TRANSPORTATION RESEARCH RECORD 1045

Innovations in Transportation Planning and Development

TRB
TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. 1985

Transportation Research Record 1045
Price $7.40
Editor: Catherine Nizharadze
Compositor: Harlow A. Bickford
Layout: Marion L. Ross

mode
1 highway transportation
2 public transit

subject areas
11 administration
12 planning

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Printed in the United States of America

Library of Congress Cataloging-in-Publication Data
National Research Council. Transportation Research Board.
Innovations in transportation planning and development.

(Transportation research record ; 1045)
1. Transportation—Congresses. 2. Transportation—Planning—Congresses. I. National Research Council (U.S.). Transportation Research Board. II. Series.

TE7.H5 no. 1045 380.5 s 86-8804
[HE11] [380.5'068]
ISBN 0-309-03961-4 ISSN 0361-1981

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Contents

Addresses of Authors

Bovy, P. H. L., Institute of Town Planning Research, Delft University of Technology, Berlageweg 1, Delft, The Netherlands
Curry, David, Crain & Associates, Inc., 343 Second Street, Suite A, Los Altos, Calif. 94022
Dowling, Richard G., DKS Associates, 1419 Broadway, Suite 700, Oakland, Calif. 94612
Fambro, Daniel B., Transportation Center, The University of Tennessee, 731 Andy Holt Tower, Knoxville, Tenn. 37996-0170
Glazer, Jesse, Crain & Associates, 343 Second Street, Suite A, Los Altos, Calif. 94022
Heathington, Betty S., Bureau of Educational Research and Service, The University of Tennessee, 731 Andy Holt Tower, Knoxville, Tenn. 37996-0170
Heathington, K. W., The University of Tennessee, 731 Andy Holt Tower, Knoxville, Tenn. 37996-0170
Jansen, G. R. M., Institute of Town Planning Research, Delft University of Technology, Berlageweg 1, Delft, The Netherlands
Khisty, C. J., Department of Civil and Environmental Engineering, Washington State University, Pullman, Wash. 99164
May, Adolf D., University of California, 109 McLaughlin Hall, Berkeley, Calif. 94720
McDowell, Bruce D., Advisory Commission on Intergovernmental Relations, 1111 20th Street, N.W., Suite 2000, Washington, D.C. 20575
Parry, Stephen T., Southern California Rapid Transit District, 425 S. Main Street, Los Angeles, Calif. 90017
Post, Patti, Patti Post and Associates, 3101 Malcolm Avenue, Los Angeles, Calif. 90034
Spivack, Gary S., Southern California Rapid Transit District, 425 S. Main Street, Los Angeles, Calif. 90017
van Maarseveen, M. F. A. M., Traffic and Transportation Unit TNO, P.O. Box 45, Delft, The Netherlands

Olympic Park-and-Ride Advance Reservation System

PATTI POST, STEPHEN T. PARRY, and GARY S. SPIVACK

ABSTRACT

The Games of the 23rd Olympiad were celebrated in Los Angeles July 28 to August 12, 1984. The Southern California Rapid Transit District (RTD) operated a dedicated fleet of 550 buses during the Games for spectators at the Olympics. Described in this paper is one aspect of RTD's Olympic services, the advance reservation system designed for the Olympic park-and-ride lines. The goals of this reservation system were twofold: one goal was to provide an attractive service to patrons; the other goal was to enable the level of service provided to be tailored to demand. Both goals were achieved. Patrons were pleased with the service and cost savings were realized because of efficient use of personnel and equipment. Ticketron operated the reservation system and processed nearly 190,000 reservations during the 72-day sales period. Reservations were available by mail (37 percent of total orders), over the telephone (36 percent), and in person (61 percent). Sales began slowly and peaked at more than 7,500 per day.

The Games of the 23rd Olympiad were celebrated in Los Angeles July 28 to August 12, 1984. Twenty-three sporting events were conducted at venues (competition sites) scattered across the Southern California area. The Southern California Rapid Transit District (RTD) operated a dedicated fleet of 550 buses for spectators at the Olympics; this fleet served the vast majority of the venues. Service included special park-and-ride, express, and shuttle lines, operated in addition to the regular line service. Described in this paper is one aspect of the Olympic services, the advance reservation system developed for the Olympic park-and-ride lines.

GOALS OF THE ADVANCE RESERVATION SYSTEM

The goals of the advance reservation system were twofold.

One goal was to provide an attractive service to patrons. By offering reservations, RTD could guarantee that those with reservations would get a seat on a park-and-ride bus within a specific 20-min time period. This guarantee limited possible uncertainty on the part of potential riders about the convenience of taking the bus. Although actual travel time was subject to current traffic conditions, people with bus reservations could be sure that they would arrive at their events on time, in comfort, and with a minimum of fuss.

The second goal of the reservation system was to allow the level of service provided to be tailored to demand. Information on reservation requests was used to modify initial allocations of equipment. By tailoring the service in this way, equipment would not be sent out to stand idle, and busy locations could receive equipment not needed elsewhere. Minimizing idle equipment kept down both equipment and labor costs.

MODEL OF TRAVEL BEHAVIOR

Initial bus capacities for each park-and-ride line were based on a model of spectator travel behavior. This model was based on venue-specific mode split targets, seating capacities of the venues, event schedules, and spectator behavior at previous special events.

During spring 1983, the local transportation agencies, Los Angeles City Department of Transportation, Los Angeles Police Department, California Department of Transportation, California Highway Patrol, RTD, and the Los Angeles Olympic Organizing Committee (LAOOC), met to determine target mode splits for all modes for each Olympic venue. Public transit's share of travelers ranged from 0 percent for some small, remote venues not served by public transit to 40 percent at Exposition Park, site of the opening and closing ceremonies, athletics (track and field), swimming, diving, and boxing. Shares were also assigned to charter buses, although no charter representatives participated in the meetings. For Exposition Park, 25 percent of the spectators were allocated to charters, leaving only 35 percent to come in private automobiles.

Service sufficient for meeting the mode-split targets for public transit was to be provided by RTD with some assistance from local municipal bus operators. RTD then went a step further and allocated the overall mode split for transit between the different types of service it offered: park and ride, express from downtown Los Angeles, short-haul shuttles, and regular line service.

This process resulted in the derivation of a percentage of spectators to be transported by RTD to each venue by each type of service. By using these derived percentages and the stadia capacities provided by LAOOC, the number of spectators to be transported from each RTD park-and-ride lot was calculated for each venue and for each competition session. Ridership was allocated to the individual park-and-ride lots based on lot size and the geographic distribution of ticket sales.

At each lot, the ridership was spread over the expected window of travel to determine needed capacities in periods of 20 min. Capacities were designed to accommodate the entire allocated ridership within a 2-hr period, although for the convenience of the traveler reduced levels of service were offered both before and after the 2-hr window.

Bus capacities at each lot were checked and adjusted if necessary to keep total ridership within the limits that could be accommodated by parking in the designated lot and nearby parking areas. For this calculation, an average automobile occupancy of 2.5 persons per car and a 15-percent turnover rate were assumed. Also assumed was a factor of 25 percent for walk-ins and others who came to the lot without reservations.

VENDOR SELECTION

RTD considered the possibility of operating a reservation system itself but quickly decided that the service should be run by a contractor with the appropriate facilities and experience. The vendor was selected through the RTD's regular competitive bid process. Bids on the contract came from firms of two types: firms in the business of selling tickets to cultural and sporting events, and firms specializing in fulfillment services, adept at filling mail and telephone orders for products.

Bids were judged on the following: (a) the firm's ability to process mail, telephone, and in-person orders; (b) the cost per order; and (c) an evaluation of the firm's ability to quickly adapt their services to a new situation. Ticketron was selected as the vendor for the advance reservation system.

The Ticketron organization is structured such that many local Ticketron outlets are independent stores. However, two chain stores also participate as a group, Sears, Roebuck and Co., and Tower Records.

Both RTD and Ticketron hoped that Sears would be willing to participate in the RTD Olympic park-and-ride program. The 22 local Sears stores would have provided outlets convenient to almost everyone in Southern California, advertising would have been simplified, and Sears was already identified with the Olympics as one of the distributors of ticket order forms for Olympic events. Sears, however, declined to participate because it believed that the unique nature of the program, and the extra work and inventory control required, would add more effort than it was capable of handling.

Tower Records readily agreed to participate in the program and their eight local stores were the only outlets listed in the RTD Olympic information brochure. Their stores were soon joined by nine independent outlets. Later, in response to tremendous demand, more independent stores were added. By the end of the program, 28 outlets were participating.

OPERATION OF THE RESERVATION SYSTEM

All reservations on RTD park-and-ride lines were handled by Ticketron. RTD service centers, which normally sell RTD monthly bus passes, sold the daily gold passes without reservations and directed all requests for reservations to Ticketron. Ticketron was able to process telephone, mail, and in-person orders. The usual Ticketron telephone numbers were used and additional operators were added as needed. Ticketron had several telephone numbers, allowing most people in Southern California to reach them with a local call. However, they did not have an incoming toll-free line (800 number). Callers from outside the local calling area were responsible for the applicable telephone charges. Telephone lines operated from 9:00 a.m. to 9:00 p.m. Monday through Saturday and 10:00 a.m. to 6:00 p.m. on Sunday.

A mail-order reservation form was included in a brochure developed by the RTD entitled RTD Bus Service Guide to the 1984 Olympics. Over one million copies of this brochure were distributed by RTD and supplemental reservation order forms as well as brochures were available at all local Ticketron outlets (Figure 1).

Accommodating walk-in orders was considered essential. Telephone and mail orders were to be cut off 10 days before the day of travel to ensure sufficient time for the person making the reservations to receive the passes and reservations in the mail. A strong buying surge was anticipated as the Games neared. Only in-person ordering could accommodate this last-minute demand.

Ticketron outlets were attractive for other reasons as well. People could go to a Ticketron outlet, complete their transaction, and leave with their reservations and passes. Because tickets were checked at the time of purchase, many people felt more comfortable with this manner of purchase, which obviated the use of the postal service and eliminated the possibility of orders being filled incorrectly.

However, using Ticketron outlets had two drawbacks to the customer. Cash was required for all transactions, and a trip to the local Ticketron outlet was required. As the time of the games approached, some outlets experienced lines of patrons waiting to make RTD park-and-ride reservations. At the same time, however, the outlets had queues, the telephones were also busy, and those making reservations over the telephone were subject to busy signals and waits.

Because there were three ways of ordering, patrons were able to choose the method they preferred. Also, orders were distributed between the choices, thus adding to the capacity of the entire system. Reservations were first accepted on June 1, 1984, and were sold until one day before the day of travel.

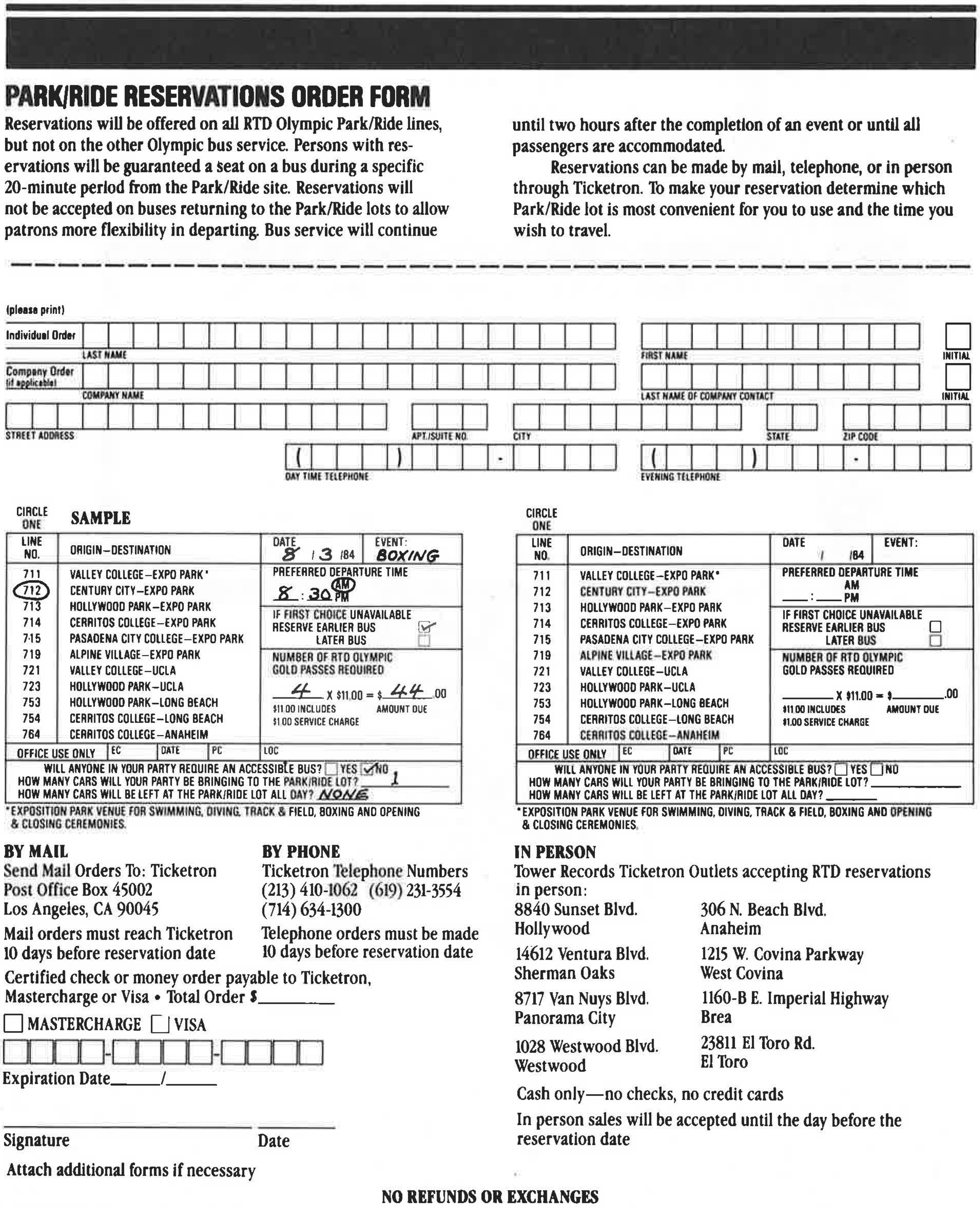
People making reservations indicated the day on which they wanted to travel, the park-and-ride lot they wanted to use, their destination, and their desired departure time. The Ticketron clerk would check the availability and, if necessary, suggest alternatives. When a match was made, the transaction was completed and recorded in the Ticketron computer. The customer then received (in person or by return mail) RTD gold passes for the desired day and Ticketron reservation tickets indicating the date, time of reservation, point of origin, and destination. The passes and tickets were packaged in a preprinted envelope describing the park-and-ride procedures; they are shown in Figure 2.

Reservation holders received a reservation for a specific 20-min period (e.g., 8:00 a.m. to 8:19 a.m.) for travel to their venue. No reservations were offered or accepted for return trips. Patrons were required to be at the loading area of their park-and-ride lot by the start of the 20-min period and were guaranteed a seat on a bus sometime during that period. The number of buses scheduled for each 20-min period was based on event schedules and reservation demand. Reservation holders were to be boarded first, with walk-ins being carried on a space-available basis, probably as standees.

RESERVATIONS AND THE GOLD PASS

Gold passes were valid for unlimited travel on all RTD lines (including the special Olympic service) on the date for which they were issued. Many patrons who planned to use the longer distanced express services as a means to get to a special Olympic shuttle found the passes without reservations financially attractive.

Initially, Ticketron processed only requests for reservations that included the purchase of a gold pass. To minimize confusion, customers wanting to buy gold passes without reservations had to purchase them at one of RTD's 11 Customer Service Centers. Although the passes were accepted on the park-and-



PARK/RIDE RESERVATIONS ORDER FORM

Reservations will be offered on all RTD Olympic Park/Ride lines, but not on the other Olympic bus service. Persons with reservations will be guaranteed a seat on a bus during a specific 20-minute period from the Park/Ride site. Reservations will not be accepted on buses returning to the Park/Ride lots to allow patrons more flexibility in departing. Bus service will continue until two hours after the completion of an event or until all passengers are accommodated.

Reservations can be made by mail, telephone, or in person through Ticketron. To make your reservation determine which Park/Ride lot is most convenient for you to use and the time you wish to travel.

(please print)

Individual Order — LAST NAME — FIRST NAME — INITIAL

Company Order (if applicable) — COMPANY NAME — LAST NAME OF COMPANY CONTACT — INITIAL

STREET ADDRESS — APT./SUITE NO. — CITY — STATE — ZIP CODE

DAY TIME TELEPHONE ( ) -

EVENING TELEPHONE ( ) -

CIRCLE ONE **SAMPLE**

LINE NO.	ORIGIN–DESTINATION
711	VALLEY COLLEGE–EXPO PARK*
[✓ 712]	CENTURY CITY–EXPO PARK
713	HOLLYWOOD PARK–EXPO PARK
714	CERRITOS COLLEGE–EXPO PARK
715	PASADENA CITY COLLEGE–EXPO PARK
719	ALPINE VILLAGE–EXPO PARK
721	VALLEY COLLEGE–UCLA
723	HOLLYWOOD PARK–UCLA
753	HOLLYWOOD PARK–LONG BEACH
754	CERRITOS COLLEGE–LONG BEACH
764	CERRITOS COLLEGE–ANAHEIM

DATE 8 / 3 /84

EVENT: BOXING

PREFERRED DEPARTURE TIME 8 : 30 [✓ AM] PM

IF FIRST CHOICE UNAVAILABLE RESERVE EARLIER BUS ☑ LATER BUS ☐

NUMBER OF RTD OLYMPIC GOLD PASSES REQUIRED 4 X $11.00 = $ 44 .00 AMOUNT DUE

$11.00 INCLUDES $1.00 SERVICE CHARGE

OFFICE USE ONLY EC DATE PC LOC

WILL ANYONE IN YOUR PARTY REQUIRE AN ACCESSIBLE BUS? ☐ YES ☑ NO

HOW MANY CARS WILL YOUR PARTY BE BRINGING TO THE PARK/RIDE LOT? 1

HOW MANY CARS WILL BE LEFT AT THE PARK/RIDE LOT ALL DAY? NONE

*EXPOSITION PARK VENUE FOR SWIMMING, DIVING, TRACK & FIELD, BOXING AND OPENING & CLOSING CEREMONIES.

CIRCLE ONE

LINE NO.	ORIGIN–DESTINATION
711	VALLEY COLLEGE–EXPO PARK*
712	CENTURY CITY–EXPO PARK
713	HOLLYWOOD PARK–EXPO PARK
714	CERRITOS COLLEGE–EXPO PARK
715	PASADENA CITY COLLEGE–EXPO PARK
719	ALPINE VILLAGE–EXPO PARK
721	VALLEY COLLEGE–UCLA
723	HOLLYWOOD PARK–UCLA
753	HOLLYWOOD PARK–LONG BEACH
754	CERRITOS COLLEGE–LONG BEACH
764	CERRITOS COLLEGE–ANAHEIM

DATE / /84

EVENT:

PREFERRED DEPARTURE TIME ___ : ___ AM PM

IF FIRST CHOICE UNAVAILABLE RESERVE EARLIER BUS ☐ LATER BUS ☐

NUMBER OF RTD OLYMPIC GOLD PASSES REQUIRED ______ X $11.00 = $______.00 AMOUNT DUE

$11.00 INCLUDES $1.00 SERVICE CHARGE

OFFICE USE ONLY EC DATE PC LOC

WILL ANYONE IN YOUR PARTY REQUIRE AN ACCESSIBLE BUS? ☐ YES ☐ NO

HOW MANY CARS WILL YOUR PARTY BE BRINGING TO THE PARK/RIDE LOT? ______

HOW MANY CARS WILL BE LEFT AT THE PARK/RIDE LOT ALL DAY? ______

*EXPOSITION PARK VENUE FOR SWIMMING, DIVING, TRACK & FIELD, BOXING AND OPENING & CLOSING CEREMONIES.

