intent, and type of participants. It also often depends on session topics, program schedule, and especially on personalities and styles of faculty. Using both dimensions, one can graphically illustrate the overall balance achieved in a given PD program as shown in Figure 1. Such a conceptualization is useful because it helps differentiate programs in educational terms. It also helps clarify the goals of the program, as perceived by participants, and thus provides guidelines for modifications to the program. It is obvious from this discussion that evaluation is an important function: A composite picture of the overall balance of a program can be obtained by gathering various types of input (written evaluations, oral evaluations, informal discussions, and perceptions of staff).

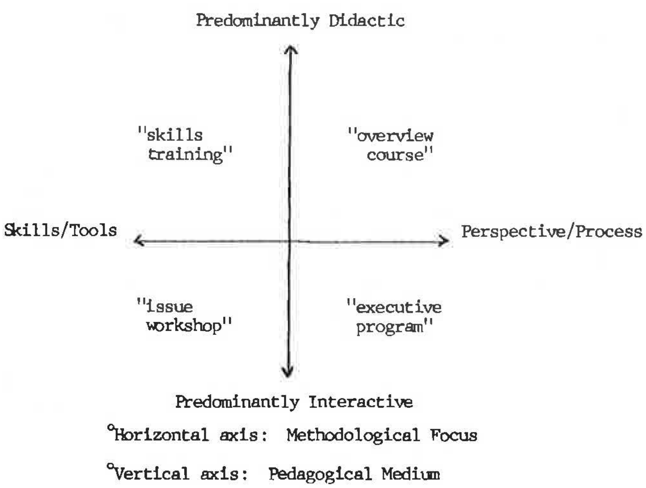

FIGURE 1 Overall balance of professional development program.

Program Logistics

Finally, amid all these pedagogical considerations, one should be aware of the logistic complexity of putting together PD programs and of the impact this will have on the overall success of the program. Program design is perhaps the most intellectually stimulating aspect of PD activities, but the most difficult part is the million mundane actions needed to carry out the planning, marketing, preparation, implementation, and evaluation of the program. These are what ensure a smoothly delivered program, one that provides a truly complete learning experience. An academic institution should carefully consider this often-neglected issue to determine if the benefits derived from putting together the program are worth the effort.

CONCLUSION

There is a definite need for increased employee development opportunities in the transit industry, and the academic community shares the responsibility for expanding these opportunities. Of the three types of employee development that were identified in this paper, apprenticeship training, continuing education, and professional development, the last category holds the greatest potential for enhanced involvement of academic institutions.

During the last 2 years many academic institutions have started offering professional development programs for the transit industry. Several key issues have been identified from the experience of the Institute for Urban Transportation at Indiana University. In particular, the choice of topic, the choice of faculty, the student mix, the overall balance of the program, and the program's logistics raise difficult problems in the design and implementation of a professional development program.

In spite of these difficulties, involvement in professional development activities is a stimulating experience. Such programs offer a unique forum of exchange among participants. The program brings together professionals from very different backgrounds and agencies in an environment isolated from their daily responsibilities. It provides the opportunity and time for them to exchange experiences, become familiar with the peculiarities of this industry, and especially to realize the commonality of the problems they face. To some extent this exchange function is as important as anything that is taught in the classroom.

Finally, academic involvement in professional development activities provides a unique mechanism for improving communications between the academic community and the industry and for overcoming existing barriers (7,p.5). Identifying relevant topics, addressing real concerns of the industry, and the direct exchange that takes place in and out of the classroom are real and practical mechanisms for establishing a dialogue. In the long run, this is a critical concern of both parties. The current increase in activity in the professional development area is a good beginning that will enable more stimulating interaction to be developed.

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Practical Application of Systems Models and Action Research: Training and Organizational Renewal

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ABSTRACT

Transportation agencies, like most public organizations today, are undergoing rapid and major changes that challenge their ability to adapt and function effectively. The University of Massachusetts/Institute for Governmental Services, training unit for the Massachusetts Department of Public Works (MDPW), has been helping MDPW meet the challenge of organizational survival and renewal. The use of systems models to understand the impact of change on MDPW, guide development of strategies for providing training to an organization in transition, and help MDPW personnel rebuild their capacity to cope with change is discussed. The Kotter organization dynamics model, a descriptive model that trainers used to gather information about MDPW and analyze the impacts of change on MDPW as an organizational system, is reviewed. The organization states model, a prescriptive model that proposes that trainers and managers must modify their usual problem-solving strategies when working with an organization in crisis, as was MDPW, is outlined. Using the models helped trainers establish the credibility and responsiveness of the program and secured the support of MDPW managers. To develop and deliver training, trainers used action research as their operational approach to working with MDPW experts, managers, and line staff and with FHWA officials. Action research stimulated organizational problem solving and change and assured that training met changing needs. How trainers have been delivering training to MDPW has been as important to organizational renewal as what training is offered.

Transportation agencies, like most public organizations today, are undergoing rapid and major changes that challenge their ability to adapt and function effectively. Meeting this challenge requires that organizations learn new survival skills and that training units adopt new approaches to delivering training and educational programming. It is increasingly important that training units help their organizations develop the ability to adapt, solve problems, and take more control of their own future.

The University of Massachusetts/Institute for Governmental Services, training unit for the Massachusetts Department of Public Works (MDPW), has been helping MDPW meet the challenge of organizational survival and renewal. Staff employed systems models to assess MDPW, to guide development of strategies for working with an organization in transition, and to maintain the training staff's ability to respond to MDPW's changing needs.

It is shown that, through an action research approach to planning and delivering programming, training staff are not only improving employee performance but are also helping MDPW develop problem-solving skills. How staff have been delivering training has been as important to organizational renewal as is what staff have been programming. Applications of the models and results of using the models in MDPW are presented.

BACKGROUND

Maintaining responsiveness to an organization in transition is a challenge to any training unit. It is a particular challenge when the organization and the unit are both undergoing major changes. Brief profiles of the MDPW, a changing organization, and of the Institute for Governmental Services of the University of Massachusetts, an external training unit, will provide a context for the applications of systems models and action research methodology.

MDPW

During the past 30 years MDPW has undergone significant organizational changes. Changes in national highway program trends and in federal and state influences on MDPW have significantly affected the organization's mission, staffing, resources, and power. In response to changing national trends, MDPW's mission now focuses on maintenance of highways and bridges and reconstruction of critical arteries. In the 1980s the organization has fewer resources, fewer employees, and less decision-making power than it had in the 1950s. Vignettes of MDPW's evolution follow.

1950s and 1960s

In the 1950s, in response to a national emphasis on construction of the Interstate system, MDPW's mission stressed the construction of state highways. To accomplish this mission, the organization operated with a comfortable budget and a full staff of 4,500-5,000 people. The organization was proud of its capacity to build highways and attract engineers to adequately paid, professional, and secure positions. Through the 1960s MDPW was powerful. The nature of its federal funding gave autonomy from state budget problems; the department made its own decisions and set its own course with little or no direction from the governor's office. By the late 1960s, however, public groups were banding together to challenge the location of major highways, and the federal government was beginning to stress a balanced transportation program. This meant that highway divisions had to share funding with public transit divisions.

Changes in staffing patterns occurred in the 1950s. Since that time the department has hired few young people at entry-level positions. Civil service restrictions and competition from private sector organizations and other state departments of transportation (DOTs) offering higher wages contributed to this change. As a consequence, MDPW has lost the age diversity that allows an organization to maintain its adaptability.

1970s

By the 1970s the national highway program emphasis on highway construction was coming to an end. Budget cuts left MDPW with 3,400 employees, the majority nearing retirement. When consultants took over many tasks, ostensibly to save money, employees resented the change, believing that MDPW personnel should continue doing the tasks and maintaining their skills. The power balance changed as the governor's office, working through a strong state secretary of transportation, set policy and MDPW responded.

1980s

During the 1980s the nation's highway departments have been experiencing major changes related to an increasing emphasis on public transit, rapid deterioration of highways and bridges as a result of high volumes of traffic, and increasing need to plan replacement of significant numbers of retirees. In addition to coping with these issues, MDPW has felt the impact of Proposition 2 1/2, the state's local property tax limitation law, and of the turnover of all railroad bridges, many seriously deteriorated, to the department.

Changes in MDPW during the last 3 years have been particularly severe. The department has lost its sense of purpose and its decision-making power and has experienced budget and critical staffing cuts that affect the organization's capacity to respond to federal mandates and to critical service needs.

There is growing recognition that maintenance of highways and bridges should be the department's priority. Although there is some federal funding for the maintenance-focused Four-R program, it is not sufficient; this is a major change from the well-funded emphasis on highway construction.

In 1981 budget cuts eliminated many resources and forced termination of about 1,100 employees and demotion with pay cuts of 500 more. As employees, primarily young newcomers, were terminated, the average age of personnel rose to 57. The cutbacks and loss of critical skills made it necessary to contract out more work at all levels of operation. Morale, already low, plummeted as the department lost its decision-making power to the governor's office. Despite the layoffs and constant shifting of personnel necessitated by demotions, the MDPW was expected to continue doing its job.