BY MAIL

Send Mail Orders To: Ticketron
Post Office Box 45002
Los Angeles, CA 90045

Mail orders must reach Ticketron 10 days before reservation date

BY PHONE

Ticketron Telephone Numbers
(213) 410-1062 (619) 231-3554
(714) 634-1300

Telephone orders must be made 10 days before reservation date

Certified check or money order payable to Ticketron, Mastercharge or Visa • Total Order $______

☐ MASTERCHARGE ☐ VISA

☐☐☐☐-☐☐☐☐-☐☐☐☐

Expiration Date_____/_____

Signature ______ Date ______

Attach additional forms if necessary

IN PERSON

Tower Records Ticketron Outlets accepting RTD reservations in person:

8840 Sunset Blvd.
Hollywood

14612 Ventura Blvd.
Sherman Oaks

8717 Van Nuys Blvd.
Panorama City

1028 Westwood Blvd.
Westwood

306 N. Beach Blvd.
Anaheim

1215 W. Covina Parkway
West Covina

1160-B E. Imperial Highway
Brea

23811 El Toro Rd.
El Toro

Cash only—no checks, no credit cards

In person sales will be accepted until the day before the reservation date

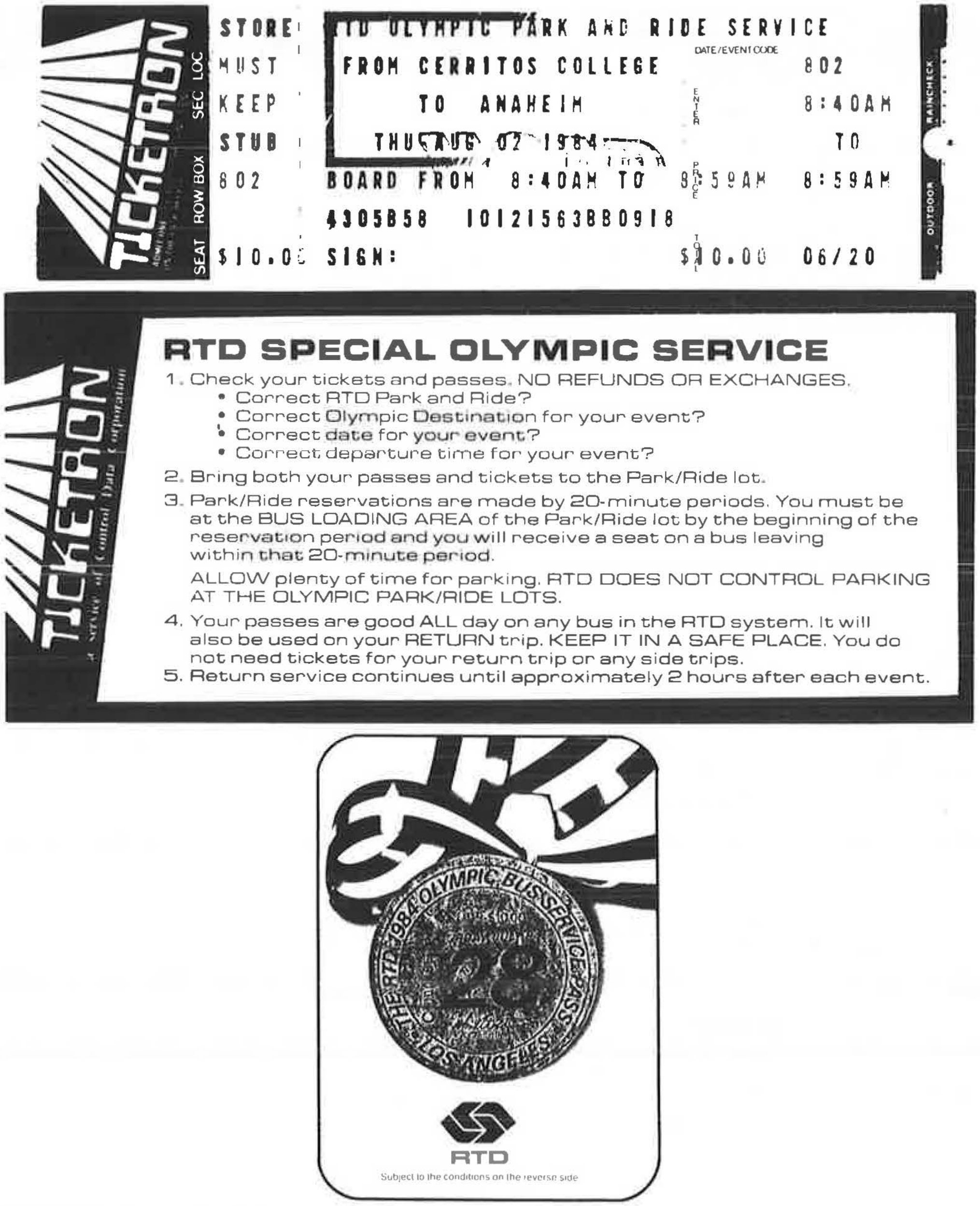
NO REFUNDS OR EXCHANGES

FIGURE 1 Reservation order form.

ride lines, reservations were necessary for guaranteed seating. Ticketron issued reservations only in conjunction with the purchase of passes. It was not permissible to buy a pass at RTD and then obtain a reservation ticket from Ticketron.

Customers continued to request gold passes without reservations from Ticketron. Demand was especially strong in geographic areas such as Orange County that were not served by RTD Customer Service Centers. Accordingly, on July 10, 1984, Ticketron began selling gold passes without reservations and cautioned the buyers about the limitations on their use at park-and-ride lots. Ticketron sold over 28,000 gold passes without reservations in the 18 days before the Games.

RTD gold passes, valid for one day of unlimited travel, sold for $10.00 each at RTD Customer Service Centers. Customers using Ticketron to make a reservation or purchase a pass without a reservation were charged an additional fee. In-person transactions



TICKETRON

STORE MUST KEEP STUB

SEC LOC 802

SEAT ROW BOX

$10.00

RTD OLYMPIC PARK AND RIDE SERVICE

FROM CERRITOS COLLEGE

TO ANAHEIM

THU AUG 02 1984

BOARD FROM 8:40AM TO 8:59AM

4305B58 101215638B0918

SIGN:

DATE/EVENT CODE 802

ENTER 8:40AM TO 8:59AM

PRICE $10.00

TOTAL $10.00 06/20

RAINCHECK

OUTDOOR

TICKETRON

A service of Control Data Corporation

RTD SPECIAL OLYMPIC SERVICE

1. Check your tickets and passes. NO REFUNDS OR EXCHANGES.
   - Correct RTD Park and Ride?
   - Correct Olympic Destination for your event?
   - Correct date for your event?
   - Correct departure time for your event?
2. Bring both your passes and tickets to the Park/Ride lot.
3. Park/Ride reservations are made by 20-minute periods. You must be at the BUS LOADING AREA of the Park/Ride lot by the beginning of the reservation period and you will receive a seat on a bus leaving within that 20-minute period.

   ALLOW plenty of time for parking. RTD DOES NOT CONTROL PARKING AT THE OLYMPIC PARK/RIDE LOTS.
4. Your passes are good ALL day on any bus in the RTD system. It will also be used on your RETURN trip. KEEP IT IN A SAFE PLACE. You do not need tickets for your return trip or any side trips.
5. Return service continues until approximately 2 hours after each event.

FIGURE 2 Reservation ticket, envelope, and RTD gold pass.

cost $0.75 per reservation (or per pass, if one was bought without a reservation), and the fee for telephone and mail orders was $1.00 for each gold pass. These transaction charges, partially subsidized by RTD to keep the price low, were considerably lower than Ticketron's customary charges. For each pass sold, RTD paid Ticketron $0.80, which was less than the usual 10 percent fee paid by RTD to commissioned agents of pass sales.

ACCESSIBILITY OF SERVICE

Accommodation for patrons requiring lift-equipped buses was included in the design of the reservation system. The reservation form included a question on the need for accessible equipment, and Ticketron set up procedures for recording this information. During the program, 556 requests for accessible equipment were recorded, a substantial number of which occurred during the first week of the program. Subsequent checking indicated that as many as 90 percent of these requests were recorded in error by Ticketron operators who misunderstood their instructions. Actual ridership requiring lift-equipped buses was not recorded separately, but indications are that it was quite low.

RESERVATION PATTERNS

Customers selected their reservation time period from what was available at the time of purchase based on their individual travel desires. They balanced their own estimate of travel time with their desired arrival time plus the additional amount of time they wanted to have as a cushion.

In general, people chose to arrive well before their reserved departure times. This was most pronounced for opening and closing ceremonies, which were scheduled for late afternoon on weekends. There was less urgency to arrive early for weekday morning events, some of which began at 8:00 a.m., requiring departures at 6:00 a.m.

The most popular reservation periods were those that started on the hour, particularly 7:00 a.m., 8:00 a.m., and 2:00 p.m. The adjacent time slots filled only after these were sold out.

Opening day was the strongest early seller. Later, the popular lots began to sell out on the days on which track and field events were being held. When the coliseum was not in operation, all of the lots had capacity for more cars and riders.

SALES OF RESERVATIONS

During the 72-day sales period, 189,260 reservations were sold. In addition, 63,431 RTD gold passes were sold without reservations for a total of 252,691 passes sold.

Through the middle of July, telephone reservation orders accounted for about one-half of the sales and in-person orders for about 45 percent; the remaining 5 percent of sales were by mail. When mail and telephone orders were closed out, all subsequent orders were taken in person. The final breakdown was 61 percent in person, 3 percent by mail, and 36 percent by telephone. Gold passes sold by RTD (35,269) were all over-the-counter purchases. Ticketron sold a few passes by mail or over the telephone, but 98 percent of their sales of gold passes were in person.

Sales of reservations through the initial 17 Ticketron outlets, by telephone, and by mail began on Friday, June 1, 1984. First-day sales of 913 reservations showed that many people had been waiting for the program to begin. Media coverage was good, with television interviews of the enthusiastic first customers. RTD brochures were not widely distributed until the second week of the program, so initial sales were prompted solely by news reports, word of mouth, and calls to RTD telephone information operators.

Sales increased steadily although slowly during June from a weekday average of 430 reservations per day during the first full week of the program to a weekday average of 1,580 reservations per day during the last week of June. Figure 3 shows sales of reservations by day of sale. During the following week (the first week of July) sales increased dramatically, reaching a weekday average of 4,080 per day. Weekend sales, although still substantially lower than weekday sales, also increased. Sales during subsequent weeks showed continued momentum, as sales averaged about 7,500 per weekday. Sales continued during the Games but at a significantly lower level.

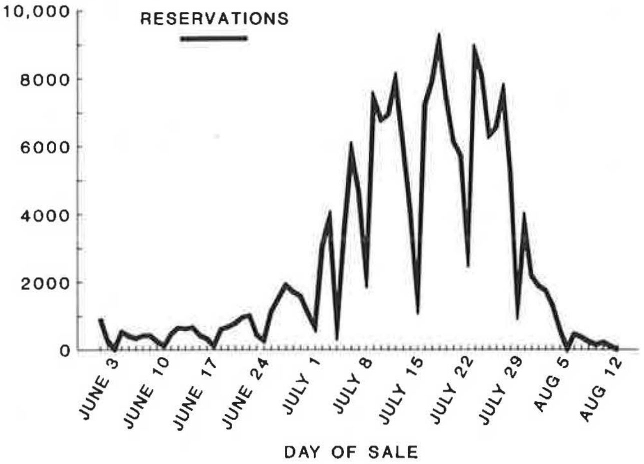


FIGURE 3 Sales of Olympic park-and-ride reservations by day of sale.

Of the 190,000 reservations sold, nearly 95 percent were for service to Exposition Park, site of the boxing, swimming and diving, and track and field venues, as well as the opening and closing ceremonies. The other three park-and-ride destinations split the remaining 5 percent of the reservations as follows: UCLA, 3.7 percent; Long Beach, 1.6 percent; and Anaheim, 0.1 percent. Ridership on park-and-ride lines was similarly skewed, as shown in Table 1.

TABLE 1 Reservations and Ridership of Olympic Park-and-Ride Lines by Destination

	Reservations		Passengers	
Destination	000s	Percent	000s	Percent
Exposition Park	179.0	94.6	209.1	95.5
UCLA	7.0	3.7	6.4	2.9
Long Beach	3.0	1.6	3.2	1.5
Anaheim	0.3	0.1	0.3	0.1
Total	189.3	100.0	219.0	100.0

DISTRIBUTION OF RESERVATIONS

Distribution of the number of reservations by line and by park-and-ride lot is given in Table 2. Seven park-and-ride lots fed 11 park-and-ride lines as shown in Figure 4. Initially, the most popular lots were at Cerritos College, Valley College (and the adjunct lot in Van Nuys), and Pasadena City College.

TABLE 2 Number of Reservations by Park-and-Ride Lot and Line

		Reservations	
Park-and-Ride Lot	Line	Number	Percent
Valley College	Line 711–Exposition Park	30,933	
	Line 721–UCLA	4,052	
	Subtotal	34,985	18
Hollywood Park	Line 713–Exposition Park	36,930	
	Line 723–UCLA	2,912	
	Line 753–Long Beach	1,315	
	Subtotal	41,157	22
Cerritos College	Line 714–Exposition Park	37,838	
	Line 754–Long Beach	1,687	
	Line 764–Anaheim	259	
	Subtotal	39,784	21
Pasadena City College	Line 715–Exposition Park	34,358	18
Alpine Village	Line 719–Exposition Park	5,254	3
Van Nuys	Line 711A–Exposition Park	5,566	3
Century City	Line 712–Exposition Park	28,156	15
	Total	189,260	100

Hollywood Park began to sell only after the big, popular lots and the small lot at Alpine Village reached capacity. Eventually, Hollywood Park outperformed the other lots. It was the biggest lot, but also had the most expensive parking fees. Table 3 gives the number of spaces in the Olympic park-and-ride lots and the parking fees.

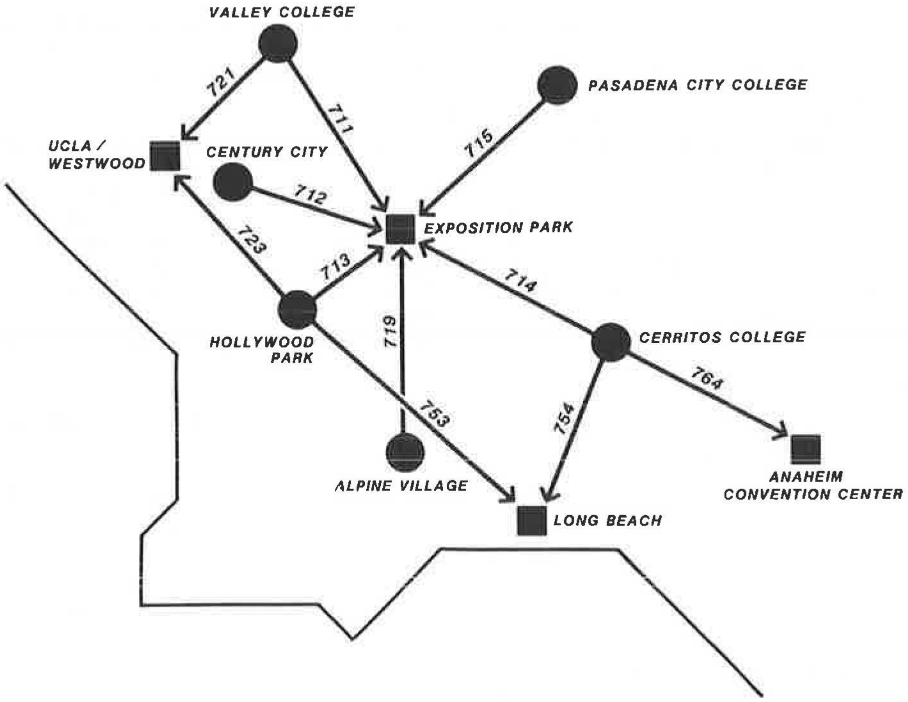


FIGURE 4 Map of park-and-ride service system.

TABLE 3 Number of Parking Spaces and Parking Fees in Olympic Park-and-Ride Lots

	No. of Parking Spaces	Parking Fee ($)
Valley College	2,220[a]	None
Van Nuys	325	None
Century City	3,500[b]	6.00
Hollywood Park	5,000	10.00[c]
Cerritos College	1,600	None
Pasadena City College	1,650	5.00
Alpine Village	350	None
Total	12,125	

Note: Park-and-ride lots were chosen based on the following criteria: minimum of 1,500 spaces, open 6:00 a.m. to midnight, available each day of the Olympics at little or no cost to RTD, and close to freeways. Locations were selected in each geographic sector of the area with emphasis on those sectors with the largest number of ticket holders. Some exceptions to the above criteria were made. The Van Nuys location was an old bus yard near Valley College and operated as a supplemental location on peak days. Alpine Village was limited to 350 spaces and operated only on weekdays. It was the best available lot in that sector and sold out virtually every day.

[a] For service to Exposition Park, 1,300 spaces (1,250 on weekdays); for service to UCLA, 900 spaces.

[b] Parking structure: approximately 800 monthly parking permits were issued; only 1,000 spaces were guaranteed for park-and-ride use, but many more were available.

[c] First week, $7.50; second week, $10.00.

ADJUSTMENTS TO PARK-AND-RIDE LOT CAPACITIES

LAOOC set the ticketing policy for the Games. For the more popular events, tickets were limited to two or four per household and no group arrangements were available. Tickets to the popular events were allocated by lottery, with 50 percent designated for Southern California residents, 30 percent to other U.S. residents, and the remainder to official sponsors and National Olympic committees. With the tickets so scattered, carpool formation was made more difficult.

Based on the ticket distribution plan, data from previous special events in Los Angeles, and the assumption that kiss and ride and carpooling would take place, an average of 2.5 persons per car was used in planning the use of the park-and-ride lots. There were also indications that local recreational vehicle parks and some hotels might provide van service to the lots.

Ridership was allocated to each lot based on the original estimates of lot size and an average of 2.5 passengers per car. Some but not all of the lots had adjacent commercial or on-street parking. Data from early mail and telephone orders indicated the average automobile occupancy would be lower than 2.5, perhaps 2.25 persons per car. This information was derived from answers to questions on the reservation form. It now appears that the Ticketron operators or the customers did not fully understand the questions. Also, as they got busier, the Ticketron operators neglected to ask the questions. The end result was sporadic, unreliable data. As a precaution, however, capacities were lowered in line with the lower automobile occupancy.

Detailed records of car volumes were not recorded at the parking lots that did not charge parking fees. Some figures are available for those lots that charged fees. Dividing ridership by occupied parking spaces yielded figures between 2.5 and 3.0 passengers per car. The higher figures were for lots with parking available nearby. Actual automobile occupancy for cars entering the park-and-ride lots was about 2.5 persons per car.

Capacities of the parking lots were adjusted midway through the sales of reservations as better sales information became available. In several cases, lot capacities were initially overestimated and estimates had to be reduced. RTD did not control the lots and could not offer reserved parking. Still, RTD believed it had an obligation not to cause the lots to overflow, particularly in areas with no adjacent parking. With conservative assumptions about automobile occupancy and turnover, no lots overflowed.

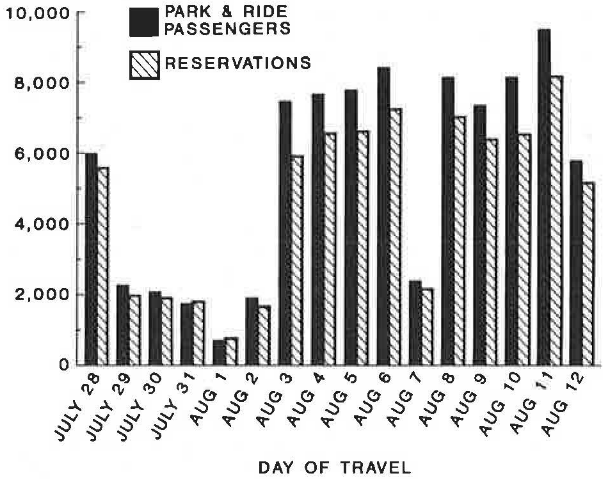


FIGURE 5 Number of RTD Olympic park-and-ride service reservations and level of ridership by day of travel.

DAILY VARIATION IN RIDERSHIP

Figure 5 shows the sales of reservations and level of ridership by day of travel. Ridership, expressed in number of roundtrip passengers, varied with the different daily event schedules. Because 95 percent of the reservation holders and 80 percent of the riders were destined for Exposition Park, most of the daily variation can be explained by changes in the operation of the three Exposition Park venues. On August 1, 1984, the day with the lowest level of ridership, the coliseum and swim stadium were inactive; only preliminary boxing matches were held that day at the sports arena. On August 11, 1984, the day with the highest level of ridership, all three venues held double sessions of finals in their sports.

RIDERS WITHOUT RESERVATIONS

Ridership on park-and-ride lines was about 20 percent higher than the number of reservations. As reservations sold out, people were encouraged to come as standbys. Reservation capacities were figured on seated loads, leaving more than 25 percent additional capacity available for standees. The number of reservations sold at any individual lot on any particular day was constrained to allow room in the parking lot for 25 percent of the riders to be people without reservations. This was part of the effort to keep bus use efficient and to prevent an overflow of cars at the parking lots, an effort that was successful.

BUS CAPACITIES

Initial bus capacities were based on event schedules and the model of travel behavior as adjusted for parking lot constraints. The model predicted desired travel times fairly well, and the reservation system acted to flatten and spread out the peaks. As popular times sold out, people were channeled to adjacent time periods.

EARLY PASSENGER ARRIVAL AT TERMINALS

On several days, particularly opening day, service did not begin early enough. This was true on both park-and-ride lines and shuttles. Shuttles, which were scheduled to begin 4 1/2 hr before the start of opening ceremonies, were started early when hundreds of impatient people were lining up at the terminal and stops, some arriving 2 hr before the advertised start of service.

Similar situations occurred at the park-and-ride lots on opening day. Lots were scheduled to open about 3 hr before the start of the event. Many of the lots were crowded even before RTD personnel arrived 1/2 hr before the scheduled beginning of service. It is still unexplained why people, who would never expect an airplane or a train or even a regular bus to run ahead of schedule, would expect Olympic bus service to begin 1 or 2 hr early. Some of the people who arrived early at the park-and-ride lots were standbys, those who could not or chose not to get reservations. Many of the others, however, were reservation holders with later reservation times. It now appears that these people either bought times they did not want because their first choice was sold out or they did not believe that the scheduled times would be adhered to.

RTD personnel at the park-and-ride lots [the passenger assistance force (PAF)] consisted of venue captains and their assistants, who supervised the operations; fare exchange personnel, who sold tickets and tokens to those without passes; and passenger assistants, who loaded the buses and counted the passengers. Venue captains and assistant venue captains were drawn from the ranks of RTD's road supervisors and instructors. The others were volunteers from RTD's management staff.

The PAF received 1 day of training covering details of the special Olympic service and specific procedures for each of the tasks. Most of the passenger assistants and fare exchange personnel had had little or no previous experience with bus operations. Moreover, the problem of patrons arriving early and demanding transportation had not been foreseen. Consequently, crowd control measures had to be developed more or less on the spot. On most occasions, passenger loading adhered to the 20-min time periods established by the reservation system. However, on those occasions when large volumes of riders appeared and equipment levels permitted, passengers were loaded as they arrived without regard to whether they had reservations or the times of those reservations.

In most cases, there was sufficient equipment available to board everyone within 20 min of their arrival at the lots. At other times, such as opening day, waits were longer. However, the lots were always cleared early enough to deliver everyone to their venues by the start of the event.

PROBLEMS

Two general types of problems were encountered during the operation of the Olympic park-and-ride program: first, there were difficulties in explaining the complexities of the Olympic bus service through a third party; and second, Ticketron had trouble keeping up with the orders.

The RTD brochure described the entire Olympic service, but some people were left with unanswered questions. Neither the Ticketron telephone operators nor the ticket clerks in the outlets were prepared to explain the system to inexperienced bus riders. RTD telephone information operators were trained to perform that function, but reaching them required an additional telephone call. Also, RTD information lines were frequently busy.

Ticketron had a variety of problems in keeping pace with the orders. Sales began slowly but soared at the beginning of July. A rush at the end had been anticipated but they were still unable to keep up. Consequently, telephone orders were cut off early and additional outlets were added to accommodate the demand for reservations.

Reservation clerks filled orders by using computer terminals. The 33 terminals in the Ticketron central office were more than had been needed for other special programs. For the Olympic program, the 33 terminals were staffed for two shifts and performed well. Problems that arose were due to the slowness of the ticket printers.

Orders were grouped and printed in batches. Tickets for each day of travel were printed, packaged, and mailed separately because the system was not designed to link them. Herein lay the source of most complaints. People ordered tickets for several days of travel at one time but received them separately. Some orders went astray or were delayed in the mail. Ticketron handled numerous complaints from people who had received partial orders. Most of these complaints were resolved when the remaining tickets subsequently arrived.

Given that printer capacity was the bottleneck, there was no reason to expand the capacity of the telephone operators beyond a certain point. All terminals were staffed all day, in contrast to the usual practice of staggering shifts to overlap only for a few hours; however, a third shift was not added.

Previously, Ticketron had conducted little mail-order business. Most of their business consisted of in-person transactions and orders that were purchased by credit card and picked up at a later date. Accordingly, they had a small staff trained to print tickets, stuff envelopes, and mail orders. The Olympic program overwhelmed their staff. Overall, the number of errors in filling orders was small; many of the errors, however, could be attributed to placing on the small staff demands to which they were not accustomed.

Long lines at the Ticketron outlets were another problem. Some customers demanded information and assistance beyond the ability of even the most well-intentioned clerks, slowing the processing of others. Over time, many clerks lost patience. Signs were posted at each outlet to inform customers about which dates and lots had sold out so that people would not wait needlessly. Additional outlets were added to relieve the pressure, and, occasionally, non-RTD Ticketron business was sent to outlets not participating in the RTD reservation program.

COST SAVINGS

One of the goals of the reservation system was to tailor service to demand in an attempt to keep costs at a minimum. Original estimates of equipment requirements were based on the mode-split targets, model of travel behavior, and roundtrip travel times. As reservations were placed, they were monitored and appropriate changes were made to estimates of capacity. In some cases service was added whereas in others it was reduced.

The final schedules reflected the latest information from the reservation system. However, schedules were finalized 10 days before each day of Olympic service and sales of reservations continued until one day before. Last-minute changes were effected through streamlined procedures and extra effort on the part of the RTD's planning, scheduling, transportation, and maintenance departments.

The number of buses actually put into service varied greatly from the original estimates. Service to the venues outside Exposition Park was reduced to reflect the lower-than-expected level of ridership. Service to Exposition Park was also reduced from some lots on the days when the coliseum was not operating. When the coliseum was operating, however, service was generally added.

The largest change between original estimate and final schedule was at Hollywood Park, which never sold out. An average of 38 buses was used to go to Exposition Park from Hollywood Park on each of the days the coliseum was in session, a substantial reduction from the 84 buses originally scheduled.

Overall, service was reduced on the park-and-ride lines a total of 900 bus-days. Even without reservations, much of that service might have been eliminated by the operations staff as it became apparent that it was not needed. With reservations, demand was predictable and it was possible to better match service to demand.

Putting a dollar figure on the actual number of buses that were not deployed is difficult because some of the service may have been eliminated anyway. Some of the buses would have been used for less than a full day. Considering these and other factors, the cost savings that resulted from using a reduced number of buses was in excess of $150,000 during the 16 days of service.

Other aspects of the savings cannot be quantified. The process of scheduling buses was smoother and more reliable with reservations than it would have been without them. Not only was service cut back ahead of time, but it was also added in advance, saving much aggravation, waiting, and operator overtime. Patrons were directed to lots with available capacity, preventing lots from overflowing. Peaks were spread, allowing better utilization of equipment and personnel.

SUMMARY AND CONCLUSIONS

The Olympic park-and-ride advance reservation system was a success. The problems encountered were relatively minor. Both the riding public and the RTD management benefited from having the system in place.

Given the chance to do it over again, only a few aspects of the program would be changed. RTD control of the parking lots would have improved planning, operations, and customer relations. Such control would have allowed parking and bus transportation to be combined and sold as a package. RTD could then have charged one uniform fee for its services regardless of park-and-ride location. Also, if people reserved parking spaces with their bus reservations, RTD would have better understood the number and timing of cars arriving at the lots.

Ticketron performed well under circumstances substantially different from those under which it usually operates. With hindsight, it can be seen that there is a need for more, if not all, of the local outlets to participate in the program from the beginning to spread the load and reduce confusion. Additional lead time would have allowed for the printing of special RTD ticket stock, although the RTD gold passes would still have been sold.

The limited capacity of the ticket printer can only be overcome by redesigning their system to allow batching of orders and by using faster equipment and experienced personnel.

Publication of this paper sponsored by Committee on Transportation Planning Needs and Requirements of Small and Medium-Sized Communities.

Comparison of Small-Area OD Estimation Techniques

RICHARD G. DOWLING and ADOLF D. MAY

ABSTRACT

Three different techniques for estimating or forecasting the vehicular origin-destination (OD) patterns within small areas such as central business districts are evaluated. The proportional technique estimates the OD table based solely on cordon gate traffic counts and internal zone trip generation estimates within the small study area. The LINKOD model technique estimates the OD table based on cordon counts, trip generation estimates, and traffic counts made within the study area. The regional technique employs a regional travel behavior model to identify regional travel patterns and extract a vehicular OD table for the small study area within the region. The regional technique was found to be the most accurate and the proportional technique the least accurate at estimating OD tables that, when assigned to the small study area street network, reproduced observed traffic volumes within the small area. However, the tradeoff between accuracy and data requirements was not linear. The regional technique required significantly more data and yet was only moderately more accurate than the proportional technique. The three techniques yielded very different estimates of the small-area OD table and yet when the three different OD tables were assigned to the street network, much of the difference was masked out by the assignment process. It was concluded that large errors in the OD estimation process could be tolerated at the expense of a small sacrifice in accuracy in the estimated traffic volumes. Based on this result, the potential of simplifying the OD estimation problem was then investigated. The internal zones were aggregated and all internal-internal cells in the OD table were deleted from the matrix. The result was a minor loss in accuracy when estimating traffic volume. The conclusion of this research is that the small-area vehicular OD table estimate does not have to be very precise to yield useful traffic volume estimates. One can simplify the OD estimation problem through aggregation and the use of simple OD estimation techniques. Although simpler OD estimation techniques are less accurate, the loss in accuracy is small compared with the savings in effort.

Increased interest in the refinement and optimization of traffic operations in small areas, such as central business districts (CBDs), has led to the development of refined traffic forecasting tools such as the CONTRAM (1) and MICROASSIGNMENT (2) traffic assignment models. However, these detailed analytical tools require as one of their inputs a vehicular OD table for the small study area, which traditionally has been obtained by means of expensive and time-consuming license plate, postcard, or roadside interview surveys. The difficulty of conducting OD field surveys at the fine level of detail required for CBDs has discouraged practitioners from using these refined traffic models for small study areas; consequently, investigators have begun to explore alternative, simpler techniques for estimating the vehicular OD patterns in a small study area.

Representative samples of these simple OD estimation techniques are investigated in this paper; their relative data requirements and performance are compared; techniques for simplifying the OD estimation problem are suggested; and the conditions for applying each technique are recommended.

TERMINOLOGY

A small study area is a subarea of a larger region. A typical small study area may be a 1-mi^2 (2.6-km^2) central business district located in a region with a 30-mi (50-km) radius. A study area is small when most of the trips observed in the study area are external trips (trips entering and/or leaving the small study area).

For purposes of OD estimation, it may be necessary to look at a larger area such as the whole region; however, the purpose of the effort is to develop OD data and traffic forecasts for only a small subarea within the region. Thus, the term "small study area" refers to a small area for which detailed traffic forecasts are desired and not the potentially larger area that may be considered in estimating the small area OD table.

The small study area is isolated from the region by a cordon line that has entry and exit points called gates where traffic can enter or leave the small study area. The region is defined as a large area containing the end points of more than 90 percent of the trips observed in the small study area.

The small study area OD table consists of zone-to-zone trips (internal-internal), zone-to-gate trips (internal-external), gate-to-zone trips (external-internal), and gate-to-gate trips (external-external).

OD ESTIMATION TECHNIQUES

Three OD estimation techniques will be discussed in this section: the regional technique, the LINKOD technique, and the proportional technique.

Regional Technique

When one does not have OD information for a small study area, the conventional approach has been to extract the small-area OD table from a travel behavior model calibrated for the region in which the small study area is located. The regional model is used to estimate the regional OD patterns; assign the vehicle trips to the regional network; and identify those trips entering, leaving, or passing through the small study area. Most standard traffic modeling packages have routines to identify the vehicular OD table for a small subarea.

This regional technique is theoretically straightforward; however, practically it is quite difficult. A regional model must be developed and calibrated if one does not exist or is not accessible to the investigator. If a preexisting model for the region is used, one must often revise the regional model zone system and network for the small study area and update the input data for the model; within the small study area, one must also relocate the person-trip end points to their respective vehicle-trip end points.

The regional technique is necessary to be able to forecast the effects of network changes (both within and outside the small study area) on the small-area OD patterns, but may not be necessary if one wishes to only simulate existing small-area OD patterns. Alternatively, one could estimate the small-area OD table strictly on the basis of information obtained within the small study area.

LINKOD Model Technique

Gur et al. (3-5) have developed a gravity model for small study areas that weights the likelihood of external trips by using each cordon gate according to the type of street facility at the entry and exit gates, and the change in direction of travel between the entry and exit gates. This initial estimate of the OD table (from the gravity model) is then adjusted so that an equilibrium assignment of this OD table reproduces the observed traffic volumes on the street within the small study area. This technique is used in the computer model LINKOD (3-5). This LINKOD model technique thus reduces the data requirements for estimating a small-area OD table to traffic counts and trip generation data collected exclusively within the small study area.

Proportional Technique

An even simpler approach is available. Again focusing on the small study area alone, one can estimate the small-area vehicular OD table by using the proportional technique. The row and column totals of the OD table are estimated from cordon gate counts and trip generation estimates for the internal zones. The estimated number of trips for each cell of the table is then as follows:

$$T_{ij} = T_i \times T_j/T \qquad (1)$$

where

T_{ij} = number of trips from i to j,
T_i = total number of trips originating at i,
T_j = total number of trips destined to j, and
T = total number of trips in table.

These estimates (T_{ij}) are then Furness adjusted (6) to sum to the desired row and column totals.

Comparison of Techniques

The proportional technique requires the least amount of data and consequently would be expected to produce the least accurate simulation of the existing small-area vehicular OD table. In contrast, the regional technique requires the most data and analytical effort and would be expected to be the most accurate. The LINKOD model technique would be expected to be intermediate in accuracy. This is indeed the case as demonstrated in the next section; however, as will be shown, the trade-off between accuracy and data requirements is not strictly linear.

EVALUATION

The accuracy of the three techniques was determined by comparing the ability of the estimated OD tables (when assigned to the small study-area street network) to reproduce observed traffic volumes. The small study area selected for this evaluation was the CBD of San Jose, California. The San Jose CBD includes about 69 city blocks covering an area of about 1 mi^2 (2.6 km^2) (see Figure 1).

Chenu (7) used the regional technique to simulate a 1975 OD table for the San Jose CBD. The model-estimated OD table was Furness adjusted to match the observed cordon gate volumes for the CBD. This CBD OD table was then used to test and validate the MICROASSIGNMENT model.

Later, Han et al. (8) tested the ability of the LINKOD model to simulate the same 1975 OD table for the San Jose CBD. The same MICROASSIGNMENT model was used to simulate the extensive traffic count input information for LINKOD as well as to subsequently test the OD table output by LINKOD. This was admittedly a hypothetical test of LINKOD with 100 percent turning movement count information synthesized by the MICROASSIGNMENT model.

A simple, proportional OD table was developed by using the same cordon gate traffic counts and trip generation estimates that were derived by Chenu and used by Han. This table was also assigned to the San Jose CBD network by using the MICROASSIGNMENT model.

The resulting traffic-volume estimates of the three tables (regional, LINKOD, and proportional) were compared at three screen lines crossing the CBD (see Figure 1). The results are given in Table 1. Figures 2, 3, and 4 show the resulting scatter diagrams for each technique.

As the results indicate, the regional technique is most accurate and the proportional technique is least accurate. The LINKOD model technique is fairly close in accuracy to the regional technique. Considering the large difference in data requirements for each OD estimation technique, the resulting volume estimates are fairly close. The regional technique requires not only the same information as does the proportional technique (CBD trip generation and cordon counts) but requires as well trip distribution and network data for the entire region. Yet for all of this extra information and computational effort, one improves the accuracy of the estimated traffic volumes by just one-third over that of the simple proportional technique.

However, a direct comparison of the LINKOD- and proportional-estimated OD tables with the regional-technique estimated table (shown in Table 2) shows that the three tables are very different. The mean absolute difference between tables approaches or exceeds 100 percent of the mean number of trips per cell. The root mean square (RMS) difference is 5 to 8 times the mean trips per cell.

As has been found in previous research [see e.g., Texas DOT (9)], Tables 1 and 2 show that much of the difference among OD table estimates is masked by the traffic assignment technique. This would appear to indicate that one could be less elaborate in estimating the OD table without unduly sacrificing projection accuracy of traffic volume.

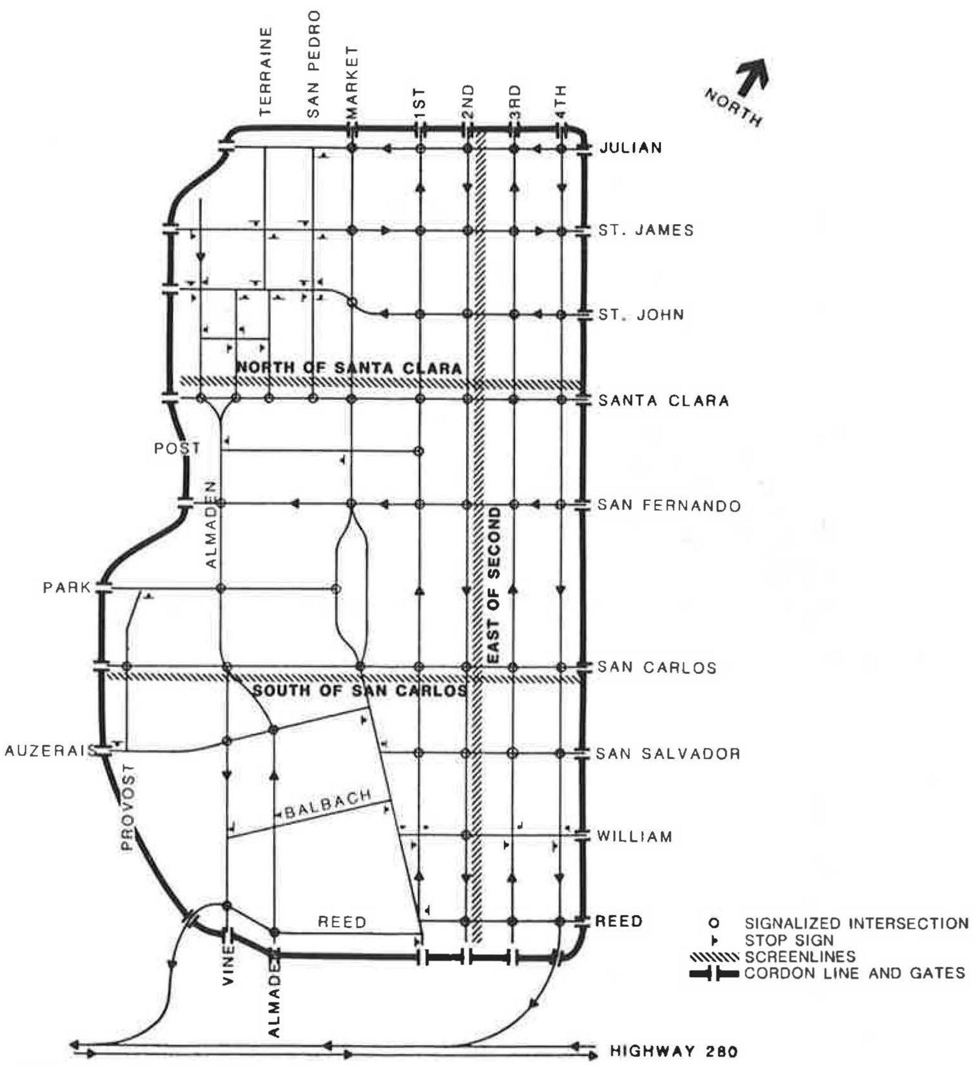


FIGURE 1 San Jose CBD study area.