Currently, department managers are working with a new governor, a new secretary of transportation, and the FHWA to rebuild and refocus the organization. Slowly MDPW is rehiring to achieve a staffing level of 3,123. By hiring 100 junior civil engineers with engineering degrees, the organization hopes to increase its technical competence and decrease the average age of employees, presently 57 years. Managers and federal highway officials are concerned with planning for replacement of retirees with critical skills and with developing adequate staffing of critical functions.

In 1984 the department will face many new challenges including the orientation and integration of new employees; a move to a new, modern, central office building equipped with new information processing technologies; and a realignment of the organizational structure.

Institute for Governmental Services

The Institute for Governmental Services links the educational resources of the University of Massachusetts with practitioners in public agencies to improve the functioning of state government. For more than 13 years the institute has delivered management and supervisory training to state agency personnel, carried out research, and produced publications.

In 1980 the MDPW obtained FHWA funding and contracted with the institute to manage, develop, and deliver statewide education and training programs for MDPW employees at all levels. Institute staff, experts in training and education technology, were to serve MDPW as an external training group, maintaining their own office at the university.

The staff, working with MDPW advisors and state community college personnel, established an Associate in Civil Engineering Technology degree program at several of the colleges. In response to a training need assessment conducted at MDPW in the 1970s, staff also delivered a series of generic management and supervisory training programs. The offerings reflected the institute's emphasis on traditional supervisory courses.

The new training program experienced a great deal of resistance from MDPW managers and employees who were not accustomed to either organized department-wide training programs or supervisory training. Training had previously been developed by various in-house training officers who put together sessions on technical subjects for their own divisions.

In late 1980 MDPW advisors indicated that a focus on technical and engineering skills would serve current needs better than the supervisory training. They wished to continue some supervision courses so that all managers and supervisors would be trained, but requested a change in emphasis for the next year. In early 1981 MDPW established three advisory committees that identified training needs in supervisory, clerical, technical, and engineering areas.

The new focus signified major changes for training staff. In offering supervisory training, staff drew on their own expertise and delivered courses that they had designed largely on their own. Presentation of technical skills courses required a different type of expertise and a different mode of working with MDPW. To develop skills courses, staff would have to work closely with MDPW technical and engineering experts. Thus the style of operation became a highly participative one.

This change and two others, which occurred about the same time that MDPW was experiencing organizational upheavals, significantly affected the evolution of the training program. In late 1981 MDPW assigned a new monitor to work with the institute training team. The new monitor adopted a problem-solving approach in working with staff to realign programming with MDPW's changing needs. Training staff have relied on their monitor's guidance regarding sensitive issues and policy matters, on his sense of the MDPW organization, and on his excellent support. By 1982 this monitor and the program were located in MDPW's Personnel Department; this increased the potential for closer ties with other personnel functions.

Also in late 1981 training staff began involving their FHWA monitor as a training resource person. Because FHWA was conducting an adequate staffing study of MDPW, the FHWA monitor had valuable ideas to contribute about critical skill needs and departmental units that required strengthening. In 1982 this monitor began attending training programs and, in some cases, participating in the classroom activities. He has been very helpful in planning and resource identification roles.

SYSTEMS MODELS AS PROGRAM DEVELOPMENT TOOLS

To plan and work effectively with an organization undergoing rapid change, training staff needed some models for examining the complex events. Models provide frameworks for understanding and interpreting vast amounts of data and complex interrelationships. Systems models enable trainers to gather information about organizations, examine information and events systematically, understand the impact of events on each other, and develop appropriate plans or strategies for a given organization or situation.

The institute training team employed two systems models to (a) analyze MDPW, (b) develop strategies for working with MDPW and for maintaining flexibility and relevance of programming, and (c) plan modifications of their programming and role as trainers. Further, they used the models to maintain perspective on organizational events and changes and recognize opportunities for helping MDPW stabilize itself. The two models were (a) Kotter's organization diagnosis model that examines organization dynamics and the impacts of change and (b) an organization states model focused on characteristics of organizations in decline and crisis.

In the following sections the models are described, how training staff applied the models is explained, and changes the staff made as a result of using the models are reviewed.

Kotter Organization Dynamics Model

Training staff used the Kotter organization dynamics model to understand MDPW as it went through a critical period and to reassess the organization as it emerged from the depths of a crisis. Applying the model as a diagnostic tool, staff developed a picture of MDPW and prescribed appropriate actions and stances for the training team vis-à-vis MDPW. The components of the model are described next.

Outline of the Model

The Kotter model provides a framework for collecting and examining data over a wide range of organizational dimensions. As shown in Figure 1, this systems model employs six structural elements and a set of key processes (1). It explores the dynamic interactions of the elements and the key processes and sets forth criteria for assessing organizational effectiveness.

This descriptive model is most useful as a tool for identifying organizational strengths and weaknesses; planning changes; and identifying the systemic consequences of changes over short, moderate, and long time periods. The model proposes the following six elements:

1. Employees and other tangible assets: the size, number, and characteristics of an organization's employees, plant, offices, tools, equipment,

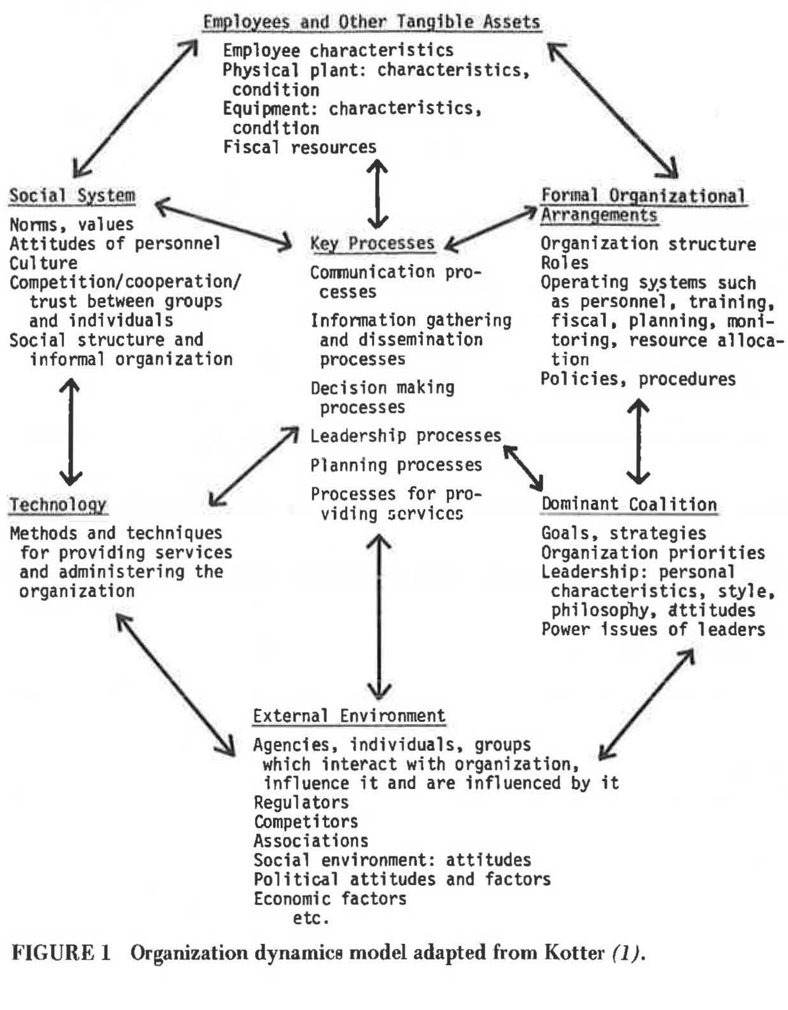

FIGURE 1 Organization dynamics model adapted from Kotter *(1)*.

land, and money. Includes such factors as employee age, ability, and training.

2. Formal organization: the formal systems (such as hierarchy, structure, roles, personnel functions, training, fiscal functions, resource allocation) that regulate the organization's employees and machines.

3. Dominant coalition: objectives and strategies, characteristics of leadership, and relationships among those employees who engage in policy making and oversight of the organization. Examines power issues.

4. External environment: includes task environment individuals or agencies such as suppliers, clients, competitors, regulators, and associations that affect the organization's products and services. Also includes wider environmental factors such as public attitudes, economy, politics, social views, and so on.

5. Technology: includes major techniques or technologies (such as maintenance management systems, computers, patching techniques, and so on) that employees or machines use to carry out organizational processes.

6. Social system: involves the organization's culture with its norms, values, attitudes, and relationships among individuals and groups.

The key processes, the central element in this system, affect the six elements described and are affected in turn by the condition of each element. The key processes include the organization's information processes such as communication (How do people communicate? Is communication effective?), decision making (Who makes decisions and how?), information gathering and dissemination (How do managers gather information from employees or from the public? How do they inform people? How do they use information they gather?), and energy transformation processes such as service-providing strategies (e.g., snow and ice control, maintenance). The effectiveness of the key processes is a crucial indicator of the organization's short-term operational health.

Figure 2 shows some examples of MDPW data in the Kotter model categories. The data shown might be typical of issues confronting many state highway departments.