TABLE 1 Comparison of Estimated Screen-Line Volumes

	OD Estimation Technique		
Statistic[a]	Regional	LINKOD	Proportional
Total no. of screen-line trips	19,700	19,400	23,400
Percent of counts	96	94	114
Mean absolute error	100	112	147
Percent of mean volume[b]	15	16	21
Root mean square error	125	142	188
Percent of mean value[b]	18	21	27

[a] Estimates compared with 30 traffic counts totaling 20,600 peak-hour trips for 3 screen lines as shown in Figure 1.

[b] Ratio of error to mean trips per cell times 100 percent.

A review of the OD table estimated by using the regional technique indicated that the vast majority (80 percent) of the cells in this table contained zero trips. Less than 2 percent of the 18,000 cells in this table contained more than 10 trips and yet these few cells contained 69 percent of the total trips in the table. In particular, the cells representing internal-internal trips represented 50 percent of the cells in the OD table and yet contained only 1 percent of the trips.

Thus, it was decided to test the option of simplifying the OD estimation problem by aggregating the 100 internal zones to 13 internal zones and eliminating internal-internal cells from the OD table. The three OD tables were each aggregated and truncated to about 1,000 cells.

The original MICROASSIGNMENT model, which had been used to estimate traffic volumes for a finely detailed CBD network with each turning movement represented by a link, was no longer appropriate for a highly aggregated OD table. Therefore, a much simpler network was selected (with intersections represented as nodes) and a standard incremental, capacity-restrained algorithm was used to assign the traffic [TRANPLAN (10)].

The screen-line volume results showed a moderate decrease in accuracy when each OD table was aggregated. The RMS error for the regional technique increased from 18 percent at the disaggregate level to 30 percent at the aggregate level. For the proportional technique, the RMS error increased from 27 to 36 percent. The LINKOD model could not be tested at the aggregate level because of time constraints unrelated to the LINKOD model; however, its results at the aggregate level would also be expected to be intermediate between those of the regional and proportional techniques.

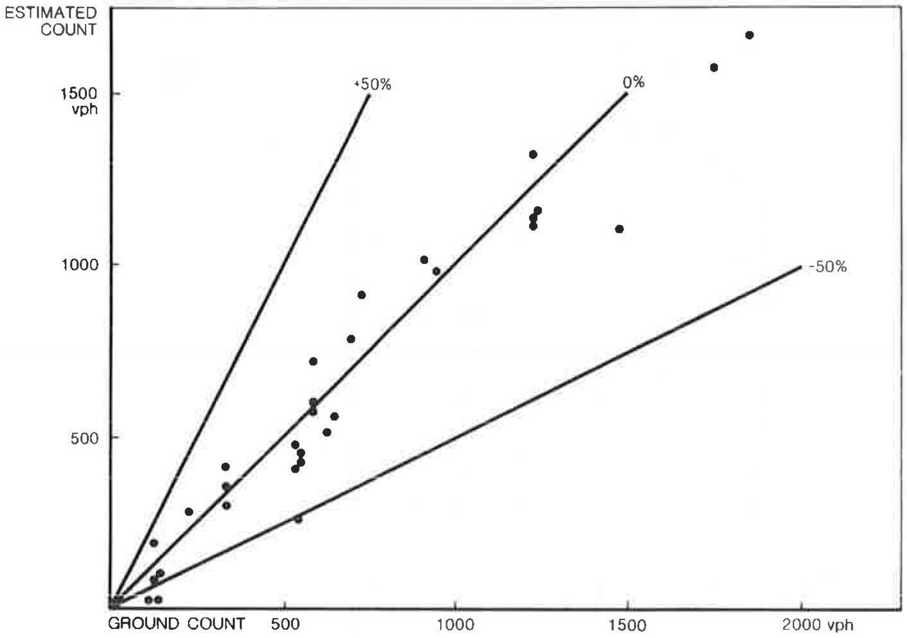


FIGURE 2 Screen-line scatter diagram—regional technique.

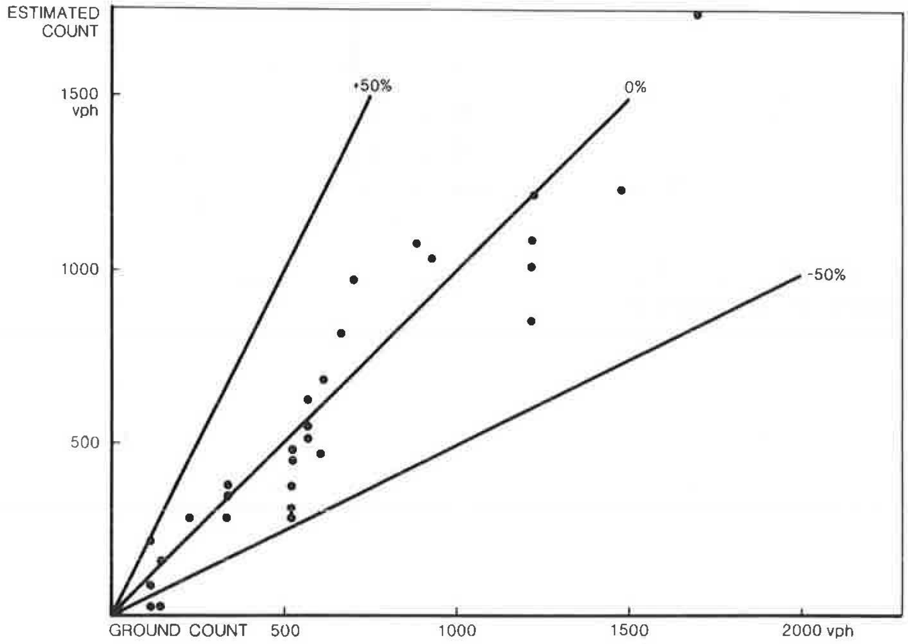


FIGURE 3 Screen-line scatter diagram—LINKOD model technique (100 percent counts).

Figures 5 and 6 show the scattered diagrams comparing the model-estimated screen-line volumes for the regional and proportional techniques with the observed traffic counts.

Figure 7 is a summary of the results of these tests, comparing the accuracy of the resulting internal screen-line volume estimates with the amount of data required for each technique.

To show how rapidly the error in traffic volume estimates is reduced by simple information, two additional points are shown in Figure 7. One point, Table with Zero Trips, is the know-nothing estimate in which no information is available and all volumes are estimated to be zero. The second point, Table of Mean Cell Volumes, shows the improved accuracy if just one piece of information, the total number of trips in the system, is known. The best estimate for each cell of the OD table is then the total number of trips divided by the number of cells in the table.

As can be seen in Figure 7, there is a rapid flattening of the curves when the row and column totals (trip generation and cordon gate counts) of

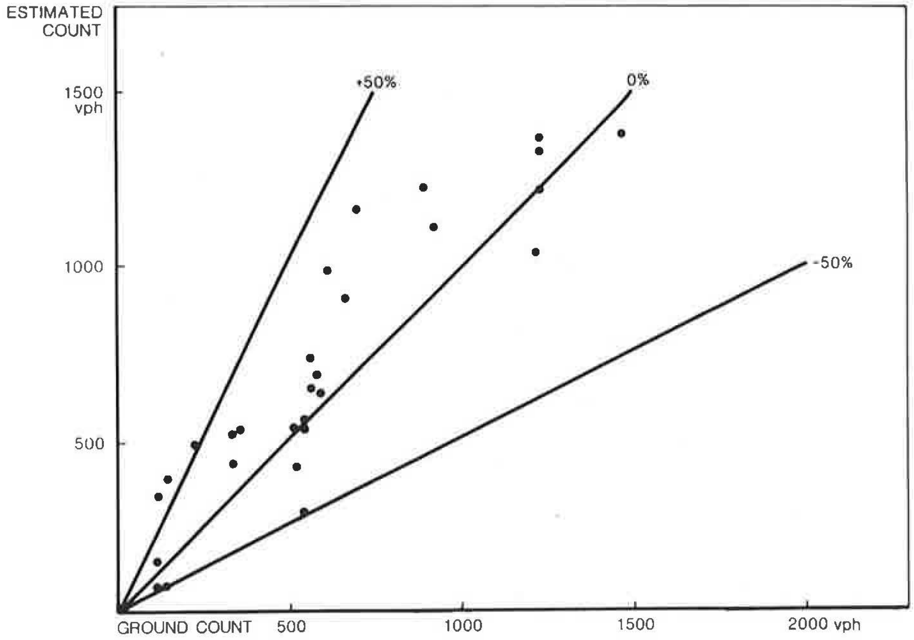


FIGURE 4 Screen-line scatter diagram—proportional technique.

TABLE 2 Comparison of Estimated OD Tables

	OD Estimation Technique		
Statistic[a]	Regional	LINKOD	Proportional
Total no. of trips in table	16,200	16,400	15,800
Percent of regional approach	100	101	98
Mean absolute error (MABS) (trips)	0	0.87	1.02
Percent of mean cell value[b]	0	89	105
Root mean square error (trips)	0	6.28	9.46
Percent of mean cell value[b]	0	645	973

[a] All tables compared with OD table estimated by regional technique.
[b] Ratio of error (MABS or RMS) to number of mean trips per cell of the regional-technique estimated OD table.

the small-area OD table are known. Further large increases in data result in only minor improvements in accuracy.

CONCLUSIONS AND RECOMMENDATIONS

The comparison of these three techniques for estimating small-area vehicular OD tables has demonstrated that a relatively large amount of error and aggregation can be tolerated in the estimated OD table without unduly reducing the accuracy of the traffic volume estimates. Indeed, when the row and column totals of the OD table are known, it is difficult to further improve the accuracy of resulting

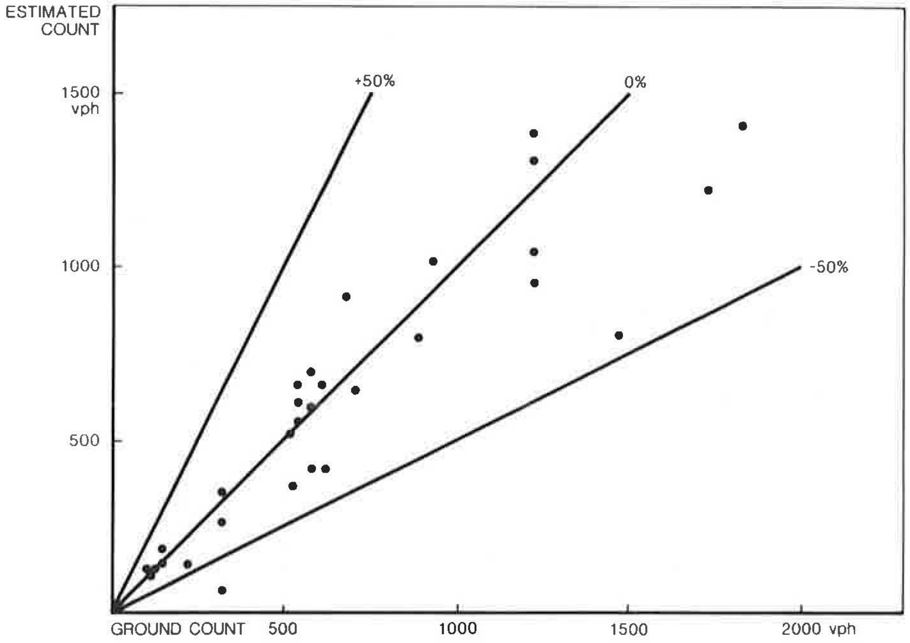


FIGURE 5 Screen-line scatter diagram—regional technique (aggregated, truncated table).

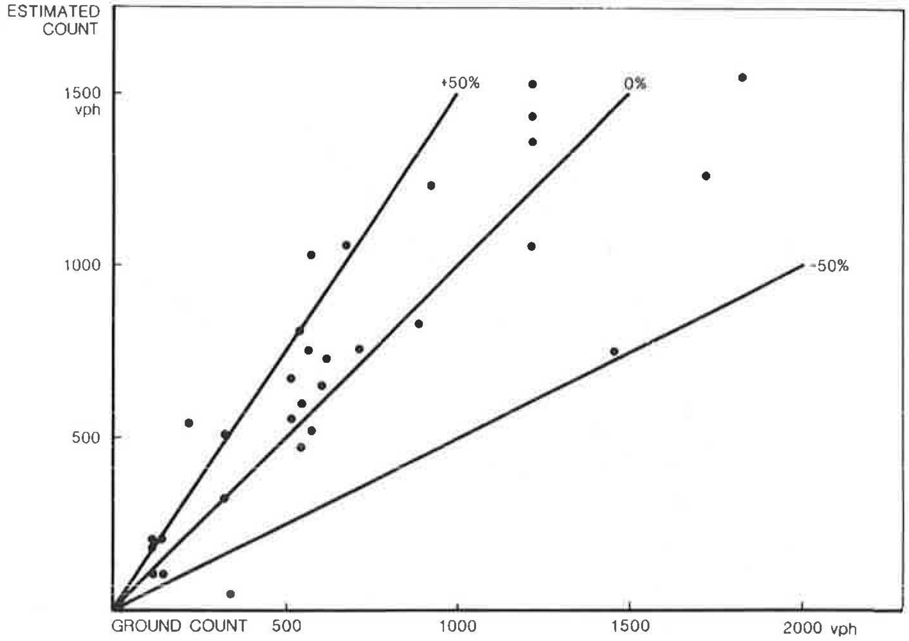


FIGURE 6 Screen-line scatter diagram—proportional technique (aggregated, truncated table).

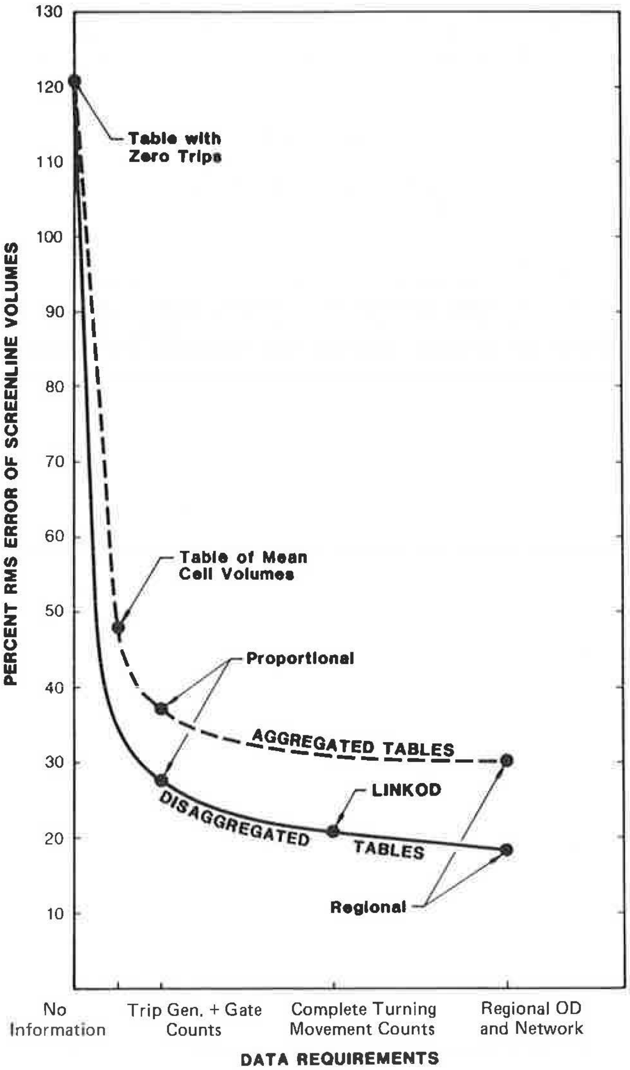


FIGURE 7 Cost-effectiveness of OD estimation techniques.

traffic volume estimates. The regional and LINKOD model techniques require a significant amount of additional data and yet yield only moderate improvements in accuracy.

It must be pointed out, however, that often the purpose of CBD traffic studies is to make very detailed evaluations of circulation improvement alternatives and therefore a high degree of accuracy in the traffic volume estimates may be required. Nevertheless, even the most accurate technique considered in this paper, the regional disaggregate technique, still has a great deal of error in its volume estimates.

Figure 8 gives a summary of the recommended applications for each of the techniques. Where accuracy is less critical but forecasting is still required, there appears to be an opportunity for a simplified version of the regional technique that could reduce the data requirements of this approach without unduly sacrificing accuracy. One possible technique for simplifying the regional technique is described by Dowling (11).

IS ACCURACY IMPORTANT?

IS OD FORECASTING REQUIRED?	YES	NO
NO	LINKOD TYPE TECHNIQUE	PROPORTIONAL TECHNIQUE
YES	REGIONAL APPROACH	SIMPLIFIED REGIONAL APPROACH

FIGURE 8 Recommended applications for small-area OD techniques.

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Publication of this paper sponsored by Committee on Transportation Planning Needs and Requirements of Small and Medium-Sized Communities.

Estimating OD Tables Using Empirical Route-Choice Information with Application to Bicycle Traffic

M. F. A. M. van MAARSEVEEN, G. R. M. JANSEN, and P. H. L. BOVY

ABSTRACT

A new method for estimating origin-destination (OD) tables is presented that uses road counts and route-choice information. The innovative feature of the estimation method, a refined version of the information-minimizing approach, is the use of empirical route-choice information. The method has been applied in an evaluation study of a cycleway network in a medium-sized city in the western part of The Netherlands. In this study, OD matrices were estimated to determine changes in travel patterns of bicycle users caused by the implementation of a new bicycle network scheme. The method that proved to be useful can be applied equally well to automobile traffic by using route information derived from, for example, license-plate surveys.

Unlike in the United States, the bicycle is a major transportation mode for urban travel in The Netherlands. A modal share of 50 percent is not uncommon. After a period of steady decline of bicycle use, policies are being designed to enhance this inexpensive, low-energy mode without any negative effects on the environment.

BICYCLE NETWORK SCHEME

In October 1982, the public works department of Delft, a medium-sized city with a population of 100,000 in the western part of The Netherlands, started implementing an ambitious bicycle network scheme. This scheme consisted of a considerable extension and improvement of existing bicycle facilities in such a way that a citywide, comprehensive, and hierarchical cycleway network was generated. The plan was intended to make cycling safer, faster, and more comfortable, in particular for those groups of the population that are captive users of the bicycle mode (e.g., pupils and younger students). The second, more general, objective was to promote the bicycle mode to reduce usage of cars for local trips.

The basic idea was to realize a comprehensive cycleway network. In this respect, the project was unique even by Dutch standards. The characteristic feature of the planned system was that the network would consist of three subnetworks hierarchically related: an urban network, a district network, and--at the lowest level--a local network. The urban level network would consist of a grid of corridors that traverse the entire urban area and would be connected with regional bicycle facilities. The district level network mainly would have two functions: providing access to major, specific district facilities (e.g., schools and shopping centers) and linking the districts with the urban network. The facilities at the local level would provide access to houses and other adjoining land development.

The bicycle network scheme involved a variety of measures, related both to infrastructure (new cycle tracks and constructions such as bridges and tunnels, improvement of cycleways and intersections, extension of bicycle park facilities) and operations (various traffic signal control changes, exempting cyclists from one-way traffic systems).