By collecting information about each of the elements and the key processes, a trainer can develop a basic picture of an organization at a given time and can identify potential problem areas, strengths, and weaknesses of the organization and of the trainer's knowledge of the organization.

A basic picture of the organization, although helpful, is only a beginning. By examining the impact of structural elements on each other (for example of environment, employees, technology, and social systems), it is possible to observe the dynamics of an organization as a system, to identify systemic problems, and to forecast the consequences of creating changes in any part of the system. For example, as a result of external legislative decisions or changing state revenues, the organization may have lost employees with the critical skills re-

Employees and Other Assets

Average age is 57
Present staffing about 2900, desired 3123
Skill levels inadequate for technological needs
Move to new central office in 1984
New office will have new info technologies
Maintenance equipment in poor condition

Social System

Different norms and culture in central office and districts
Lost pride in work and in Department
Many people want to see DPW strong again want to be professional
Rumors rampant

Key Processes

Communication at all levels and between all divisions poor
Info processes are being examined and new technologies considered
Those with on-line info don't often contribute to decisions
Administrative processes being studied for improvement
Snow/ice control processes changing in response to environmental concerns

Formal Organizational Arrangements

Central office + 8 dists., maintenance depot, lab
Board of commissioners, chief,deputy chiefs, Directors, DHEs
Chief's span of control too large for effectiveness
Freq. discussion of reorg.
New managers reorganizing some divisions
Policies, procedures outdated in process of review

Technology

Computer systems will change with move to new building
Wordprocessing new, not integrated into organization
Maintenance management system resisted; is under review
Salting/sanding techniques being reexamined
Difficult for DPW to keep pace with new technologies

Dominant Coalition

Bridge maintenance a priority
Construction of central artery and third tunnel priority
Four of five commissioners and chief new in 1983
Leaders emerging

External Environment

Considers relationships,influence, power issues with: Federal Highway Administration
Governor/Secretary of Transportation
State Legislature, individual legislators
Public and public interest groups
Environmentalists
Unions, local DPWs
Contractors, consultants, associations etc.
Considers impact of: Highly political state
Economic conditions, Proposition 2½
Potential employees' desire to work at DPW at state salary levels
etc.

FIGURE 2 Examples of MDPW data in the Kotter model.

quired to operate the type of technology or equipment that the organization uses to achieve its goals. This may affect the organization's social system, creating an image of the organization as weak and ineffective and lowering morale. Trainers may be aware of such interrelationships, but the model makes them explicit and frequently identifies connections or consequences an observer might otherwise overlook.

Kotter proposes three time frames for understanding organizational dynamics, short, moderate, and long run:

1. Short run (present time to 6 months): In short-run dynamics, the cause-and-effect relationships among the six structural elements and the key processes are the main focus. Although each key process can affect each element and vice versa, the total system of structural elements influences any one cause-and-effect relationship. For example, if the dominant coalition does not have good decision-making skills or if external authorities take over decision-making responsibilities, the key process of decision making would be weak and ineffective. The consequences of this relationship would be reflected in all other elements: in a poor image of the organization by employees and the public, in weak organizational systems and poor accountability measures, and so on.

2. Moderate run (6 months to 6 years): In the moderate run, the alignments or consistencies between the six structural elements alone are of major concern. Here the issue is whether the structural elements are aligned (consistent, congruent) or nonaligned (in opposition). For example, if the organization does not develop an adequate staff of trained, skilled employees who can implement the technologies the organization must use, employees and technology will be nonaligned and the organization will be spending its resources and energy ineffectively. Nonalignments sap energy from the organization and ultimately interfere with the success of short-run improvement strategies. Serious nonalignments over a long time can result in decline or demise of the organization; this condition typifies the MDPW.

3. Long run (6 to 60 years): In the long run, the major concern is again with the six structural elements. This time, however, the model focuses on the adaptability of the elements and their relative potency as driving forces within the organization. The driving force is that element that seems to have most influence on the growth and development of the organization over a period of time. Factors in the external environment have become the driving force for many public agencies. It is important to ask whether the organization needs to develop a different driving force to become more effective or regain its health. Perhaps the dominant coalition should take back control of the organization from the external environment.

In the long run, it is important that organizations have flexible, adaptable elements to respond more effectively to changes and turbulence. When an organization's elements become nonadaptable or rigid, the organization is less likely to be capable of adjusting to new demands. Some examples of rigid elements are outdated or poorly maintained technology and equipment; lack of trained personnel; lack of age and talent diversity in staff; and failure to revise mission, roles, and procedures. After assessing the adaptability of elements, it is necessary to improve the flexibility of rigid elements.

The Kotter model can help trainers and managers identify problems and forecast the consequences of solutions or changes. When trainers or managers develop strategies for organizational improvement, whether it is training, structural change, or introduction of new technologies, they must examine the consequences of the strategies for the short-run relationships and the alignments and adaptability of elements. They must assure that they are not creating serious new problems with their strategies.

Use of the Model at MDPW

Using the Kotter model to learn about MDPW, institute training staff developed a systematic and realistic view of the organization and of the training team's capacity to serve it effectively. They observed why the organization was in crisis, noted the complex interrelationships underlying the crisis, identified where the power and influence for change lay and what might occur as changes were made. These observations suggested strategies for working with MDPW.

As MDPW emerged from its most critical period, training staff reassessed their picture of the organization. They determined that their training strategies were helping MDPW develop and maintain the adaptability of some of its structural elements, for example:

1. Employees: increasing job-related skills through training and education programs.
2. Dominant coalition: increasing awareness of effective management and supervisory techniques and practices.
3. Technology and equipment: increasing maintenance skills and potential for improved maintenance; increasing knowledge of the use of technology.
4. Social systems: providing support to managers and supervisors during layoffs, checking rumors and feeding back facts to people in the training programs, improving employee self-perception and morale by helping employees develop new skills.

Training staff will continue to use this model to gather information about MDPW, reexamine the organization as it continues to change, and plan appropriate training strategies. Staff have introduced the model to FHWA officials and some MDPW managers as a tool to use as MDPW rebuilds and renews the department.

Organization States Model

After examining descriptive data about MDPW as an organizational system, training staff employed a prescriptive model to identify the appropriate behavioral strategies to use with an organization in a particular operational state. They applied a new organizational states model to characterize MDPW's operational state and the team's state and to forecast the strategies the team could most effectively use with MDPW.

The organization states model provides a framework for identifying organizational environment and behavior characteristics that typify certain states of organizational evolution and suggest intervention strategies. The model proposes three states or conditions--status quo, problem solving, and fabric crisis--that may characterize an organization at particular points in its evolution. Each state is represented by a continuum of stages ranging from positive to negative. Organizations may evolve from one stage to another and from one state to another.

Each organization state is characterized by a definable type of organizational environment and behavior. The characteristics have implications for trainers and managers because strategies that work in organizations in one condition may be inappropriate or ineffective in organizations in another condition. This suggests that trainers need to determine what state and stage their organization is in and what it is moving toward. The status quo, problem-solving, and fabric-crisis states are characterized next.

Status Quo

The status quo state typifies bureaucratic organizations that may need to change their operations but prefer to stay the same, fear change, or suffer from inertia. Organizations in this state respond in primarily reactive ways to environmental demands and problems. Under stress, the organization may adhere to rules, procedures, and rigid accountability measures as a means of maintaining control of its environment. Employees may see the organization as stable, predictable, sterile, rigid, slow to respond, and outdated.

Problem Solving

In contrast, an organization in a problem-solving state actively responds to internal and external demands. The organization uses problem-solving methodologies to cope with and control opportunities; problems; and difficulties of growth, operations, or existence in a particular environment. Organizations in this state have the capacity and energy to examine themselves, develop corrective strategies, and plan for their future. Employees might describe their environment as flexible, adaptable, creative, unstable, and unpredictable.

Fabric Crisis

Organizations in the fabric-crisis state are in some stage of decline or disintegration. In the most severe stages of this condition, the fabric of the organization--its mission, structure, norms, and culture--is being torn apart. A large number of the organization's vital systems are in questionable repair, and the organization is fighting for survival. Overwhelmed by its own deterioration, the organization lacks the energy or capacity to redirect or realign itself. Employees might describe their environment as paralyzed, demoralized, out of control, or dying.

The model proposes that organizations can move from either status quo or problem solving into crisis. A status quo organization might move into crisis because, to use Kotter's terminology, it lost its adaptability and capacity to respond and so was overwhelmed by new demands or changes. A problem-solving organization might move into crisis because it tried to adapt or change too many aspects without returning to a stage of status quo to stabilize the change. Even a healthy problem-solving organization may be overwhelmed by massive change.

An organization in the early stages of fabric crisis might enter problem solving as a means of renewal; or it might restabilize and accept a constant crisis state as its status quo. Trainers and managers must learn how to help their organizations move from one stage to another and from one state to another.

Crisis State

Because many public agencies are facing crisis conditions, the model focuses on the crisis state. It suggests that employees in organizations in crisis and the organizations themselves suffer deep morale problems and loss of energy and capacity to help themselves. The process of organizational decline reflects the stages of death and dying described by Elisabeth Kubler-Ross: denial, anger, bargaining, depression, and acceptance (2).