EVALUATION STUDY

In view of the experimental nature of the bicycle network scheme and the huge amounts of expenditures involved ($25 million), a careful evaluation of the plan needed to be made. A number of studies were performed to this end: an analysis of changes in safety, an evaluation of the use of the network, and an in-depth attitudinal survey with the purpose of determining potential modal shifts. In this paper, discussion is limited to the evaluation of the use of the new network.

The effects of the network scheme on travel patterns of bicycle users were determined by using a comprehensive before-and-after survey. The main evaluation items were the changes in origin-destination (OD) pattern and in the route choice behavior of these travelers. More specifically, evaluation of network use needs to address the following aspects:

- Effectiveness of the network scheme: What are the effects on the travel patterns of various groups of bicycle users? What are the changes in the accessibility of various activity centers?
- Structure of the network: Do bicycle users choose routes according to the hierarchical principle of the network? Do they use the most direct routes? How does the network perform in view of the spacing of the urban corridors?
- Route-choice behavior of bicyclists: Which factors influence route-choice behavior?

In this paper, only the establishment of OD tables of bicycle trips will be addressed.

A NEW METHOD FOR ESTIMATING OD MATRICES USING EMPIRICAL ROUTE INFORMATION

To determine changes in travel patterns of bicycle users, an OD matrix has to be estimated before and after the scheme is implemented. A new method for estimating OD matrices was developed that uses road counts and empirical information on routes followed by bicycle users. Use of this empirical route information is the innovative feature of this estimation technique.

In view of the specific nature of bicycle travel, it was decided to set up a manifold measuring program to determine actual bicycle use in a study area within the city of Delft before and after the realization of distinct facilities. The program consisted of extensive continuous and periodic traffic counts, short roadside interviews, and a mail-back route-choice survey. The most essential part of the approach was the determination of the routes that were actually followed during bicycle trips. The resulting information played a crucial role in the evaluation study of the use of the network in both the route choice analysis and the estimation of OD matrices.

It is worth mentioning that the method presented can, in principle, also be applied to automobile traffic. The necessary route-choice information of automobile drivers can be gathered by roadside interviews or license-plate surveys. The only essential difference is that with automobile travel the procedure should be able to take account of congestion effects.

ORGANIZATION OF THE PAPER

In this paper, the authors confine themselves to the estimation problem of an OD matrix using various sources of information, although these sources are incomplete. First, the approach adopted in the before survey of the evaluation study of the network use is described. Second, the problem of estimating OD matrices from traffic counts is discussed in a general setting. The discussion is meant to demonstrate that route-choice behavior is the key link between the desired information (the OD matrix) on the one hand and the available observations (link volumes) on the other. In other words, route-choice information is essential to the estimation problem posed. Further, how the method of information minimization can take into account the route-choice information is indicated.

In the section on Application, the procedures used to estimate an OD matrix of bicycle traffic within the scope of the evaluation study are described in detail. Attention is given to the processes of data collection and preparation and to the ways in which the various kinds of information are used. Empirical route-choice information is continuous throughout the section. In the final section, some estimation results are presented.

STUDY APPROACH

The study focused on the actual use of the cycleway network in the northwest part of Delft (an area with a population of 20,000) before and after the realization of the bicycle network scheme. The study area (approximately 250 hectare) encloses several activity centers (primary and secondary schools, shopping center, hospital, railway station, etc.) and adjoins the inner city (see Figure 1).

Because it was expected that a substantial part of the relevant bicycle trips were made by noninhabitants of the study area passing through (some 30 to 40 percent), it was decided to collect data mainly from traffic counts and a cordon roadside interview coupled with a mail-back route-choice survey. Specifically, the data collection program consisted of the following:

- A cordon roadside interview. A random sample

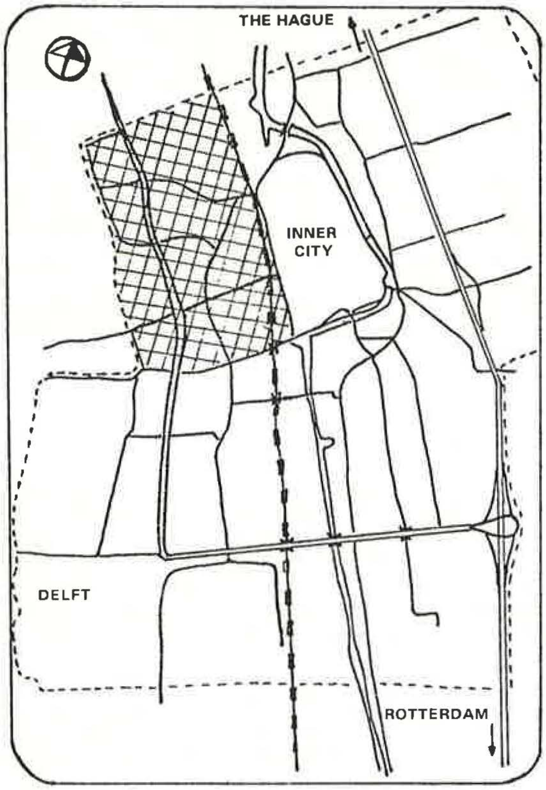


FIGURE 1 Study area.

of bicyclists leaving the study area was stopped at roadside interview stations located at the cordon line; information was obtained regarding origin, destination, purpose, gender, and age.

- A mail-back route-choice survey. In addition, a route-choice questionnaire was handed out to each person interviewed; he was asked to complete the form and to return it by mail. The main question concerned plotting on a city map the route followed for the trip during which the traveler was interviewed.
- Continuous traffic counts. During the whole survey day, all bicycle trips leaving and entering the study area were counted in 15-min intervals to determine the extent of and daily fluctuations in the traffic volumes in question.
- Periodic traffic counts. Traffic volumes were counted inside the study area at a large number of intersections and links during each of five short time periods (25 min) scattered throughout the day. The locations of the counts were selected in such a way that the study area was intersected by a number of imaginary screenlines, which divided the area into 10 zones. As a consequence, it was impossible to ride from one zone to another without passing one or more counting points.

In addition, some information (although incomplete) was available from previous traffic counts as well as from a recent home interview taken from a random sample of inhabitants of the study area. All these fairly diverse pieces of information were used for the establishment of the OD matrices. For the purpose of analysis of the OD pattern of bicycle trips that make use of the cycleway network in the study area, the city of Delft and the surrounding area were divided into 63 zones, 25 of which were situated inside the study area; the latter zones were subzones of the 10 screen-line building zones mentioned earlier.

According to the location of the trip ends, that is, OD zone inside or outside the study area, the bicycle trips can be subdivided into 4 categories:

Origin-destination zone	Inside study area	Outside study area
Inside study area	Internal trips	Outbound trips
Outside study area	Inbound trips	Through trips

The roadside interview together with the continuous traffic counts provided reliable and detailed information with respect to through traffic and outbound traffic (i.e., trips leaving the study area). In other words, a part of the OD matrix, the shaded cells in the matrix, could be estimated directly from the results of the roadside interview.

The main problem with the study design that was adopted was the determination of the internal traffic flows and to a lesser extent the inbound traffic flows of the study area (the nonshaded cells of the OD matrix). Information with respect to the flows in both quadrants had to be derived primarily from the periodic traffic counts (on the screen lines inside the study area) and from the continuous counts on the cordon line of the trips entering the study area. However, a simple estimation of these nonshaded parts of the OD matrix from these counts was not possible because of the interference with through and outbound trips.

For this reason, in order to derive estimates for the nonshaded cells in the OD matrix, an approach was chosen in which the entire OD matrix, at an aggregate level, was estimated simultaneously by using all the available information. In this approach, a crucial role was played by the empirical route information obtained from the mail-back route-choice survey. For example, it was possible to derive information on the number of outbound and through trips that pass a particular counting point from this survey.

For estimation purposes, the authors developed and used an extended version of the information minimizing approach, which is described in detail in the next section.

THEORY OF OD MATRIX ESTIMATION

OD Matrices and Traffic Counts

Essentially, the estimation of OD flows from traffic counts is the inverse process of that of assignment, in which link volumes are estimated given an OD matrix [e.g., Willumsen (1), Bell (2)]. The key issue is the absence of a unique solution to the equivalent mathematical problem: in general, several OD tables may be constructed that reproduce the same set of link volumes. This stems from the number of OD pairs (unknown variables) usually being significantly larger than the number of independent observations. The information contained in traffic counts may be called incomplete in this respect.

Let V_a denote the observed volume at link a; then the fundamental equations of the estimation problem are given by

$$V_a = \sum_{i,j} p_{ij}^a T_{ij} \quad \text{for all a} \qquad (1)$$

where T_{ij} denotes the number of trips from zone i to zone j; and p_{ij}^a, $0 \leq p_{ij}^a \leq 1$, is the proportion of traffic from zone i to zone j that uses the counted link a. For the time being, assume that these proportions are known. Subsequently, this assumption will be reconsidered in detail.

In practice, the number of unknown quantities T_{ij} is usually substantially larger than the number of independent observations [i.e., the number of mutually independent linear equations in Willumsen (1)]. Then the mathematical problem is ill specified and many solutions exist. The problem of interdependency between the counts and the resulting potential inconsistency of the data will not be discussed here [see van Zuylen (3)].

Within the practical limits of an investigation, it is recommended that the number of independent observations be maximized, which requires a sophisticated plan for the counting program. Furthermore, it is worthwhile to reduce the set of solutions by adding essentially new information of a different kind (see also a succeeding section on Application). Unfortunately, this approach still is not nearly a guarantee for a unique solution to the estimation problem and it will be necessary to choose among the set of alternative feasible solutions according to some rule.

The Information-Minimizing Method

One approach to tackling this problem of choosing one solution is to calculate the information contained in the trip matrix (T_{ij}). Because the information available in the set of traffic counts is insufficient for determining a unique trip matrix, it appears reasonable to choose a trip matrix that adds as little information as possible to that contained in Equation 1. This approach has been followed by van Zuylen (3-5) using Brillouin's information measure. In the information-minimizing approach, the original estimation problem is transformed into a mathematical optimization problem: minimize the associated information measure with respect to the independent variables T_{ij} under the constraints given in Equation 1. The solution to the optimization problem can be written in the form

$$T_{ij} = t_{ij} X_o \underset{a}{\P} X_a p_{ij}^a \qquad \text{for all } i \text{ and } j \qquad (2)$$

where t_{ij} denotes an a priori estimate of T_{ij} (e.g., an old trip matrix). In the absence of any a priori information, one simply substitutes $t_{ij} = 1$ for all i and j. The quantities X_o and X_1 (for all a) have to be computed numerically by substituting Equation 2 into the fundamental Equation 1. This numerical problem can be solved using some recursive algorithm, or in particular, the computer program NEST (Network flow ESTimation) developed by van Zuylen (5).

Route Choice

A serious problem in estimating OD matrices from traffic counts is the determination of the proportion of the trips between a particular OD pair that takes a specific counted link, that is, p_{ij}^a. The fundamental Equation 1 shows that the route-choice proportions p_{ij}^a determine the mathematical relationship between the measurements V_a and the unknown quantities T_{ij}.

In case each OD pair uses only one route (and it is known which one), the proportions p_{ij}^a having values 0 or 1 indicate which of the OD pairs use link a. However, in many applications many alternative routes are used for a considerable number of OD pairs, which makes the problem much more complex. In this context, a route should be seen as some ordered sequence of counted links.

So far, it has been assumed that the route-choice proportions are known. In normal practice, however, these proportions are often unknown just as is the trip matrix. The question arises about how to choose the proportions p_{ij}^a in more complex applications. Although until now little research has been done about the consequences of an erroneous choice of these proportions, the fundamental equations suggest that these errors carry over into the estimated trip matrix considerably.

Refining the Method

In more complex applications, and as in the authors' case favorably circumstanced by available (incomplete) route-choice information, it is plausible to treat the route-choice proportions in the same way as the unknown trip matrix. The information-minimizing approach can be adapted accordingly, simply by splitting up the cells in the OD matrix. The following two definitions apply:

T_{ijr} = route flow, the number of trips from zone i to zone j that use route r (the total number of routes may differ for each OD-pair); and

δ_{ijr}^a = 1 if link a is part of route r of OD pair (i,j) and 0 otherwise.

Then, the fundamental equation can be written as

$$V_a = \sum_{i,j,r} \delta_{ijr}^a \qquad \text{for all } a \qquad (3)$$

where the variables T_{ijr} represent the quantities to be estimated.

Note that the problem of identifying the OD route flows that take a specific counted link, that is, the determination of the route-choice indicators δ_{ijr}^a, is still present. In the authors' case, this information was derived from the mail-back route-choice survey.

However, the proportions p_{ij}^a are estimated simultaneously with the unknown trip matrix; they are given by

$$p_{ij}^a = \left(\sum_r \delta_{ijr}^a T_{ijr}\right) \Big/ \left(\sum_r T_{ijr}\right) \qquad \text{for all } i, j, \text{ and } a \qquad (4)$$

Following the information-minimizing approach, it can be shown (6) that the solution to this estimation problem is given by

$$T_{ijr} = t_{ijr} X_o \underset{a}{\P} X_a^{\delta_{ijr}^a} \qquad \text{for all } i, j, \text{ and } r \qquad (5)$$

where t_{ijr} represents some a priori estimate for T_{ijr}. Hence, the numerical solution can be derived in a way similar to that done previously. Finally, the unknown trip matrix satisfies

$$T_{ij} = \sum_r T_{ijr} \qquad \text{for all } i \text{ and } j \qquad (6)$$

Equation 6 could also be used as an additional constraint (compare with Equation 3) in case partial information about the OD matrix is available from other sources (e.g., roadside interview).

The main advantage of the latter approach is that all kinds of additional information (such as empirical route-choice information) can be dealt with in a straightforward way, as will be shown in the next section. Moreover, although outside the scope of this paper, the explicit approach in terms of routes allows for an elegant and direct handling of interdependencies between measurements.

The price that must be paid, however, is the largely increased number of unknowns in the estimation problem in more complex applications. Therefore, the use of additional information is strongly recommended. Although the estimates of the route flows T_{ijr} will be relatively less reliable than the estimates of the OD trips in the former approach, the authors believe that the resulting aggregate trip matrix is more reliable because the authors use significantly more information in deriving it and therefore do not have to rely on untested assumptions.

Application of the refined version of the information-minimizing approach is particularly preferable if the problem satisfies the following conditions:

1. The available information is diverse in nature (e.g., counts, routes, trip rates) and incomplete, and a substantial part of the information refers to traffic counts;
2. The information obtained from various counts and other sources cannot be treated as being independent;
3. Several alternative routes are used by the trips between most of the OD pairs (i.e., routes that differ in their ordered sequence of counted links).

This is precisely the case with the evaluation study of the bicycle network scheme.

APPLICATION

Data Collection

According to the data collection program described in the section on Study Approach, the various data were collected on the survey day, September 29, 1982, from 7:00 a.m. to 7:00 p.m. Within this period, more than 25,000 bicyclists were counted leaving the study area at 1 of the 15 roadside interview stations at the cordon line. Approximately 4,000 of these bicyclists (a 16 percent sample) were interviewed and given the route-choice questionnaire. More than 2,500 of these questionnaires were completed and sent back, implying a response of some 60 percent after editing.

In the opposite direction, 24,912 bicyclists were counted entering the study area. Table 1 presents an overview of the net results of the data collected at the cordon line. Moreover, at the screen lines inside the study area, 169 bicycle traffic flows (corresponding to 9 intersections and 33 road links) were counted periodically, during each of 5 25-min time periods scattered throughout the survey day.

Data Preparation

The OD Matrix

The study design--in particular, the partitioning of the study area by the screen lines into 10 zones--only permits estimation of the internal trips at the level of these 10 zones. In addition, in estimating the number of internal trips from the traffic counts inside the study area, the authors were only interested in those parts of through and outbound bicycle trips that were within the study area. For these reasons, the OD matrix to be estimated was defined in such a way that each OD zone corresponded with either 1 of the 10 internal zones mentioned earlier, or 1 of 13 feeding nodes at the cordon line (Roadside Stations 3, 4, and 5 were combined into a single OD zone). Consequently, the OD matrix of interest is a 23-by-23 matrix.

TABLE 1 Net Results of Data Collected at Cordon Line

Roadside Station	Entering Bicycle Trips (counts)	Leaving Bicycle Trips		
		Counts	Inverviews	Routes
1	1,592	1,548	288	168
2	3,016	3,254	474	265
3	205	139	74	30
4	480	439	113	52
5	280	521	144	94
6	4,580	4,577	545	265
7	3,121	2,250	384	238
8	1,949	2,888	274	181
9	595	678	145	72
10	3,638	3,578	504	301
11	1,641	767	186	88
12	1,039	1,676	234	119
13	547	832	192	105
14	543	473	113	67
15	1,686	1,677	220	149
Total	24,912	25,296	3,863	2,194

Note: Data were collected on September 29, 1982, from 7:00 a.m. to 7:00 p.m.

Route Choice Indicators

Having defined all the OD pairs, it was necessary to determine the route-choice indicators δ^{a}_{ijr}, that is, to solve the following identification problem: which routes are used for each OD pair and what are the counting points that each route passes? This problem was solved by using the results of the empirical route-choice survey. (A completed route-choice survey consisted of a map of the study area with an X at the point of origin and the point of destination and a line drawn between these two points, indicating the route chosen.) In general, these results indicate that in urban areas a large number of alternative routes are used for bicycle trips (Figure 2).

For the purpose of route-choice analysis, a network description of the entire cycleway network in the city of Delft (including illegal bicycle links that were actually used) was set up and stored in a computer. (This description of the cycleway network consisted of a map of the study area marked with the counting points, which were numbered, and the routes between these points.) The empirical routes were coded in terms of the network description (an ordered sequence of links and nodes) and also stored. Furthermore, each counted flow was uniquely represented by an ordered set of nodes (two nodes for a link, three or four nodes for an intersection). Searching the routes for these ordered sets yielded a file of aggregate routes that were completely characterized by an ordered sequence of counted links (more precisely, of counted flows). Table 2 gives the distribution of the number of counting points over the set of available routes; on average, each route passed 3.3 counting points, and each counting point was taken on average by some 36 routes.

The routes used for the through and outbound trips (and the corresponding route-choice indicators) can be taken directly from the results of the

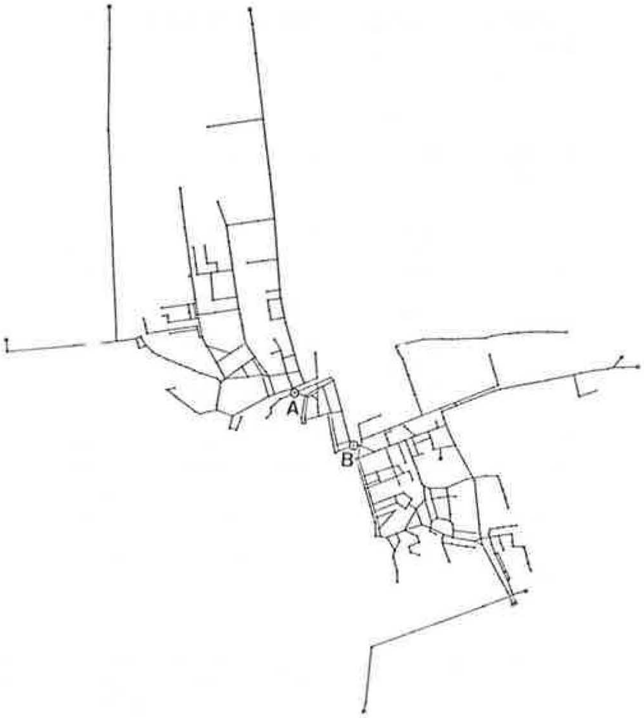


FIGURE 2 Selection of empirical bicycle routes passing nodes A and B.

TABLE 2 The Number of Counting Points by Route

No. of Counting Points	No. of Routes	Percentage
1	553	25.2
2	451	20.6
3	207	9.4
4	265	12.1
5	325	14.8
6	273	12.4
7	53	2.4
8	42	1.9
9	24	1.1
10	0	0
11	1	0.0
Total	2,194	100.0

route-choice survey. Routes for the internal and inbound trips, however, were not observed and had to be generated in an automatic fashion by using the data file of the aggregate observed routes and the network description. These routes were generated by applying splitting-up and reversing procedures to original routes. That is, for each route, the OD zones that the route passed were examined; and for each OD pair, a subroute connecting them was subsequently derived (again in terms of an ordered sequence of counted links).

Moreover, the resulting file of subroutes was further extended by reversing the direction of these subroutes and determining the corresponding ordered sequences of counted links (accounting for alternative routes in one-way traffic systems). In this manner, the problem of estimating the routes (and the route-choice indicators) for internal and inbound trips was satisfactorily solved. The data in Table 3 show that the 393 OD pairs that actually occurred or possibly could occur used 953 different routes (at the considered level of aggregation). In particular, note that both the number of OD pairs and the number of actually used alternative routes by OD pair for through trips were relatively small.

TABLE 3 Some Characteristics of the Estimated OD-Matrix

Type of Trip	No. of OD Pairs[a]	No. of Routes[a]	No. of Trips
Through	83	124	8,333
Outbound	105	296	16,589
Inbound	105	257	16,212
Internal	100	276	7,224
Total	393	953	48,358

[a] Actually or possibly used.

Estimation Constraints V_a and t_{ij}

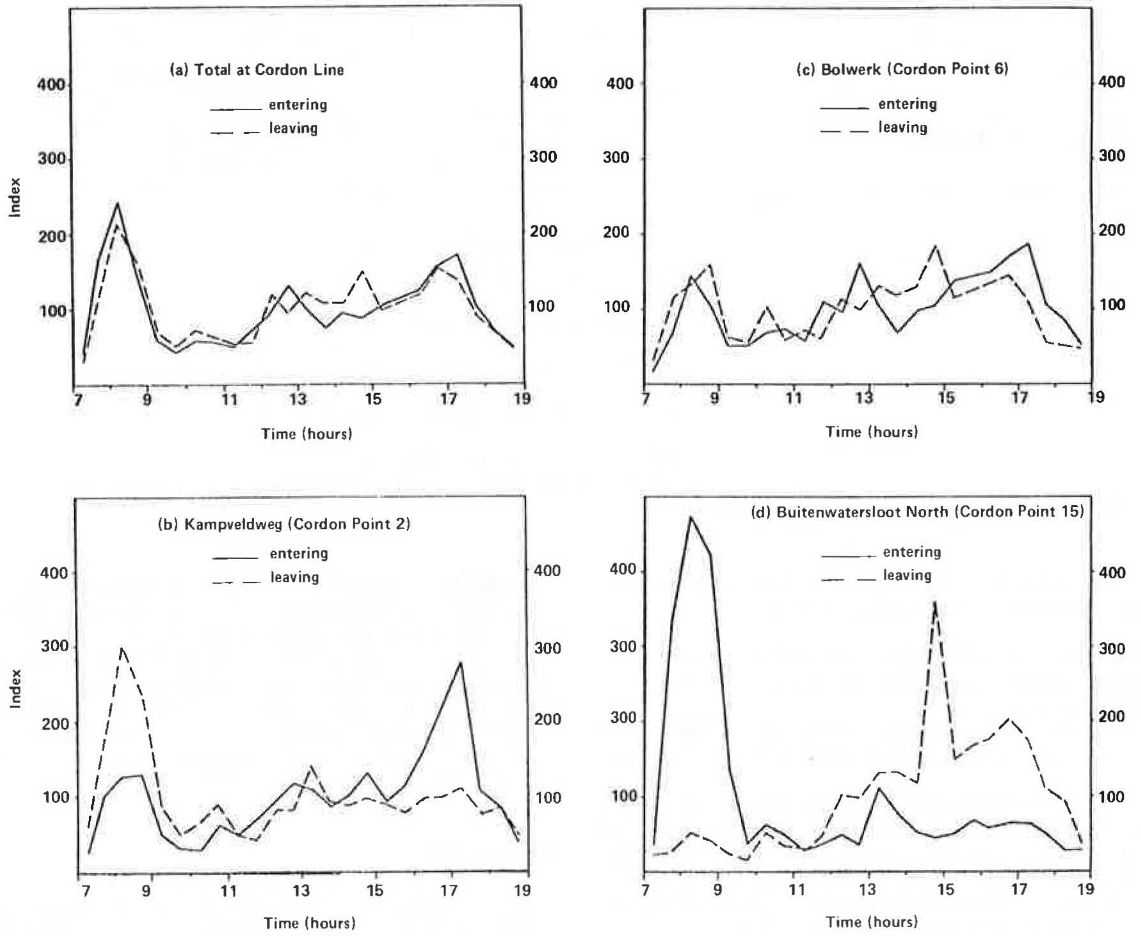
What are the constraints to be imposed on the route-flow estimation problem, that is, specification of Equation 3? First, continuous traffic counts at the cordon line (both traffic leaving and traffic entering the study area) are available, yielding 26 traffic volumes for the feeding nodes (the left side of Equation 3).

In addition, there are periodic counts; however, these have to be expanded to daily totals to be useful as constraints. The periodic traffic counts were expanded by using a special estimation procedure using route information, taking into account the correlation between periodic and continuous counts and the daily fluctuations in continuously measured traffic volumes.

It was found that the daily fluctuations at the cordon line highly depend on the location of the counted link. Figure 3 shows the variation of bicycle traffic intensities during the survey day for the total entering and leaving flows at the cordon line (a), and for a selection of roadside stations at this cordon line (b to d). In these diagrams, successive half-hour intensities are expressed in terms of index figures with respect to the average half-hour intensity on the spot throughout the survey day (index = 100).

Differences in the daily fluctuations among roadside stations could be ascribed mainly to differences in trip purposes; for example, trips at Station 2 (b) are predominantly work trips, trips at station 6 (c) are in the direction of the city center and have mixed purposes, and the flows at Station 15 (d) include a substantial number of school trips.

Therefore, it was concluded that it was necessary to develop an appropriate estimation procedure to expand the periodic counts to daily totals. For each periodic counting point, the set of matching routes in the route-choice survey was selected and the distribution of these routes among the roadside stations at the cordon line (the continuously counted links) was examined. Having determined the correlation between the periodic counting point and each of the continuously counted links at the cordon line and by using detailed results of the continuous counts, a weighed bicycle-traffic intensity pattern throughout the day was derived for each periodic counting point. Based on this representative intensity pattern and by using the counts in the measurement periods scattered throughout the day, a rather reliable estimate was derived for the daily total at each periodic counting point.



Note: Index = 100 refers to the average half-hour intensity on the spot.

FIGURE 3 Time-of-day pattern of bicycle flows at four spots.

A third group of constraints has to do with the observed trip flows. Previously, it was noted that the roadside interview yields reliable estimates for that part of the OD matrix that corresponds with through and outbound trips. Let t_{ij} denote the estimate of the number of (through or outbound) trips corresponding to OD pair (i,j) based on the results of the roadside interview. It is then plausible to pose the following constraint:

$$t_{ij} = \sum_r T_{ijr} \qquad (7)$$

for each OD pair forming through or outbound traffic. The authors obtained 188 of these constraints.

In summary, three categories of constraints can be distinguished:

1. 26 continuously counted link volumes,
2. 125 estimated daily link volumes of periodically counted traffic flows (some small counts were combined), and
3. 188 estimated OD volumes of through and outbound trips.

All constraints are linear equations in the unknown route flows T_{ijr} with coefficients having values 0 or 1, and allow for a straightforward application of the refined version of the information-minimizing approach.

A Priori Information t_{ijr}

It is well-known that a priori information affects the estimation results to a considerable degree and that its use is generally highly recommended. The authors are in the favorable position that a considerable part of the route-flow matrix could be estimated in advance by using the roadside interview and the route-choice survey. Thus, reliable a priori information is available with respect to those route flows t_{ijr} that correspond to through and outbound trips. A priori information with respect to inbound flows was derived from the a priori estimates of the traffic flows in the opposite direction.

Finally, the missing a priori information (the internal trips) was taken from the available results of a recent home interview. This interview contained various kinds of information from a 26-percent sample of households within the study area, including information about the main characteristics of all bicycle trips made during a single working day. Only internal trips were selected and, after expansion, an a priori route-flow matrix for internal trips was constructed and used in the estimation process, assuming that internal trips were made primarily by inhabitants of the study area.

ESTIMATION RESULTS

The information-minimizing approach was applied by using the computer program NEST (Network flow ESTi-

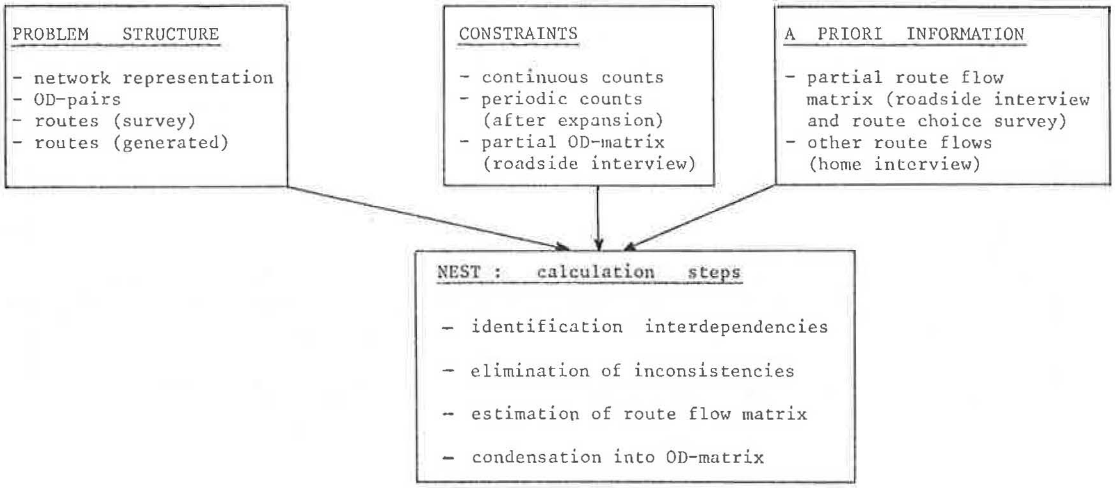


FIGURE 4 Outline of the estimation process.

mation) developed by van Zuylen. This program requires the following input (Figure 4):

- Definition of OD pairs to be estimated (in the authors' case, OD pairs by route yielding 953 unkown variables T_{ijr}).
- Definition of observed links (the left side in the constraints, and in the authors' 339 observations).
- Coupling of observations with route OD pairs, that is, listing for each observed link the route OD pairs included in the link flow; or, alternatively, listing for each route OD pair the observed links it takes. (In fact, this corresponds to indicating the value of the route-choice indicators δ^a_{ijr}.)
- Observed link volumes (the actual values for the left side in the constraints) V_a and t_{ij}.
- A priori estimates of the route flows for each cell of the route OD matrix (optionally) T_{ijr}.
- Some program parameters.

The program carries out the following calculation steps successively (Figure 7):

1. Identification of interdependencies between link flow observations by setting up a Gram-Schmidt orthogonalization process;
2. Elimination of inconsistencies in observed link volumes assuming Poisson-distributed link volumes and by using a maximum likelihood approach [compare with van Zuylen and Branston (5)];
3. Estimation of the route-flow matrix by using a recursive algorithm to solve Equation 2, starting from an a priori trip matrix [compare with van Zuylen and Branston (5)]; and
4. Condensation of route flows into OD trips.

For the estimation problem considered, the identification of interdependencies between observations was most time consuming; this part of the calculations took approximately 24 hours of running time on a microcomputer (Televideo TS-802H). When this was done, the computer processing time was reduced significantly. Leaving the structure of the estimation problem unchanged, it was possible to rerun the program with different data (link volumes and a priori estimates) in less than one-half hour of computing time. The program detected 15 interdependencies between observations. Related inconsistencies between observed link volumes were eliminated, which was extremely useful in the authors' case in which most of the link volumes were estimates.

Application of the method described yielded satisfactory estimation results, especially considering that this was the first time (at least to the knowledge of the authors) that both the information-minimizing method and the computer program NEST were applied to a problem of this size (953 unknown variables and 339 constraints). The estimation results are presented at an aggregate level in the last column of Table 3.

CONCLUSION

It is concluded that no detailed assumptions on route-choice behavior should be made in estimating trip matrices, but instead empirical information should be collected. An extended version of the information-minimizing approach was developed that is based on routes in terms of ordered sequences of observed links. This method allows for an explicit consideration of interdependencies between measurements and, what is much more important, for a straightforward processing of various types of additional information.

The approach is developed and applied within the framework of an evaluation study of a bicycle network scheme. In this study, empirical route-choice information with respect to bicycle trips was successfully used. This information plays a crucial role in various parts of the estimation procedure.

The application shows that no part was only specific to bicycle travel; thus, the estimation method is, in principle, equally well applicable to automobile traffic. The only difference with bicycle travel is that congestion should be taken into account in the procedure (e.g., Fisk and Boyce 7).

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Publication of this paper sponsored by Committee on Transportation Planning Needs and Requirements of Small and Medium-Sized Communities.

Is Urban Planning Education Necessary for Civil Engineers?

C. J. KHISTY

ABSTRACT

The Education Committee of the Urban Planning and Development Division of the American Society of Civil Engineers undertook a nationwide survey of undergraduate civil engineering programs to investigate whether civil engineering graduates were sufficiently prepared to practice in the urban planning arena. The findings of this survey are presented and discussed in this paper. The interface between urban planning and civil engineering as well as the appropriate role of civil engineers in urban planning are also discussed. The results of the survey indicated that almost 90 percent of the respondents believed that civil engineers should participate in urban planning activities; 88 percent believed that urban planning education should be obtained by taking either a required or elective course. Minor changes in civil engineering curricula were also suggested.

Historically, the civil engineer has been involved in many aspects of city, urban, and regional planning. This involvement ranges from the technical aspects of land development, transportation systems, and utility systems to the socioeconomic and political aspects of presenting proposals at public meetings or working with community groups in the analysis of alternatives. In such a context, the fundamental question arises: How should civil engineers be prepared for such activities? More specifically, are civil engineering graduates currently sufficiently prepared to practice in the urban planning arena, or should there be planning courses in the typical civil engineering undergraduate curriculum?

OBJECTIVES

Given the basic question, the Education Committee of the Urban Planning and Development (UP & D) Division of ASCE undertook a nationwide survey of civil engineering programs to investigate this question. The primary objective of this paper is to present and discuss the results of this survey.

Other questions germane to this topic are, What is the interface between civil engineering and urban planning? What is the appropriate role of civil engineers in urban planning? What changes (if any) are necessary in civil engineering undergraduate curricula for civil engineers to fulfill their appropriate role in urban planning? In this paper, the author attempts to answer these questions as well.

SCOPE OF URBAN PLANNING

Planning is a basic human activity that involves thinking ahead or organizing to get things done. The term "urban planning and development" covers those activities concerned with the planning and development of towns, cities, and regions. Planners deal with problems people have holding their communities together, coping with pressures of urbanization and development, and trying to provide an opportunity for everyone to improve the quality of life. Apart from just physical planning, most planners are forced to wrestle with policy issues connected with solving urban problems. Although functional specialization is becoming increasingly popular, planners believe that the strength of their profession lies in the integrated approach to problem solving, the understanding of public policies, and the use of citizen feedback (1).

Planning has developed through an eclectic accretion of concepts from a wide range of disciplines. Pollard, in a cogent article on the state of the art of planning (2), showed that there were at least 3,700 basic relationships between the elements of a plan and people and organizations involved. Therefore, the best definition of "planner" is the three-word definition "one who plans"; this should be interpreted as one who contributes significantly to the planning process because no one can be expected to do it all. Effective planning requires close working relationships between many diverse professions, organizations, and individuals; it must be responsive to the needs of many segments of society. Add to these the elements of politics and the variety is infinite (2).

The comprehensive planning process that was formulated in the mid-1960s was based on the premise of rational choice. It evolved out of the early experiences with large-scale urban transportation studies in the mid-1950s and early 1960s. A new image of planning, based on public participation, began to emerge across the United States in the late 1960s and early 1970s. Today, it is generally understood that planning must satisfy the information requirements of the decision maker and of the decision-making process (3). In summary, "the world moves into the future as a result of decisions not as a result of plans" (4).

CIVIL ENGINEERS IN URBAN PLANNING

The number of civil engineers involved in urban planning in the United States is hard to estimate, and their degree of involvement is even more difficult to assess. What is known generally, however, is that there is a significant interface between civil engineering and urban planning.

There are about 85,400 active members (excluding student members) of the ASCE, of whom 8,546 are currently affiliated with the UP & D Division. This affiliation works out to 10 percent of the total membership. ASCE has 22 divisions, of which 3 are closely related in some way with urban planning and development. If the affiliation of these three divisions, indicated below, is added to that of the UP & D Division, the total of 34 percent is impressive (5,6).

ASCE Division	No. of Members
Highways	10,815
UP & D	8,546
Urban transportation	3,216
Water resources planning and development	6,064
Total	28,643

During the years, there has been controversy among several disciplines about the place of the civil engineer in urban planning. Planners historically have come from several professions, such as architecture, civil engineering, economics, landscape architecture, political science, and sociology. Only recently has the profession of urban planning had its own undergraduate curriculum (7).

As early as 1961, ASCE stated the following (8):

> The roots of urban growth lie in the service systems that make possible the intensive use of land. These service systems are provided by civil engineering practice, which is one of the logical disciplines upon which to base a practice of urban planning.

Clair summed it up as follows (7):

> The planning, development, and redevelopment of our cities involve the exercise of numerous disciplines but none more than that of civil engineering, which embraces the broad areas of planning and development of land for residential, commercial, and industrial uses; transportation, including parking, traffic, transit, highways, streets, airports, railroads, and harbors; sanitary engineering, including water supply and distribution, sewerage works, flood damage prevention, and waste disposal; a wide variety of other public works; and urban renewal, with all the varied technologies involved in slum clearance, rehabilitation, and conservation of urban areas.

Civil engineers have played an important part in making possible the modern city, both through the scientific method and through the development of the art of engineering. As generalists they have been competent in heading teams of planners. As specialists in planning endeavors, such as planning, designing, and laying out public works, transportation systems, and industrial developments, they have had few contenders. In these planning fields, civil engineers have by virtue of their education and experience served as urban transportation planners, highway planners, water-resources planners, pollution control specialists, and land-use planners, to name just a few.

It is generally conceded that the nature and success of the civil engineer's continued participation both as a generalist or as a specialist will depend on a requisite viewpoint. Some of the more senior members of the profession are disturbed that civil engineers appear to be playing a lesser role in planning than was the case two or three decades ago. Others are concerned that civil engineering as taught in many professional schools is not adequate for many positions in urban planning.

THE ENGINEERING-PLANNING INTERFACE

In the past 20 years the civil engineering profession in general, and some of its components in particular (e.g., transportation, environmental engineering, and planning), have acquired theoretical underpinnings, methodological tools, and a vast range of public and private involvement. Today, the profession carries a distinct societal responsibility and this responsibility is increasing (9).

Naturally, there is an increasing need for professional sociotechnical problem solvers in areas historically viewed as being in the realm of civil engineering; this is particularly so in areas such as transportation, environmental, and water resources planning. A major reorientation in societal values in the United States has been in progress for at least the past 15 years. Now that the basic technological infrastructure is in place in terms of community support systems, and federal funding is becoming more difficult to obtain, society now appraises projects with a broader spectrum of socially desirable criteria (9).

In the past, simple economic efficiency, with which engineers were all too familiar, was the dominant concern. The broadened view of evaluation criteria and impacts means that design and decision processes of the recent past are now inadequate. Public agencies are responding in increasing numbers to the change in societal values. Planning, designing, and implementing projects requires a new mix of professional talents, which has led to a need for individuals with multidisciplinary backgrounds as integrators. This need for engineers who are not only competent engineers but who are also capable of dealing with the wide range of issues in planning is real (9). A leading midwestern university has the following to say in this context (10):

> There are many skillful engineers who can do an excellent job of physical design and construction, using the best available technology, once the policy and social parameters have been specified. But the engineer who deals competently and creatively with policy and social factors is rare. Likewise, there are many planners who are insensitive and naive when it comes to matters of technology and physical science.