When employees and organizations are experiencing denial, anger, or depression, rational problem-solving and planning techniques normally used by trainers to solve organizational problems are not, by themselves, effective. The environment is an emotional not a rational one. Thus for organizations in a crisis state, strategies must include nurturance; development of support systems for individuals and work groups; and, at a later stage, rebuilding the capacity to respond and take control of the situation. The role of the trainer is, at first, that of counselor, listener, and healer. Then, to prevent employees from wallowing in negativity and paralysis, the role changes to reality counselor and problem solver.

As institute training staff applied the organization states model to MDPW and to their own team as an organization, it was apparent that MDPW had been moving through stages of fabric crisis for some time, but the team functioned in a problem-solving state. To increase their effectiveness, training staff modified the rational problem-solving strategies they normally used and drew on their experience as counselors and nurturers. They continually reassessed MDPW's state and adapted their strategies to help the department move to a healthier stage or state.

RESULTS OF APPLYING SYSTEMS MODELS

The training team used the Kotter and organization states model to modify their own roles and to reorient the training program. As a result of the changes they made, the team created a more effective and responsive program and gained support of the organization for their activities.

Modification of Training Staff Roles

During the period of rapid change and declining morale within MDPW, the training team's role as external trainers became somewhat problematic. Their location in an office outside MDPW allowed training staff to maintain perspective on the turbulent situation, but it also isolated them from sources of information about changes. It was critically important for training staff to remain informed about changes and aware of the tenor of MDPW's organizational environment, because these factors affected programming, sometimes seriously.

To increase information flow and improve the team's ability to respond to MDPW, training staff increased their linkages to MDPW and their visibility within MDPW. They accomplished this in three ways.

First, they located their program assistant, responsible for academic programming, at MDPW 3 days a week. This immediately improved the quality and quantity of information sharing between the two organizations and increased the visibility of the training program. Employees could more readily ask questions about the program, give feedback about it, and discuss MDPW issues. Increased information and feedback helped staff get a better sense of the impact of changes in MDPW on the program and allowed them to respond more effectively. Training staff were able to experience MDPW's culture and events firsthand. This provided a better perspective on the organization and on more effective ways of interacting with it. The change in staff location and in perception of training staff as "internal" external trainers has significantly affected staff responsiveness, increased participation in programming, and made the program a real part of MDPW.

Second, the program administrator and training coordinator increased their visibility within the department to offer support to employees. Following the organization states model, these staff made themselves available as counselors who helped by listening, facilitating problem solving, and bringing a positive perspective. Employees began to see that staff cared about them as individuals and cared about helping the department. Consequently, employees began sharing more information and discussing organizational issues they previously would not have discussed with the training staff. One manager invited staff to attend his division's meetings to learn more about MDPW's work. The increased visibility and supportive interactions helped move the training team further into the organization and helped develop MDPW's trust in the team.

Third, staff members took a more active part in MDPW's informal communication system, attempting to reduce rumors as much as possible. Because staff were in class with employees several times a week, they checked rumors heard in class and reported back to class members on what was learned.

As a result of these changes in the training team's role, training staff were no longer seen as external consultants but rather as staff who "belonged" to MDPW. This significantly increased contacts between the training staff and MDPW, which led to improved information about organizational and training issues and more relevant programming.

Modification of the Training Program

Training staff realized that the training program provided a critical means of rebuilding MDPW's morale and ability to survive as an organization. The program could, in Kotter's terms, affect all MDPW's elements and key processes. Staff also knew that training was the only reward the department could then offer. As a strategy, staff changed the focus of training and expanded employees' opportunities to participate in training activities.

New Focus for Training

Drawing largely on the organization states model, training staff focused short-run training on improvement of morale. They increased the number of courses that would give employees opportunities to strengthen their abilities to cope with changes and to accomplish basic tasks. Most important, they scheduled a series of stress management seminars for all levels of personnel and made available books on stress. They offered highly practical programs such as typing and report and letter writing to develop skills employees could use immediately. Working closely with instructors, staff tailored a supervisory course to examine issues of leadership and planning in a crisis environment and motivation under stressful conditions.

Generic training was no longer appropriate for MDPW. To assure that all courses reflected methods of coping with the environment in a positive manner, staff discussed the new emphasis with instructors and structured courses to reflect that emphasis.

Increased Opportunity for Participation

Despite the possibility that understaffed units might not be able to send trainees and that classes might not be filled, training staff continued to offer classes as usual. However, they changed the training format from 10-week sessions on one topic to predominantly 1-day sessions that placed fewer time demands on trainees and their units.

Training had previously been offered at a few central sites. To improve the opportunities for district employees to attend training, staff began taking programs to individual districts. In some cases, training staff developed and delivered special programs to meet the needs of the more distant districts. This enhanced the perception of the program as responsive to needs.

As a result of the reevaluation and modifications of the program, employees came to class with increasing willingness. Attendance improved despite many problems in trainees' offices. There was significantly less resistance to training than there had been in the early days of the program, and the credibility of the program and staff increased. Managers began requesting specific programs for their employees.

Summary

In summary, systematic analysis of MDPW, using the Kotter and organization states models, helped training staff realign their roles and the programming for MDPW. The models clearly provided direction and control in a time of great turbulence; they facilitated effective decision making by the team. Without this guidance, the training team itself might have moved from a problem-solving state to a stage of fabric crisis. In such a state the team and the program would have been of little value to MDPW. Instead, the foundation laid during the critical changes of 1981 has strengthened the ability of the training team to help MDPW move from crisis toward restabilization.

ACTION RESEARCH APPROACH TO TRAINING

Systems models helped staff understand MDPW and their relationship to MDPW within a dynamic systems context. The models facilitated the forecasting of various intervention strategies and prescribed appropriate approaches for staff to take. But implementation of the plans and strategies suggested by the models required an operational strategy for working within MDPW. This approach had to be consistent with MDPW's and the training team's organizational states and with the training staff's style and assumptions about organizations.

Training staff predicated their operational strategy on their beliefs that an organization (a) can, with assistance, identify and solve many of its own problems; (b) has many human resources capable of facilitating change or teaching others their expertise; and (c) should "own" its education and training programming through participation in its development and delivery. Further, a participative process was critical because training staff offered expertise in training technology and organizations, and MDPW staff offered expertise in technical areas and knowledge of their own agency. The approach that best serves these assumptions is called action research. A form of action research thus became the basis for the training team's responsiveness to MDPW, for the relevance of the training, and for some organizational change related to training.

Action research generally involves the following steps: structured information gathering about an organization's problem areas and needs, feedback of the information to groups of employees, analysis and prescription for action, action, and evaluation and feedback into new assessments of needs and issues.

Action research involves members of the organization in defining their own problems and needs and in determining what actions should be taken to resolve problems. At each step organization members may influence and modify action steps. The process helps organization members learn how to carry out information gathering, problem solving, and action step processes on their own. This helps create and maintain a healthy problem-solving organization.

Training staff use the action research approach to identify training and education needs, develop programming, help MDPW establish systems that support use of newly developed skills, and strengthen organizational problem-solving skills. Training staff's use of action research and the results they achieved are described next.

Identifying Needs and Developing Courses

To identify needs, training staff engage in a multistage information-gathering process. They interview MDPW managers, supervisors, foremen, and laborers about needs, then work with ad hoc advisory committees to refine needs and develop course outlines. To gain additional perspective, staff discuss training issues with their FHWA monitor.

Identification of Performance Problems

Initial discussions focus on task areas in which MDPW employees are not performing as well as they should. As the discussion continues, in committees composed of a representative group of MDPW task experts, the job tasks are examined in detail and reasons for poor performance are explored to determine what factors other than skill deficiencies may contribute to the performance problem. With input from the committee, staff define the extent of the performance problem: who is affected, what units or divisions are affected, and how. This analysis may lead to a prescription of different types of training for different levels of personnel to assure a change.

Staff always ask, "If we train people, what will prevent them from using their new skills?" Because of their organizational diagnosis work with the systems models, staff already have some ideas about what the barriers might be and how serious they might be. This analysis may show that training will only be successful if combined with changes in organizational policies, procedures, or structures. It may also suggest the need for improved communication between central office and districts. In such cases, training staff discuss the committee's findings with appropriate managers and recommend action.

Course Development

Training staff may involve advisory committee members or their FHWA monitor in course development and instruction in order to tailor courses to needs. In developing a contract negotiations course, staff worked with an MDPW expert to define the course, create MDPW-specific handout material and simulations, and instruct the class. The FHWA monitor participated in the course, modeling the steps he wanted MDPW negotiators to follow.

Examples of the Action Research Approach

Training staff have found the action research approach extremely useful for creating successful training and education programs. The approach not only helps develop relevant programming, it also prepares the organization to support programs and reinforce use of new skills. Three examples of the use of this approach follow.

Action Research Approach to Technical Assistance

Training staff employed the action research approach in responding to a manager's request for training assistance. The manager identified a potential problem with his clerical personnel and invited training staff to diagnose the situation and deliver appropriate training.

Staff first met with clerical supervisors to elicit their views of the situation, then proposed that they meet with clerks to expand the perceptions of the problem. Subsequently, staff conducted an information-gathering session with clerks to determine what they saw as issues and concerns and what solutions they envisioned. With all this data in hand, training staff summarized responses, identified potential problem areas, and suggested both training and organizational change activities. They presented their findings and recommendations to the manager and supervisors and then to the clerks.

Training staff then developed a series of training activities to meet needs identified by the clerks and supervisors and provided assistance with organizational change tasks. The manager supported the training effort, writing to all trainees to encourage them to use what they had learned and praising them for changes he had noticed.

In this example, the action research approach involved department personnel in identifying their own problems and prescribing solutions. Training staff facilitated the gathering and sharing of information that was available in the system but that was not in the open where it could be used. Staff provided follow-up training and resources that not only improved performance skills but also improved teamwork.

Action Research Approach to Course Design and Organizational Change

The most exciting application of action research at MDPW is training staff's use of a foreman advisory committee to develop courses and stimulate organizational change in the maintenance division. Because of the committee's efforts, resistance to foremanship training has been reduced significantly, policies are being changed to support use of skills, and methods of improving communications between management and the labor force are being instituted.

Establishment of a Committee

Working with the assistant maintenance engineer, training staff established an advisory committee comprised of the engineer and various levels of foremen from different districts. Two men selected for their expertise were also union officers. The committee's task was to help training staff define training curricula for foremen, bridge carpenters, and equipment operators.

At their first meeting, the committee said the foreman's job description had lacked definition for some time because of increasing contracting of labor functions and an unclear department mission. It was necessary to define the foremen's role before developing training. The foremen believed that other states defined maintenance workers' roles well and ran effective maintenance operations; they indicated they would like to learn how other states accomplished this and outlined what they wanted to learn.

Consequently, training staff, working with the assistant maintenance engineer, arranged meetings with the Maine Department of Transportation (DOT) and New Hampshire Department of Public Works and Highways maintenance division staffs. The foremen planned premeeting information packets that they exchanged with the other DOTs and planned the meetings themselves. In each state, MDPW advisory committee members met with their counterparts to discuss staffing, job descriptions, and maintenance operations and problems. Training staff observed the meetings and gave the foremen feedback on their meeting-management skills after each session. On returning, the group discussed what they had learned and made recommendations about MDPW foremen's roles to an MDPW personnel committee.

Development of Courses

Having redefined the foreman's role, the advisory committee met frequently with training staff to outline topics for the foremanship course, prepare materials for the class, and learn instruction skills. Other foremen were added to the committee to increase district representation and include potential instructors.

While developing course content, the committee identified inconsistencies in MDPW policy and procedures that would conflict with desired foreman performance. The assistant maintenance engineer, who was promoted to deputy chief of maintenance during this process, assured the group that he would revise policy and procedures. The process of developing the foremanship course thereby led to identification of problems, proposal of solutions, and action that resulted in organizational changes.

Creation of Change

After developing the curriculum, the committee considered how to introduce the course in a manner that would encourage support of the program. Historically, all levels of foremen had resisted training. The committee and the deputy chief knew the program would succeed only if the supervising foremen recommended it to their subordinates and supported the techniques being taught. So the committee worked with training staff to plan preview sessions for the supervisory foremen so they could experience the program and give feedback on it before it was offered to their staff.

The preview sessions, attended by the deputy chief, were critical events. In action research terms, the sessions expanded participation in the course development and acceptance process by "checking out" the proposed program with the people it would affect. The sessions stimulated discussion of maintenance problems that MDPW managers had not previously heard about and provided foremen an opportunity to talk directly with their division chief.

The dialog resulted in (a) agreement that maintenance foremen should meet with the deputy chief twice a year without their maintenance engineers, (b) request for statewide standard operating procedures that would eliminate inconsistent maintenance operations, (c) recognition that central office knew and understood district problems and was willing to make changes, and (d) support for the foremanship training.

Because the programming was being developed by an MDPW committee with the guidance of training staff, it was seen as a relevant grass-roots program. The potential for change in operations was seen as positive because the changes were suggested by MDPW employees as part of a problem-solving approach. They were not imposed from above or from the outside.

This example illustrates the power of an action research and training approach to create organizational change and acceptance of needed training programs. This approach requires more time and energy than traditional curriculum design and delivery, but its benefits are greater and longer lasting.

Action Research Approach to Education

In addition to using action research to plan training, staff have used the approach to plan educational programming.

After conducting a questionnaire survey of employees' educational needs, staff set up meetings to further assess the needs of employees interested in civil engineering technology courses. The meetings included MDPW employees, community college representatives, and training staff. Meetings were structured to inform MDPW employees about academic programming and the kind of commitment that participation in the programs required, and to help the college and training staff carefully define the diverse needs. Through group identification of issues, staff were able to propose courses of action that met needs of beginning, intermediate, and advanced students. This approach provided the maximum amount of information about programming, needs, commitment levels, and potential problems and stimulated a variety of suggestions for programming.

Summary

Training staff chose to use action research as their operational strategy for working with MDPW and implementing interventions suggested by the systems models. The use of action research in an organization recovering from a crisis state has proved particularly appropriate.

Use of the action research approach has helped rebuild morale and organizational pride. Those who participate on advisory committees learn they can take control of parts of their organizational life and contribute to progress and renewal. They are recognized for the programs and changes they create. Those who attend training programs and watch their peers instruct take pride in the expertise available in the department. Action research helps rebuild the skills and confidence of the organization and, most important, develops the organization's problem-solving capabilities. These skills can help lead the organization back to a vital state.

Further, use of action research has (a) assured that training and education programs meet real needs, (b) created organizational supports for training, and (c) stimulated organizational change in areas that systems models suggested were weak.

In addition to strengthening MDPW, the approach has prompted a very effective relationship between training staff and MDPW. It has allowed trainers to combine their training and facilitation expertise with the technical expertise within the organization. Thus training staff and the organization are working cooperatively to help MDPW develop its capabilities and achieve its potential.

IMPLICATIONS

The systems model and operational approach described in this paper helped the Institute for Governmental Services training team provide appropriate training and education programming to MDPW while the organization was undergoing major changes. The models offered frameworks for assessing MDPW and planning how best to serve and work with the organization.

Given the complexity and instability of MDPW's environment, how training staff delivered training became as important as what they delivered. It was critical that staff stop action and reassess not only MDPW but also their own team organization and roles vis-à-vis MDPW. The constant reassessment engaged in by the training staff helped maintain their flexibility and responsiveness to MDPW's needs. To use both Kotter and organization states model terminology, the training team needed to maintain the adaptability of its own elements and to engage in problem-solving processes to continually realign itself with MDPW's changing status. This reassessment and realignment must continue as MDPW emerges from crisis and restabilizes.

As part of their responsibility to MDPW, training staff are attempting to help that organization develop and maintain adaptability and strengthen survival skills. To do this, staff employ a form of action research that involves groups of organization members in all phases of training from needs assessment through program delivery. Using this approach, which stresses problem identification and resolution, staff are helping strengthen the organization's ability to solve problems and take control of its own future. In times of rapid change and organizational transition, this may be the most important survival skill a training unit can develop in an organization.

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Inexpensive Travel Demand Model for Small and Medium-Sized Cities

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ABSTRACT

A simplified travel demand model that uses routinely collected traffic ground counts to forecast traffic volumes on a street system is described. It is an internal volume forecasting (IVF) model based on a model first proposed by Low in 1972, and incorporates improvements suggested by Smith and McFarlane in 1978. The model is applied to the city of Spokane, Washington. Results from this application indicate that routinely collected traffic counts in a base year can be used to estimate traffic volumes in a horizon year with reasonable accuracy. By eliminating the need for a home-interview survey, the model provides an inexpensive, quick, and transparent technique for forecasting travel in small and medium-sized cities. The model is also suggested for use in cities of less developed and developing countries because of its simplicity and low cost. The output from this model is essentially trips for all purposes. Home-based, non-home-based, and other trip categories could also be obtained with additional data.

The main objective of transportation planning is to provide the information necessary for making decisions on when and where improvements should be made in the transportation system and for controlling travel and land development patterns that are in keeping with community goals and objectives (1,pp. 8-9). One of the most important pieces of information, which is crucial for such decision making, is horizon-year traffic volumes on the major links of a city's transportation network.

Conventional urban travel demand models, which are currently used to forecast horizon-year traffic volumes, have been the subject of much criticism because of their enormous costs, a significant proportion of which is spent on the collection and analysis of large amounts of data by means of a home-interview survey, for example. These data-hungry models also require extensive computer use for analysis, which further adds to their cost (2-4). Small and medium-sized cities usually lack the financial resources and expertise that are needed to use these models. In 1972 Low proposed an inexpensive travel demand model that used routinely collected traffic counts as a substitute for the conventional home-interview survey (2). Low's model has since been modified, improved, and tested by several researchers (3-6).