Although undergraduate programs in urban planning are comparatively rare, a brief look at such a program is helpful as a basis for comparison. Most planning programs are designed first to expose students to a range of issues involved in planning the social, economic, physical, and political aspects of the environment, and second to develop skills in a particular area of concentration. Emphasis is placed on interdisciplinary study. Students are required to take introductory courses on the planning process, the history of human settlement, and quantitative methods. Students usually select one or more concentrations such as environmental analysis, urban development, physical facilities planning, and social policy and community planning. In addition, there are supporting courses that emphasize management, implementation, and analytical methods. In planning schools where engineering is also taught, it is often found that transportation courses form an important part of the curriculum because of its pervasive influence on urban development and spatial patterns of behavior. This topic has been extensively examined and documented (11,12).

Figure 1 shows the overlap in subject content between undergraduate programs in civil engineering and urban planning. Curve A represents civil engineering and Curve B represents urban planning.

CURRICULUM REVISION

A variety of civil engineering curricula exist across the country. The so-called 4-year degree program ranges from 120 to 169 semester hours, with the average being about 132 (13). Running debate exists on the contents of the civil engineering curriculum. Many civil engineering educators and practitioners believe that programs at all levels must be broadened to introduce knowledge from other fields, such as the social sciences. Society, in general, expects engineers not only to design effectively and economically, but also to accept responsibility for economic, social, environmental, and other consequences of their work. Wenk sums it up as follows (13):

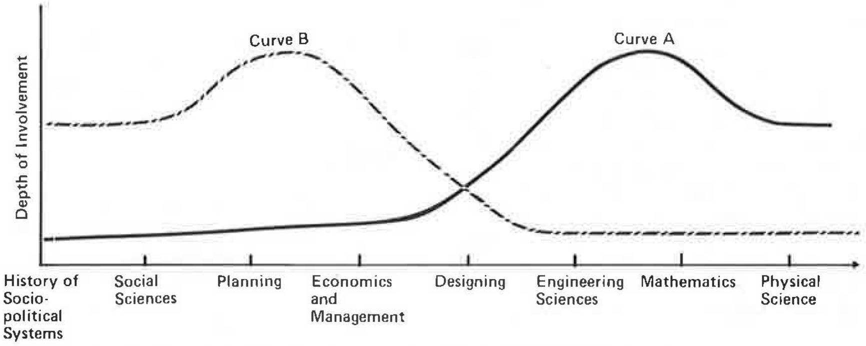
> A new agenda for engineering education may be required, distinguished less by specialization than by breadth. It would be based on technical disciplines but in the problem oriented matrix. Graduates would be characterized by versatility, comprehension of social processes, sensitivity to public policy and to the importance of critical judgment in distinguishing truth from propaganda, and fired by the images of the future and the willingness to participate in governance.

There has been pressure to increase the content of civil engineering programs in mathematics, science, engineering, and computer applications. Technical support courses such as surveying, management, communication, and professionalism and ethics have also been mentioned as areas needing urgent expansion. Such diverse currents have made it difficult for educators to decide what to include and what to exclude in a revised curriculum.

DEVELOPMENT OF THE SURVEY INSTRUMENT

The survey instrument was developed through a joint effort of the committee members of the UP & D Division, and its distribution was underwritten by the ASCE. It was sent to the chair or other administrative head of all 208 civil engineering departments and programs that were listed by ASCE as of the summer of 1981. The analysis of the results was done in 1982, and the author spoke to several of the respondents in 1983. The instrument consisted of 15 questions grouped in 4 general areas (the specific questions are given in the next section):

1. General attitudes. Two questions addressed the attitude of the respondent toward the perceived relationship between civil engineering and urban planning and the civil engineer's appropriate role in planning and development activities (see Questions 1 and 2).
2. General need for training in planning. Four



Note: Curve A is the undergraduate civil engineering program and Curve B is the undergraduate urban planning program.

FIGURE 1 Interface of undergraduate programs in civil engineering and urban planning.

questions addressed the general need for training and how it might be best accomplished (see Questions 3 to 6).

3. Explicit training needs. One question was directed to identify desirable planning-oriented topics (see Question 7).

4. Existing training. The last eight questions were concerned with obtaining specific factual information about the respondent's program (see Questions 8 to 15).

The survey instrument was directed not only to assessing the current status of urban planning education for civil engineers, but also to identifying the perceptions of civil engineering educators as to the need for such training. Note that the respondents were all educators who may or may not have had any experience with or have been acquainted with urban planning.

RESULTS OF THE SURVEY AND COMMENTS

There were 115 usable responses (55.3 percent) returned.

Question 1. How do you view the relationship between civil engineering and urban planning?

Results

14% 30 a. Civil engineers, given their traditional academic training, should generally be considered as planners.
8% 18 b. Civil engineering and urban planning are separate disciplines and should be considered as such.
37% 79 c. Civil engineers who wish to practice as planners (or in planning) should take courses in planning or undertake additional degree work.
23% 49 d. All civil engineers should have some working knowledge of urban planning concepts.
17% 37 e. Planners should be licensed in a manner similar to civil engineers and architects.

If e, should all registered civil engineers automatically be eligible for registration as planners?

6 yes 31 no

The figures provide the total number of times an item was checked and the corresponding percentage. In answering Question 1, a respondent could give one or more answers. The fact that only 8 percent of the respondents believed that urban planning and civil engineering are separate disciplines indicates the extensive interface or overlap between the two areas. A combination of items a and d reinforces the interrelationship between civil engineering and planning and the necessity for a working knowledge of planning. The weak response to item e is not surprising considering that urban planning licensing and certification in the United States has been both relatively recent and comparatively unimportant.

Question 2. What is the appropriate role of civil engineers in urban planning? (check one)

Results

9% 10 a. Civil engineers should take the lead role in urban planning activities in which they participate.
2% 2 b. Civil engineers should limit their involvement in urban planning to providing technical support (e.g., technical aspects of transportation or utility systems) to planners.
87% 96 c. Civil engineers should participate in urban planning activities only insofar as they are trained/qualified--sometimes this might entail a lead role, sometimes not.
0% 0 d. As a general rule, civil engineers should not participate in urban planning activities.
2% 2 e. Other, please specify:
110

The high response to item c further reinforces the strong ties between civil engineering and planning. These comments are interesting in that they indicate some established views held by engineers toward planning. More than one-third of the responses indicated that additional course work, probably in the shape of electives (or possibly beyond the B.S. degree in civil engineering) should be undertaken if an engineer wanted to be considered as a planner.

Question 3. In general, education and training in planning for civil engineering should be: (check as appropriate)

	Results for Undergraduate Students		Results for Graduate Students		Results for Both	
	No.	Percent	No.	Percent	No.	Percent
a. Required course(s)	21	50	10	36	11	13
b. Elective course(s)	15	38	15	54	71	86
c. Training in planning is not necessary	3	8	3	12	1	1
Total	39		28		83	

A respondent could give one or more answers to this question. The figures provide the total number of times the item was checked and the corresponding percentage. Different interpretations can therefore be made, but the broad conclusion that can be drawn from the answers is that a required or elective course in urban planning at the undergraduate level is necessary.

Question 4. In general, education/training in planning for civil engineers should be undertaken by: (check one)

Results

4 a. The civil engineering department alone.
4 b. The civil engineering department in conjunction with other departments (excluding planning departments/schools).
20 c. The civil engineering department in conjunction with the planning department/school.
80 d. The civil engineering department in conjunction with other departments in-

cluding (if possible) the planning department/school.

_2_ e. Exclusively by the planning department/school and/or other departments.

_0_ f. Such education/training should not be undertaken.

About 92 percent of the respondents believed that planning education should be undertaken by the civil engineering department in conjunction with a planning or other department. Many universities do not have an urban planning department and the only other alternative available is to obtain such expertise from other cognate areas, such as geography, sociology, political science, and urban affairs.

Question 5. In order for civil engineers to fulfill their appropriate role in urban planning, are any changes necessary in typical civil engineering undergraduate curricula?

Results

16% _18_ a. No changes necessary.
76% _85_ b. Minor changes are probably necessary.
8% _8_ c. Major changes are probably necessary.

Almost 80 percent of the respondents believed that minor changes in civil engineering curricula were necessary for the civil engineer to fulfill an appropriate role in planning.

Question 6. Do you feel that education/training in urban planning would be better accomplished in some other way than incorporating such courses into current civil engineering curricula? (circle one)

Yes--Strongly agree				No--Strongly disagree	
(1)	(2)	(3)	(4)	(5)	
6	27	26	34	16	Mean = 3.2 Standard deviation = 1.1

	Appropriate				Inappropriate	
	(1)	(2)	(3)	(4)	(5)	
Additional undergraduate or graduate work in planning	36	43	8	3	2	Mean = 1.8 Standard deviation = 0.9
On-the-job training	21	33	16	9	1	Mean = 2.2 Standard deviation = 1.0
Continuing education	25	30	15	9	2	Mean = 1.2 Standard deviation = 1.1

Other:
Real-world projects
Government publications
Internship programs
Civil engineering design courses

Most respondents took the middle-of-the-road approach. They indicated that civil engineering departments were well suited for incorporating such courses within their curricula. At the same time, there was a strong feeling that other approaches were also suitable.

Question 7. For civil engineers, what specific topics should be covered in a planning course(s) or in the context of other courses? Indications below should be in terms of hours of class time spent (assume that 40 hours represents one 1-semester 3-credit class).

The ranking of topics is shown in Table 1; the resulting order is interesting. The analytical, mathematical issues involved with urban planning are preferred over the qualitative, nonmathematical ones generally associated with planners. This ordering is ironic in the sense that it would have been generally expected that engineers, because of their technical training, would tend to select topics in which they were considered weak by society. The ordering also brings out biases that civil engineers generally exhibit toward urban planning and the capabilities of urban planners.

TABLE 1 Rank Ordering of Topics

Topic	Mean No. of Class Hours	No. of Times Mentioned[a,b]	Required Course[a,c]	Elective Course[a,d]
Economic analysis	14.8	64	37	17
Transportation system planning	13.5	71	39	21
Quantitative methods	13.1	53	24	22
Modeling/simulation	10.6	56	22	25
Urban/regional economics	10.6	45	13	25
Land-use planning	10.4	61	29	22
Utility system planning	9.9	49	22	17
Planning theory	9.8	57	19	24
Environmental impact analysis	9.7	65	29	23
Urban administration	8.8	46	11	25
Planning law	8.8	43	13	25
Land-use controls	8.1	57	29	20
Economic development	8.1	34	11	20
Alternatives evaluation	7.1	54	27	18
Spatial economic theory	6.9	27	5	18
Citizen participation strategies	6.0	41	10	22
History of planning progress	5.9	41	10	26
Urban development/redevelopment	5.6	34	8	21
Housing	4.8	29	8	16

[a] Responses to Question 7.
[b] Number of times mentioned is the number of respondents who allocated any number of hours to topic.
[c] Number of times course was indicated as a required course.
[d] Number of times course was indicated as an elective course.

Also, it will be noticed from the rank ordering that topics such as economic analysis (capital budgeting), transportation systems, and quantitative methods are more likely to be taught in traditional civil engineering curricula as opposed to planning theory, land use controls, and housing.

Question 8. Given the types of topics that you have indicated above, and the general role that you have identified for would-be engineers/planners, in what kind of context should the topics be covered? (check as appropriate)

Results

23% _42_ a. In project oriented courses where possible.
31% _56_ b. In a general planning course(s).
22% _39_ c. In a sequence of courses.
23% _42_ d. In the context of other traditional civil engineering courses.

More than one-half of the respondents (b and c) indicated that the topics mentioned in Question 7 could be covered in courses. It was not surprising to see that almost one-fourth of the respondents believed that traditional civil engineering courses would be able to address the specialized topics. This brings out the bias civil engineers generally have against planning-oriented courses. Projects, by and large, are an effective means of learning a subject and it was gratifying to have 23 percent of the respondents voting in favor of project-oriented courses. However, it must be conceded that several of the courses are not adaptable to the project type, for example, planning law, citizen participation, history, and planning theory. Probably these latter descriptive courses were not the type of courses held in high esteem by civil engineers.

Question 9. Name of your college/university:________

Question 10. Name of department:________________

Question 11. Does your department currently offer a course(s) in urban planning as a part of your required curriculum in the civil engineering program?

17 Yes 92 No If yes, how many (and specify the titles):_____

Of the 109 respondents, 17 indicated that one or more courses in urban planning were part of the required curriculum; this works out to about 15 percent of the schools surveyed. The most frequently mentioned courses were

- Transportation engineering
- Urban planning
- Planning in civil engineering
- Urban systems engineering

However, on closer examination only 8 schools (7 percent) offered courses that were indeed in urban planning.

Question 12. Does your department currently offer any such courses (as 11.) as electives?

60 Yes 53 No If yes, how many (and specify the titles).

Of the 113 respondents, 60 (53 percent) offered elective courses. The most common ones listed were

- Training planning
- Urban planning
- Transportation, general

Although these responses may appear flattering, upon closer scrutiny it was revealed that only 29 schools (25 percent) offered urban planning courses.

Question 13. Does your department currently address urban planning issues in the context of any regularly scheduled courses?

79 Yes 29 No If yes, please specify the course title(s).

Seventy-nine of the 108 departments said that they address urban planning issues in the context of any regularly scheduled courses. The most frequently mentioned courses were

7	Transportation, general
5	Highway engineering
10	Transportation planning
27	Transportation engineering
2	Urban systems planning
1	Urban problems

Note that transportation-related courses were considered the predominant ones having a planning content. Environmental courses were also mentioned.

Question 14. Total faculty members:
15 Full-time 2.4 Part-time
(mean) (mean)

Total who have competency in planning issues: (Please specify)
2.5 Full-time 0.4 Part-time
(mean) (mean)

The issue areas in which faculty had competency were

Environmental, general	7
Water resources	4
Transportation, general	13
Transportation planning	9
Urban planning	2
Economic analysis (engineering economics)	2

Total who are APA and/or AICP members:
3% Full-time 2% Part-time
(110 schools)

Question 15. Does your college/university have a planning department/school?

56 Yes 58 No

If yes, does your department cooperate with that department/school in any way?

46 Yes 10 No

Results

21 a. Develop joint courses.
12 b. Have joint faculty appointments.
21 c. Develop joint programs and courses.
43 d. Encourage students to take courses in each other's programs and coordinate courses so there is no overlap.
____e. Other, please specify. (Answers included projects, dual degrees, joint research.)

DISCUSSION

The two basic questions that were originally raised were

1. Are civil engineering graduates currently sufficiently prepared to practice in the urban planning area?
2. What changes (if any) are necessary in civil engineering undergraduate curricula for civil engineers to fulfill their appropriate role in urban planning?

The survey answers both of these questions, and in addition provides clues to others. The highlights are as follows:

- 87 percent of the respondents believed that civil engineers should participate in urban planning activities only insofar as they are trained and qualified; sometimes this might entail a lead role, sometimes not.

- 50 percent believed that the education and training in planning should be by taking a required course(s) in planning; 38 percent voted for an elective course(s).
- 92 percent believed that planning education should be undertaken by the civil engineering department in conjunction with a planning or other department.
- 76 percent voted that minor changes are necessary for civil engineers to fulfill their appropriate role in urban planning courses.
- Transportation engineering courses were considered the ones having the largest planning content.

Some further comments are offered based on the survey, the author's conversations with educators, his observations of numerous civil engineers and planners in practice, and his close acquaintance with both civil engineering and planning students.

The civil engineer confronts the realities, trends, and requirements of urban planning and development with certain advantages inherent in his or her training. The scientific method, systems analysis, and mathematical and quantification abilities provide the engineer with a clear head start. Also, the engineer's intimacy with the space and shape of the physical world provides an additional advantage. Add to this a thorough basic knowledge of environmental, geotechnical, water-resources, structural, and transportation engineering, and the potentialities are apparent.

Areas in which the civil engineer is probably somewhat weak are

- An appreciation of the multivariable, open-ended, conflict-ridden, value-laden nature of sociotechnical problems.
- An appreciation for the interrelationships between engineering and public policy.
- The ability to apply a logical, problem-solving approach to open-ended problems.
- The ability to effectively communicate in written and oral form with a variety of individuals and groups in a broad range of social and professional settings.

Engineers solve problems in a variety of ways but they are not adept in solving wicked problems. Planning deals with wicked problems. Wicked problems have no definite formulation, no clear rules, no true-false answers. They can at best be better or worse, and there is no clear test for their solution. It is claimed that each wicked problem is unique, but at the same time each is a symptom of another deeper, more extensive problem. Engineers, by and large, are fond of using precise data and coming up with determinate one-shot answers. They usually will not question values, institutions, and given decision rules. Planners are familiar with wicked problems and messy, rough, imprecise data (14).

Engineers are comfortable with design, where design implies analysis, synthesis, and understanding. However, engineers invariably emphasize analysis and there are valid reasons for this emphasis. For one, engineers' understanding of analysis is stronger than of synthesis, and secondly, their training involves considerable analysis, particularly in the traditional areas of structures and fluid mechanics. It has only been since the introduction of transportation engineering and environmental science that the notions of systems and synthesis have begun to be included in the vocabulary of civil engineers. The notion of design being synonymous with planning and optimization is also relatively new in civil engineering. Planners, on the other hand, are familiar with synthesizing information and dealing with socioeconomic problems, although they may not prove as industrious as engineers in number crunching.

CONCLUSIONS AND RECOMMENDATIONS

Urban planning and development is not the work of one person, one profession, or one organization. With today's complexities, planning can only be achieved by multidisciplinary teams. Civil engineers will continue to be involved as specialists in urban planning, particularly in planning, designing, and constructing the physical infrastructure. However, as the scope of urban planning progressively broadens and deepens, additional knowledge will be required for effective participation and team leadership. This will include the nature of the planning process; the socioeconomic, legal, and political realities; planning theory; the synthesis and coordination of team effort; and projecting into the future and formulating sound, subjective judgments.

Some specific recommendations are as follows:

- The introduction of one mandatory course in urban planning, apart from the ones in transportation engineering usually offered. The emphasis should be on the sociopolitical trade-offs necessary for planning; some planning theory would also be helpful.
- The introduction of one or more elective courses in urban planning, offered separately or jointly with transportation, water-resources, or environmental engineering courses. This would provide an opportunity for students inclined to enter the urban planning arena to be better equipped to deal with current planning issues.
- Because the civil engineering curriculum is already overburdened with other priorities, it would not be possible to add on further course work beyond what is recommended above. Civil engineers who wish to gain in-depth knowledge of urban planning must obtain formal graduate education in urban planning, or utilize university extension or self education.

ACKNOWLEDGMENT

The survey instrument described in this paper was developed by the members of the Education Committee of ASCE's UP & D Division: W.W.L. Lee, R. Seaman, R.W. Lyles, and C.J. Khisty. The distribution of the survey was underwritten by ASCE. R.W. Lyles analyzed the data.

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Significant contributions notwithstanding, the findings and views presented herein are the sole responsibility of the author and do not necessarily reflect those of the other committee members or any institution.

Publication of this paper sponsored by Committee on Transportation Education and Training.

An Evaluation of Videoconferencing with Active and Passive Sites as a Means for Technology Transfer

K. W. HEATHINGTON, BETTY S. HEATHINGTON, and DANIEL B. FAMBRO

ABSTRACT

In an effort to broaden dissemination of the information presented at the Annual Meeting of the Transportation Research Board (TRB), TRB's Executive Committee approved an experimental videoconferencing session for the January 1984 Annual Meeting. The objective of this session was to gain experience with this communication medium in order for TRB to make appropriate decisions about its future uses for technology transfer. The session's effectiveness was evaluated by 180 respondents at 4 active sites and 186 respondents at 6 passive sites. The evaluation involved such things as demographics, environmental conditions at the remote sites, the presentations, and the session's general format. The effectiveness of a videocommunication session was compared with the effectiveness of a face-to-face meeting. In addition, some preliminary cost data for this type of program were obtained. In general, the program was very well received. Some specific findings can be reported: (a) it reached a considerably different audience than would have been present at the TRB Annual Meeting; (b) the environmental characteristics at the sites were satisfactory; (c) the speakers, as a group, were well received by the respondents; (d) participants reported a significant increase in knowledge as a result of attending the program; (e) there were minimal differences between the responses from the respondents at the active sites and those at the passive sites; and (f) on an individual-participant basis, the cost of the program was within acceptable limits. As a result of these and other findings, videoconferencing was determined to have a place in the technology transfer activities of TRB and should be incorporated in appropriate areas to increase the communication to field personnel.