An evaluation of the effectiveness of a modified form of Low's model in a medium-sized urban area is presented. Socioeconomic variables needed for the model are derived from census data. A brief discussion of the development of the model, its structure, and its theoretical limitations is presented. The model is then applied to the city of Spokane (1980 population = 171,300) for the base year 1970, and a forecast of the traffic volumes on the street network is obtained for the horizon year 1980. The results are compared with actual ground counts for 1980. Conclusions about the prediction capability of the model and its suitability for general use are presented in the last section of this paper.

BACKGROUND

A travel demand forecasting model, which used routinely collected traffic ground counts, was originally proposed by Low (2) in 1972. Traffic volumes in the base year were used to calibrate the model. The horizon year's socioeconomic variables and the base year-calibrated model were then used to predict the future traffic volume in selected links of the network in the horizon year. Low's model is essentially an internal volume forecasting (IVF) procedure that estimates trips for all purposes.

Low tested the model in a small urban area in West Virginia and compared the results with forecasts obtained from conventional travel demand modeling techniques, and the results obtained were reasonably good--model root-mean-square (rms) was 24 percent.

In 1976 a similar approach was proposed and tested on a hypothetical 22-link network by Hogberg (3). He confirmed the validity of Low's approach in this hypothetical situation. An evaluation of Low's model was conducted by Smith and McFarlane (4) in 1978. Their findings indicated that the model produced reasonable estimates of both base year and future year traffic volumes. The estimation error in corridor volumes ranged between 1 and 7 percent. However, this study called attention to some theoretical limitations of the model that will be discussed later.

In 1981 Willumsen (5) compared Low's model with three similar models and asserted that, by resolving the model's theoretical limitations, it could be recommended for use in small and medium-sized cities because it offers three attractive features: (a) simplicity of use, (b) computational efficiency, and (c) low cost.

LOW'S MODEL

This model was developed on the assumption that the traffic volume on each link in a transportation network is proportional to what Low referred to as "the interzonal trip probability factor." The value of the trip probability factor provides a measure of the number of vehicular trips between the different zones in the urban area. The mathematical form of the interzonal trip probability factor is given by the following expression:

$$f_{ij} = P_i A_j t_{ij}^{-n} \tag{1}$$

where

f_{ij} = interzonal trip probability factor between zones i and j,
P_i = a socioeconomic characteristic of zone i that is related to trip production (Low used population),
A_j = a socioeconomic characteristic of zone j that is related to trip attraction (Low used employment),
t_{ij} = travel time between zones i and j, and
n = some exponent to be determined by calibration (Low assumed n = 2).

The model mechanism is explained as follows:

1. Socioeconomic variables (P_i's and A_j's) for the zones are determined for the base year, and the interzonal trip probability factors (f_{ij}'s) are calculated between all the zones in the study area.
2. Trip probability factors are assigned to the transportation network using one of the traffic assignment techniques. The all-or-nothing assignment, via the shortest routes, is probably the simplest and easiest technique appropriate for this model.
3. The total trip probability factors for selected links on the major streets are obtained by adding the f_{ij}'s assigned to each link.
4. The corresponding traffic volumes (in the base year) on each link are obtained from routinely collected traffic counts, and a linear relationship between the traffic volumes and f_{ij}'s is established using the following linear regression equation:

$$V_{k\ell} = a + bP_{ij}^{k\ell}\sum_{ij}\sum f_{ij} \tag{2}$$

where

$V_{k\ell}$ = traffic volume on the link $k\ell$,
f_{ij} = interzonal trip probability factor between zones i and j, and
a,b = parameters to be determined by calibration.

$P_{ij}^{k\ell}$ is the probability that the trip between zones i and j will use link $k\ell$. The value of $P_{ij}^{k\ell}$, using the all-or-nothing assignment technique, is

$$P_{ij}^{k\ell} = \begin{cases} 0 & \text{if the link } k\ell \text{ is not used by the trip maker between zones i and j} \\ 1 & \text{if the link } k\ell \text{ is used by the trip maker between zones i and j.} \end{cases}$$

5. The least-squares method is used to calibrate the model for the base year for which the two parameters (a and b) can be determined. Finally, to estimate the traffic volume for the horizon year, it is necessary to establish the projected interzonal trip probability factors using the socioeconomic variables of the horizon year.

MODEL DEFICIENCIES AND POTENTIAL IMPROVEMENTS

Smith and McFarlane (4) identified two misspecifications in Low's model: first, in representing trip productions and attractions by production and attraction "characteristics," and second, in the omission of origin-zone accessibility in the denominator of the probability factors.

To eliminate these two errors, Smith and McFarlane recommended "replacement of the zonal production and attraction characteristics by direct estimates of trip productions and attractions, and inclusion of origin-zone accessibility in the denominator of the probability factor" (4,p.39). This improvement resulted in a formulation that is identical to a simplified gravity model.

When Low applied his model, P_i was assumed to be the population of zone i, A_j was assumed to be employment in zone j, and the travel time exponent (n) was assumed to be two. The suggested production and attraction variables, as well as the friction factors that are used in the present study, are as follows:

1. Because work trips are the least flexible of all trips, the production zone variable (P_i) that is used here is the number of employees who reside in zone i (ER_i).
2. Similarly, the attraction zone variable (A_j) is the number of employees who work in zone j (EW_j).
3. Because the trip interchange index is of the gravity model type, it is appropriate to calculate the friction factor [$F(C_{ij})$] values in a manner similar to that used in trip distribution models. $F(C_{ij})$ is an indirect indicator of the cost of travel between zones. Based on the work of Zaryouni and Kannel (7), the friction factor is

$$F(C_{ij}) = \exp(-0.10t_{ij}) \qquad (3)$$

The second theoretical limitation can be avoided simply by dividing the attraction term (EW_j) at the destination by the total attractions ($\sum_j EW_j$) of the study area. Also, the term interzonal trip probability factor can be replaced by another term that could be called the interzonal trip interchange index (I_{ij}). This simple modification does not compromise the simplicity and the computational efficiency of the model (5). Therefore, Equation 1 can be rewritten as

$$I_{ij} = (ER)_i[(EW)_j/_j(EW)_j]F(C_{ij}) \qquad (4)$$

and the link traffic volume can be calculated as

$$V_k = a + bP_{ij}^{k\ell}\sum_i\sum_j f_{ij} \qquad (5)$$

MODEL APPLICATION

The modified model was applied to the city of Spokane as a case study area. The sequential steps of the model application are shown in Figure 1. The

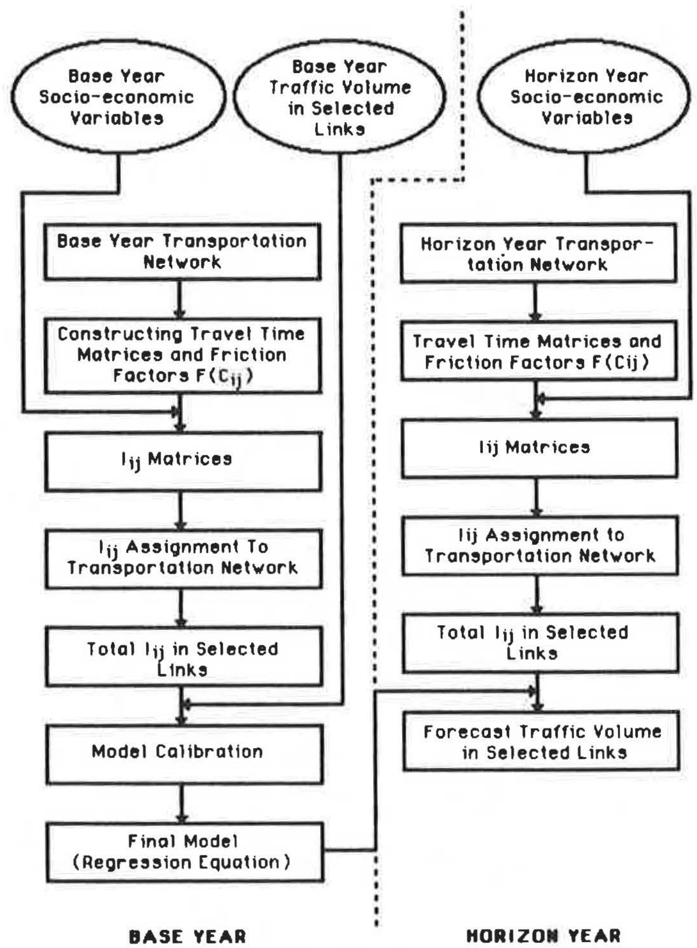

FIGURE 1 Sequence of model application.

city of Spokane was divided into 26 planning areas for the purposes of this model.

MODEL CALIBRATION

To calibrate the model for the base year 1970 the following input data were gathered:

1. A base map showing the major transportation network (Figure 2). The network configuration and the link speeds were investigated to set up travel time matrices.
2. Traffic volumes for selected links of the surface network with ground counts throughout the network. These traffic volumes are a combination of internal-internal (V_{II}), internal-external (V_{IE}), external-internal (V_{EI}), and external-external (V_{EE}) trips. V_{IE}, V_{EI}, and V_{EE} trips were subtracted from the total traffic count (V_T). Because cordon counts were not readily available for V_{EE}, V_{EI}, and V_{IE}, an approximate method of obtaining these volumes was used as suggested in NCHRP Report 187 (8). This procedure is necessary because the trip interchange indices are computed between zones within the study area and the traffic volume used must be the internal traffic volume on the link.
3. Socioeconomic characteristics, related to each production and attraction planning area. The production zone characteristics (number of employees residing in zone i) were obtained from 1970 Census data, and the attraction zone characteristics (number of employees working in zone j) were obtained from data provided by the Spokane Regional Conference.

Using the input data in steps 2 and 3, a matrix of the trip interchange indices was calculated for the base year. The resulting matrix of I_{ij}'s was then assigned to the transportation network using the all-or-nothing assignment technique.

The estimate of the two parameters a and b in Equation 5 was performed by selecting 37 links on the city's street network. This selection covered the entire set of links on the major street system (Figure 2). When the traffic volume values for these 37 links were plotted against the corresponding I_{ij}'s (Figure 3) it was observed that it would be appropriate to use two equations: the first for those links with a traffic volume of fewer than 4,500 (Figure 4) and the second for those links with a

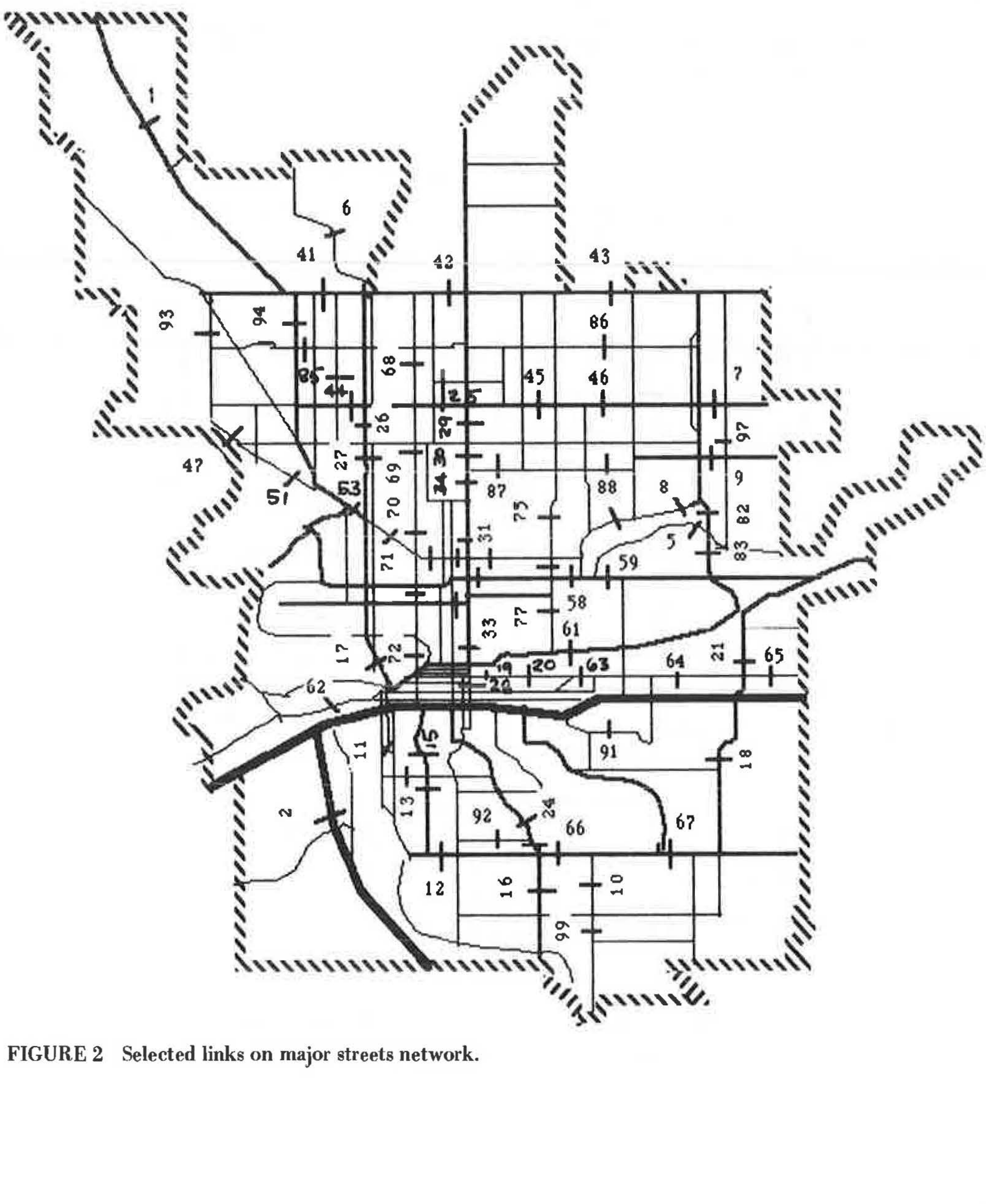

FIGURE 2 Selected links on major streets network.

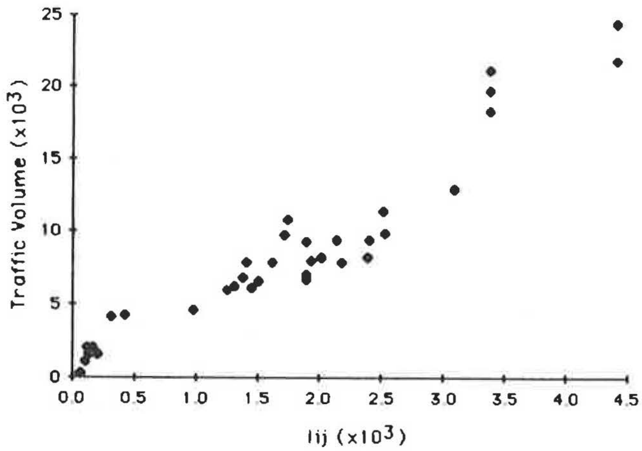

FIGURE 3 Traffic volume versus I_{ij}'s.

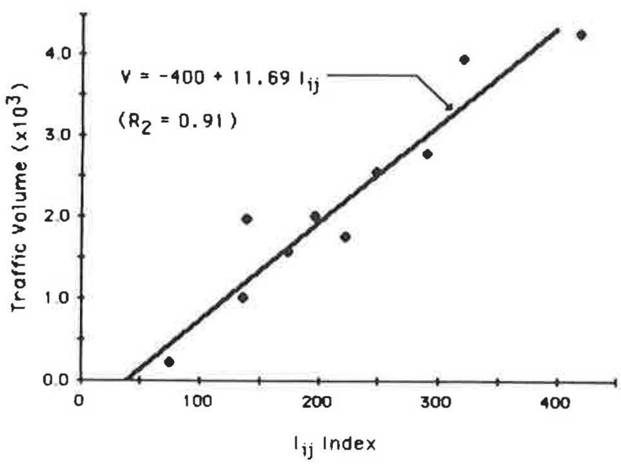

FIGURE 4 Regression line for links with traffic volume less than 4,500.

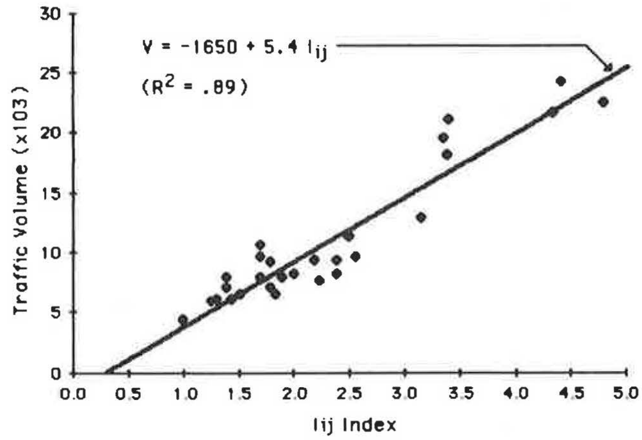

FIGURE 5 Regression line for links with traffic volume greater than 4,500.

traffic volume equal to or more than 4,500 (Figure 5). Accordingly, two linear regression equations were obtained by means of the least-squares method:

$$V^{70}_{k\ell} = -400 + 11.69 P^{k\ell}_{ij} \sum_{ij}\sum I_{ij}$$

$R^2 = 0.91 t_0 = 9.142 > t_{.005} = 3.355$
for traffic volume < 4,500 (6)

$$V^{70}_{k\ell} = -1,650 + 5.40 P^{k\ell}_{ij} \sum_{ij}\sum I_{ij}$$

$R^2 = 0.89 t_0 = 14.49 > t_{.005} = 2.779$
for traffic volume $\geq$ 4,500 (7)

MODEL FORECASTING

The calibrated model for the base year 1970 was used to forecast the traffic volume on the same links of the major street system for the horizon year 1980. It was assumed that the major street network would not change significantly between the base year and the horizon year. The only information that was necessary for the application of the modified model was the two variables (ER_i and EW_j for 1980) that were obtained exogenously. These values as well as the friction factor matrix were used to obtain the horizon year trip interchange indices (I_{ij}'s) matrix. The next step was to assign the I_{ij}'s to the transportation network. The total I_{ij}'s in each link were added, and then the internal-internal traffic volume (V_{II}) in the links was obtained from Equations 6 and 7. The external trips ($V_{EE} + V_{EI} + V_{IE}$) were added to the V_{II} trips to obtain the total link volumes (V_T) in 1980. These external trips were forecast from base year data.

PREDICTING TRAFFIC VOLUME ON OTHER LINKS FOR THE HORIZON YEAR

It is evident from the model structure that the traffic volume on those links that lie on the minimum-path route are obtained by applying Equations 6 and 7. The following procedure was used for those links on the major street network that did not lie on the minimum-path route: The predicted traffic volume (obtained from the model) and the base year traffic volume on these links were used to construct a simple regression line. The predicted traffic volume was taken as the dependent variable ($V^{80}_{k\ell}$), the actual base year traffic volume was taken as the independent variable ($V^{70}_{k\ell}$), and the following equations were obtained:

$$V^{80}_{k\ell} = 600 + 1.58 V^{70}_{k\ell}$$

$R^2 = 0.84;\ t_0 = 3.654 > t_{.005} = 3.499$
for links with traffic volumes < 4,500 in the base year (8)

$$V^{80}_{k\ell} = -1,100 + 1.38 V^{70}_{k\ell}$$

$R^2 = 0.89;\ t_0 = 14.837 > t_{.005} = 2.779$
for links with traffic volumes $\geq$ 4,500 in the base year (9)

where

V^{80}_k = estimated traffic volume on link k in the horizon year and
V^{70}_k = actual traffic volume on link k in the base year.

This is a straightforward procedure, whereby base year volumes on non-minimum-path routes are used to obtain an estimate of design year volume.

RESULTS AND MODEL ACCURACY

The output of the modified model in terms of link volumes on the major street network is given in Tables 1 and 2. For low-volume links, the ratio of actual-to-estimated traffic volumes for the horizon year ranged from 0.63 to 1.40, and the rms error was 32. For the high-volume links the corresponding range was from 0.70 to 1.52, and the rms error was 18. However, most link volume estimates were within 15 percent of the actual volumes.

A comparison of the modified model with Low's original model indicates that the modified model output gives somewhat better results. This comparison is given in Table 3. Also, a comparison of observed and estimated horizon year link volumes by volume range is given in Table 4. Although the actual-to-estimated volumes for the horizon year ranged from 0.93 to 1.27, most volume groups were within 10 percent of the actual volumes.

CONCLUSIONS

The primary objective of applying a modified form of Low's model to the city of Spokane was to evaluate its utility in estimating street link volumes in the horizon year using routinely collected traffic counts. The model produces reasonably reliable results. Because network configuration and census data are generally available, the effort required to work the model for a small or medium-sized city might involve 10-15 man-days. This effort represents a small fraction of the time and the money that are needed to run the conventional models. The model combines several conventional submodels into one process and

TABLE 1 Comparison of Actual and Estimated Traffic Volume (< 4,500)

	Base Year 1970			Horizon Year 1980		
Link No.	Actual Traffic Volume (V_o)	Estimated Traffic Volume (V_e)	V_o/V_e	Actual Traffic Volume V_o	Estimated Traffic Volume V_e	V_o/V_e
1	600	800	0.75	2,200	3,500	0.63
2	4,750	4,000	1.19	9,400	7,000	1.34
3	5,000	4,900	1.02	8,700	8,000	1.09
4	1,550	1,600	0.97	1,750	2,200	0.80
5	1,750	2,200	0.80	3,600	4,000	0.90
6	1,750	1,950	0.90	2,200	3,050	0.72
7	2,950	3,200	0.92	4,900	6,850	0.72
8	4,000	3,400	1.18	6,000	4,300	1.40
9	4,300	4,500	0.96	7,300	5,700	1.28
Total	26,650			46,050		

Note: For base year, $V_{\bar{o}}$ = 2961; $(V_o - V_e)^2$ = 1,320,000; RMS error = 434.32; and % rms error = 14.66 ≈ 15.

TABLE 2 Comparison of Actual and Estimated Traffic Volume (> 4,500)

	Base Year 1970			Horizon Year 1980		
Link No.	Actual Traffic Volume (V_o)	Estimated Traffic Volume (V_e)	V_o/V_e	Actual Traffic Volume V_o	Estimated Traffic Volume V_e	V_o/V_e
10	4,500	3,700	1.22	5,050	4,700	1.07
11	6,000	5,200	1.15	8,500	5,850	1.45
12	6,200	5,600	1.11	6,650	5,400	1.23
13	6,200	6,300	0.98	7,150	6,450	1.11
14	6,600	8,600	0.77	9,050	7,500	1.21
15	7,750	6,100	1.27	8,200	5,400	1.52
16	8,150	8,300	0.98	9,000	12,650	0.71
17	9,000	10,200	0.88	17,600	14,400	1.22
18	9,250	12,100	0.76	14,900	17,300	0.86
19	9,500	9,100	1.04	9,500	9,350	1.02
20	9,700	10,600	0.92	11,500	12,200	0.94
21	10,350	11,000	0.94	20,850	13,600	1.61
22	11,350	9,400	1.21	11,650	13,200	0.88
23	11,500	13,800	0.83	14,700	17,800	0.83
24	12,350	9,500	1.30	12,400	13,200	0.94
25	12,600	13,200	0.95	14,250	14,800	0.96
26	13,250	16,400	0.81	16,400	23,400	0.70
27	14,450	16,400	0.88	18,250	23,400	0.78
28	17,600	19,700	0.89	21,500	26,350	0.82
29	23,750	22,200	1.07	28,500	26,700	1.07
30	25,100	22,000	1.13	31,000	26,700	1.16
31	26,600	22,000	1.20	30,400	26,700	1.14
32	27,300	27,700	0.99	28,700	34,100	0.84
33	28,200	30,100	0.94	30,800	36,100	0.85
34	29,800	27,700	1.08	32,500	34,100	0.95
100	27,800	26,800	1.04	37,900	38,400	0.95
101	34,100	33,300	1.02	50,400	53,300	0.95
102	31,700	33,300	0.95	48,300	53,300	0.91

Note: For base year, $V_{\bar{o}}$ = 15,737; $(V_o - V_e)^2$ = 97,612,500; rms error = 1,937.60; and % rms error = 12.31. For horizon year, $V_{\bar{o}}$ = 19,880; $(V_o - V_e)^2$ = 359,055,000; rms error = 3,580; and % rms error = 18.01.

TABLE 3 Summary of Results

		Traffic Volume <4,500		Traffic Volume ≥4,500	
Year	Model	RMS Error	% RMS Error	RMS Error	% RMS Error
1970	Low	710	24	2,302	17
	Modified	434	15	1,938	12
1980	Low	2,234	44	3,310	19
	Modified	1,616	32	3,716	18

TABLE 4 Comparison of Actual and Estimated Traffic Volume for All Link Groups (modified model)

Group	Volume Range	Estimated Avg. Volume (E)	Actual Avg. Volume (A)	A/E	Error %
1	1,500-3,000	2,600	2,050	1.27	+26.8
2	3,001-5,000	4,100	4,250	0.96	-3.5
3	5,001-7,000	6,100	5,900	1.03	+3.4
4	7,001-10,000	8,300	8,500	0.98	-2.4
5	10,001-15,000	13,400	13,200	1.02	+1.5
6	15,001-20,000	17,550	17,400	1.01	+0.9
7	20,001-25,000	23,400	21,700	1.08	+7.8
8	25,001-30,000	26,600	28,600	0.93	-7.0
9	30,001-35,000	34,100	31,200	1.09	+9.3
10	>35,000	45,300	45,500	1.00	-0.4

the output in terms of traffic volumes can be statistically described and tested. In summary, the model is quick, reliable, and transparent for forecasting travel in small and medium-sized cities. Caution, however, needs to be exercised regarding

1. The choice of socioeconomic variables--more experience needs to be gained from further applications in cities of varying sizes;
2. The application of this model to cities having a comparatively high percentage of mass-transit patronage;
3. The fact that the output from the model is in terms of trips for all purposes; home-based, non-home based, and other trip categories could possibly be worked out with additional data;
4. External-external, external-internal, and internal-external trips--Count stations located on the cordon line would be most helpful in dealing with the forecast of such trips;
5. Using this type of model for crucial policy options--The model is sensitive only to network changes; and
6. The high potential for correlation between adjacent links on the network in the regression analysis--This problem could possibly be alleviated or at least reduced by randomly selecting links on the network rather than using two adjacent links. In a large network it may be necessary to use a Monte Carlo technique for the selection of links.

The model appears to be of particular use in the following cases:

1. Modeling small and medium-sized cities, especially freestanding cities in rural regions and extensions of metropolitan areas;
2. Modeling cities in less developed and developing countries where urbanization is taking place at a fast rate, where qualified transport planners are not available, in situations in which a country budget does not allow conventional transport models to be used, and in situations in which long-range planning has little meaning in view of the uncertain changes in urbanization; and
3. Analysis connected with the transportation system management element.

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