Teleconferencing is a communication medium that is gaining momentum in many businesses, federal agencies, universities, and other organizations that have a strong communication component as part of their overall mission. It is being promoted by some as a potential catalyst for change in the way many organizations handle communication and technology transfer. In the next decade, teleconferencing may establish itself as a central part of the communication network in an organization. Its potential appears to be very promising.

Precise, descriptive characteristics of teleconferencing vary; however, a review of several definitions helps in understanding its overall capabilities and uses. Johnson (1) defined it by using the acronym SPIES: a structured, private, interactive, electronic, scheduled meeting. Each letter of the acronym provides a specific, descriptive dimension of teleconferencing:

- Structure relates to the carefully planned goals, audience, and agenda necessary in successful teleconferencing;
- Private signifies the special network used for identified recipients;
- Interactive relates to the live programming;
- Electronic describes the type of delivery system used for teleconferencing; and
- Scheduled refers to the planned sequence of events that occurs during a successful teleconferencing program.

From Johnson's perspective, teleconferencing is electronic communication between a sender and an identified audience for a clearly identified purpose. The communication is usually two-way: both the sender and the audience participate in the event. It is characterized by its immediacy: it is a live interaction between those involved.

The multiplicity of sites is another dimension of teleconferencing. Olgren and Parker (2) stated that teleconferencing is "two-way electronic communication between two or more groups, or three or more individuals, who are in separate locations"; it links individuals or groups of people at multiple locations in a dynamic and live interaction. The need to link individuals at several sites and at frequent intervals appears to be a growing concern of many organizations today. The ever-rising volume of information to be shared is constantly forcing organizations to seek improved means of transferring information to appropriate audiences.

Teleconferencing allows people in many different locations to engage in business meetings, professional conferences, or university courses without actually traveling to the places where these events are occurring. Increasing costs associated with travel have made teleconferencing more appealing to many groups. Limited travel budgets in many organizations make it impossible for all interested, concerned individuals to attend a particular conference or training session. Not only is the actual cost involved in travel a major concern, but so are the associated productivity costs of travel time and hours spent away from the place of employment.

Elton (3) identified five types of teleconferencing:

1. Audioconferencing, in which the participants hear what others are saying and are heard by others;
2. Enhanced audioconferencing, which may include the transmission of still images from one location to another in addition to the audioconferencing;
3. Videoconferencing, in which those involved both see and hear and are seen and heard;
4. Narrowcast, in which live television is broadcast one-way from a central site to a number of other sites with the possibility of a two-way audio transmission; and
5. Computer conferencing, which involves the use of computer keyboards to transmit information from one location to another.

These categories may not be exact; for example, a videoconference may involve sending visual and audio and receiving only audio. However, these five types provide an indication of the various communication possibilities included under the teleconferencing category.

Transmission may be made by telephone lines or by satellite. The availability of satellite capacity has contributed to the increasing attention toward and use of teleconferencing. In assessing costs associated with teleconferencing, distance plays a vital role because of increased costs of telephone lines; however, when satellites are used, costs are independent of distance (3).

Teleconferencing users are varied: Xerox Corporation, 3M Company, IBM, Meade Johnson and Company, the Republican National Committee, the Roman Catholic Church, and the U.S. Department of Commerce, to name a few (1). Also varied are the purposes of such teleconferences, as demonstrated by the following examples:

- In 1982, Ohio State University held an international teleconference, Microcomputers in Education (4). The purpose was to exchange information about possible uses of microcomputers in schools.
- Teleconferencing has been used for instructional programs by the American Hospital Association, for sales meetings by Ford Motor Company, and for stockholders meetings by Texas Instruments (5).
- Isolated and remote areas often benefit from teleconferencing. Teachers in distant areas in Alaska recently engaged in a course conducted through the medium of teleconferencing (6).

Both advantages and disadvantages of teleconferencing have been cited. Marlow (5) summarized some of the reasons for its wide acceptance:

- Higher costs of travel
- Availability of satellite capacity
- Development of low-cost hardware
- Availability of earth stations and
- Encouragement by hotel, motel, and conference facilities to use teleconferencing

Surveys of organizations that have participated in teleconferencing have revealed some positive aspects users see in the system. In one survey, 29 percent of the respondents stated that they had initiated teleconferencing to save money through reduced travel costs. Twenty-eight percent mentioned the impact of reduced travel on productivity as a catalyst for their use of teleconferencing (2). In another survey, 80 percent of the respondents cited advantages of saving travel time and making meetings more cost-effective (7). Costs of a teleconference can vary dramatically; however, when compared with a face-to-face meeting, teleconferencing is usually very cost-effective. The relative cost of teleconferencing drops substantially as the size of the audience increases (8).

Increased communication is an advantage often cited for teleconferencing (2). When an organization has people in dispersed locations, the value of this type of communication increases. Some have pointed out that teleconferencing should be viewed as "a substitute for communication that does not take place but ideally should" (9).

Disadvantages cited in surveys include lack of face-to-face meetings, difficulty in watching a video screen for a long period of time, and the hesitancy of people to interact (7). The size of the audience also appears to be a concern; although a large audience makes the teleconference more cost-effective, there may be a problem in allowing adequate interaction by the entire audience (4).

Evaluations of teleconferences offer an opportunity to obtain feedback from those involved in the process. After such an evaluation, the usefulness of this medium can be assessed. Reporting on one evaluation, Nichols (4) stressed four points for those contemplating such an endeavor:

1. Plan the teleconference early. The content and programming should be completely organized well before the teleconference.
2. Match the content to the audience. This may necessitate a needs survey to possible participants. No communication effort will be successful if it is not directed toward the needs of the consumers.
3. Use skilled presenters and moderators. These individuals play such a key role that they must be competent before a television camera and an audience.
4. Be flexible. There are always last-minute problems that arise. Program planners must be able to quickly adjust to a modification in plans as unforeseen events arise.

PLANNING FOR VIDEOCONFERENCE PROGRAM

A TRB committee was formed to plan a teleconferencing program that would be of wide interest to transportation professionals. The committee decided that videoconferencing would be defined in the following manner: those at remote sites would both see and hear the broadcast. However, one group of sites would be active, that is, participants would be able to be heard during question-and-answer periods, and one group of sites would be passive, that is, participants would not be able to participate in the question-and-answer sessions. The topic chosen for the videoconference was microcomputer applications in transportation. Considering the increased use of microcomputers both at work and in the home, the committee believed that this topic would have a broader appeal than, perhaps, other more narrowly defined technical areas.

To provide a program that could be reasonably managed with volunteer help, four active sites were used; these sites were in the states of Iowa, Minnesota, Montana, and Texas. The four active sites had one-way video and two-way audio. Thus, these sites received a picture and audio from the satellite, but could not transmit a video picture. Telephone lines were used to provide for two-way audio communication between each of the active sites and the transmission site in Washington, D.C. Participants at the active sites could ask questions of those making the presentations in Washington.

The signal for the program was carried on WESTAR IV and SATCOM III-R satellites. These satellites are commonly used by hotels, public television stations, and cable television networks that offer videoconference services. Program costs were for transmitting the signal and rental time on the satellites. There was no charge to receive the signal. Thus, the number of remote sites had no effect on the cost to TRB.

Passive sites, that is, those without two-way audio, were promoted by the committee and TRB. General information on the satellite signal, along with the time of the program, were provided in newsletters, meetings, and other forms of communication to encourage the establishment of passive sites. There are no complete data on the number of passive sites receiving the satellite signal; however, information that was obtained indicated that there were 46 individual sites in at least 26 states. Three additional states taped the program and used it for later viewing. After the program was completed, 11 other states requested the tapes for viewing in their areas. The FHWA, U.S. Department of Transportation, also obtained copies of the tapes and circulated them to its division offices.

There is no firm count of the number of people who viewed the program. The largest confirmed audience was 150; the smallest was about 20 viewers. It would not be unrealistic to estimate an average of 50 viewers per site, with an estimated 50 sites having received the signal. Thus, as many as 2,500 individuals viewed this videoconference. The studio audience in the Sheraton Washington's Cotillion Ballroom where the presentations were made numbered about 200.

The videoconference presentations were similar to those at a regular session of the TRB Annual Meeting. However, those in attendance at the broadcast site in Washington, D.C., were not permitted to ask questions. The two question-and-answer sessions were reserved for the four active sites. A remote monitor received questions from each active site; these were screened and permitted to be received in the Cotillion Ballroom. Thus, the audience in the Cotillion Ballroom, as well as all of the audiences at both the active and passive sites, could hear the questions being asked. In addition, all participants could watch and hear the speaker's response to the questions.

The entire program was 3 hours long with no scheduled breaks. Individuals at the remote sites were permitted to come and go into the sessions as is normally the custom at the TRB Annual Meeting. Satellite time was purchased for a specific period, 2:00 to 5:00 p.m. Therefore, it was important that all time be used effectively.

OBJECTIVES OF THE PROGRAM

The major objectives of this experimental videoconference program for TRB were as follows:

1. To become more familiar with the technical requirements for videoconferencing.
2. To determine costs associated with videoconferencing;
3. To determine the planning requirements for conducting a videoconference;
4. To determine the acceptance of videoconferencing at both active and passive remote sites by attendees; and
5. To gain sufficient experience to make appropriate decisions about future use of videoconferencing by TRB.

A brief evaluation of the videoconference is given in this paper. A questionnaire was given to the attendees at all the active sites and selected passive sites. The discussion that follows addresses the responses to this questionnaire and the costs associated with the videoconference.

RESULTS OF QUESTIONNAIRE EVALUATION

Subject Population

A total of 404 people at 12 different sites participated in the evaluation of the videoconference. Of this total, 180 respondents were at active sites, 186 respondents were at passive sites, and 38 respondents were at the broadcast site. Active sites were Ames, Iowa; Minneapolis, Minnesota; Billings, Montana; and Austin, Texas. Passive sites were Tallahassee, Florida; Lexington, Kentucky; Lincoln, Nebraska; Bismarck, North Dakota; Knoxville, Tennessee; and Salt Lake City, Utah. The broadcast site was in the Sheraton Washington's Cotillion Ballroom. The number of respondents at individual sites ranged from a low of 22 to a high of 91.

Employment Classification

As shown in Table 1, the distribution of respondents by job type was similar at both active and passive sites. Approximately one-third of the respondents held administration jobs, one-third held planning and design jobs, and the remainder were split between operations, construction, maintenance, and research. The difference in the number of respondents who held other jobs was primarily the result of the location of one of the passive sites on the campus of a major university. Therefore, at this location, the videoconference was accessible to faculty and staff not necessarily associated with transportation agencies.

TABLE 1 Employment Classification of Respondents

	Active Sites		Passive Sites		Broadcast Site	
Primary Type of Job Held	No.	Percent	No.	Percent	No.	Percent
Administrative	58	35	47	27	7	25
Planning	27	16	28	16	10	34
Design	32	19	29	17	2	7
Operations	13	8	11	6	1	3
Construction	7	4	14	8	0	0
Maintenance	8	5	6	4	1	3
Research	12	7	11	6	7	25
Other	9	6	27	16	1	3
No response	14		13		9	
Total	180		186		38	

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

It is interesting to note that more than 80 percent of the respondents at the broadcast site in Washington, D.C., were administrators, planners, or researchers. This was different from the mix of attendees at the remote sites. At these locations, approximately 50 percent of the respondents were in these three categories.

Previous Attendance

As shown in Table 2, 17 percent of the respondents at the active sites and 14 percent of the respondents at the passive sites had previously attended a TRB Annual Meeting. Not surprisingly, 84 percent of the respondents at the broadcast site had previously attended such meetings. Of those who had previously attended a TRB Annual Meeting, approximately 50 percent at the active and passive sites had attended only one meeting. For those at the broadcast site, that is, the TRB Annual Meeting, 66 percent had attended more than three Annual Meetings.

Thirteen percent of the respondents at the active sites, 16 percent at the passive sites, and 12 percent at the broadcast site had previously attended a videoconference. Of those who had attended a videoconference, 50 percent at the active sites, 74 percent at the passive sites, and 40 percent at the broadcast site had attended only one. Approximately 20 percent at each of the sites--active, passive, and broadcast--had attended more than two videoconferences.

TABLE 2 Respondents' Prior Attendance at a TRB Annual Meeting and a Videoconference

	Active Sites		Passive Sites		Broadcast Site	
	No.	Percent	No.	Percent	No.	Percent
Previously attended TRB Annual Meeting	30	17	25	14	27	84
If yes, number of times						
1	10	40	12	48	3	14
2	5	20	7	28	2	10
3	4	16	4	16	2	10
More than 3	6	24	2	8	14	66
Previously attended videoconference	23	13	28	16	4	12
If yes, number of times						
1	10	50	17	74	2	40
2	6	30	2	9	2	40
3	2	10	3	13	0	0
More than 3	2	10	1	4	1	20

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

Age and Education

As shown in Table 3, approximately two-thirds of the respondents at the remote sites were between the ages of 36 and 55 and an additional 25 percent was between the ages of 26 and 35 years. The breakdown by age of the respondents at the broadcast site is somewhat different. In this group, the largest percentage (37 percent) of the respondents was in the 26-to-35 age group, and approximately 50 percent was in the 36-to-45 and 46-to-55 age groups.

Data in Table 3 concerning the educational level of the respondents show that they are well educated: more than 90 percent had attended at least some college; more than 75 percent were college graduates; and approximately one-third had attended graduate school. The audience at the broadcast site appeared to be even better educated: 97 percent had attended college, 90 percent were college graduates, and 70 percent had attended graduate school.

TABLE 3 Age and Education of Respondents

	Active Sites		Passive Sites		Broadcast Site	
	No.	Percent	No.	Percent	No.	Percent
Age (years)						
Less than 25	2	1	3	2	0	0
26 to 35	42	25	44	26	12	37
36 to 45	54	32	56	33	8	24
46 to 55	51	30	57	33	8	24
56 to 65	20	12	11	6	5	15
Education						
Non-high school graduate	2	1	1	1	1	3
High school graduate	14	8	10	6	0	0
Attended college	22	13	28	16	2	6
College graduate	72	42	83	48	7	21
Attended graduate school	23	13	22	12	4	12
Graduate degree	39	23	30	17	19	58

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

TABLE 4 Respondents' Experience with Microcomputers

	Use Microcomputer in Home					
	Yes		No		Total	
Use Microcomputer at Work	No.	Percent	No.	Percent	No.	Percent
Yes	40	10	60	16	100	26
No	55	15	223	59	278	74
Total	95	25	283	75	378	100

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

Experience with Microcomputers

Because the content of the videoconference concerned the use of microcomputers, respondents were asked to provide information about their experience with microcomputers, both at home and at the office. As shown in Table 4, 10 percent of the respondents used microcomputers at both work and home; 15 percent used microcomputers only at home; and 16 percent used microcomputers only at work. Almost 60 percent of the respondents did not use microcomputers either at home or work.

Environmental Characteristics at the Remote Sites

Several questions concerned environmental characteristics at the remote sites; some were about the facilities, whereas others were about the video and audio characteristics of the presentations as received at the remote sites. Respondents were asked to rate these characteristics on a scale of 1 through 5, with 1 being very unsatisfactory, 2 being unsatisfactory, 3 being indifferent, 4 being satisfactory, and 5 being very satisfactory. Thus, a rating of 4 or 5 indicated satisfactory or better acceptance of the characteristic in question. Mean ratings were calculated for each question and a statistical comparison (t-test) was made between the means of the active and passive sites. Significant differences were determined at the 0.05 level.

Facilities

Some items on the questionnaire were aimed at determining whether such conditions as the seating arrangement, temperature of the room, and the amount of space available for the respondents were satisfactory. The relatively high means shown in Table 5 indicate overall satisfaction with the facilities at both active and passive sites.

There was no statistically significant difference between the mean values of the ratings given to the seating arrangement at the active and passive sites (3.90 and 3.83, respectively). Seventy-nine percent of the respondents at the active sites and 76 percent at the passive sites rated seating arrangements as satisfactory or better.

There was no significant difference between the means at the active and passive sites concerning satisfaction with room temperature (3.84 and 3.68, respectively). Seventy-six percent of the respondents at the active sites and 69 percent at the passive sites rated the temperature as satisfactory or better. However, several respondents at one of the sites commented that it was too cold.

Respondents at the active sites believed that there was better allocation of space than did those at the passive sites. There was a significant difference between the means for the two types of sites. The mean value at the active sites was 4.11, whereas the mean value at the passive sites was 3.90.

Video Characteristics

Not only is it important that the physical facilities be adequate for participants, but it is obviously important that the video characteristics be good. Four different categories concerning video characteristics were evaluated at both the active and passive sites: picture clarity, size of screen,

TABLE 5 Summary Evaluation of Environmental Characteristics at the Sites

	Active Sites											Passive Sites											
	Respondents Choosing a Given Rating[a]											Respondents Choosing a Given Rating[a]											Significant Difference Between Means
	1		2		3		4		5			1		2		3		4		5			
Question	No.	%	No.	%	No.	%	No.	%	No.	%	Mean Value	No.	%	No.	%	No.	%	No.	%	No.	%	Mean Value	
1. How satisfactory were the following characteristics of the facilities?																							
a. Seating arrangement	2	1	18	10	17	10	98	55	42	24	3.90	4	2	16	9	24	13	105	57	36	19	3.83	No
b. Room temperature	7	4	18	10	18	10	87	50	46	26	3.84	7	4	27	15	22	12	90	49	38	20	3.68	No
c. Amount of space	2	1	10	6	10	6	97	56	55	31	4.11	4	2	13	7	19	10	109	60	38	21	3.90	Yes
2. How satisfactory were the video characteristics?																							
a. Picture clarity	0	0	10	6	14	8	91	53	58	33	4.14	1	1	1	1	12	6	96	52	75	40	4.31	Yes
b. Size of screen	0	0	4	2	5	3	102	59	61	36	4.28	1	1	15	8	13	7	107	58	49	26	4.02	Yes
c. Distance from screen to your seating	0	0	4	2	6	4	99	58	62	36	4.28	3	2	12	6	17	9	98	53	55	30	4.03	Yes
d. Color of picture	0	0	5	3	15	9	103	61	46	27	4.12	1	1	4	3	14	8	101	55	65	35	4.22	No
3. How satisfactory were the audio characteristics?																							
a. Clarity of reception	0	0	14	8	14	8	82	49	57	35	4.09	1	1	7	5	11	8	72	55	40	31	4.09	No
b. Volume	0	0	4	2	6	4	94	56	63	38	4.29	0	0	3	2	11	8	78	60	39	30	4.17	No

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

[a] 1 = very unsatisfactory, 2 = unsatisfactory, 3 = indifferent, 4 = satisfactory, and 5 = very satisfactory.

distance from screen to seating, and color of picture. Results of this portion of the evaluation are also given in Table 5.

Picture clarity received a high rating at both the passive and active sites. Although there was a statistically significant difference between the means of the active and passive sites (4.14 and 4.31, respectively), more than 85 percent of the respondents at both sites rated picture clarity as satisfactory or better.

Respondents at the active sites rated satisfaction with the size of screen higher than did those at passive sites (4.28 and 4.03, respectively). Although this was a statistically significant difference, more than 80 percent of respondents at both active and passive sites were satisfied with the size of the screen.

Respondents at active sites also rated distance from the screen to seating higher than did respondents at passive sites (4.28 and 4.03, respectively). Although their responses were significantly different, most people (more than 80 percent) were satisfied with the distance from the screen to their seating.

Concerning the color of the picture, there was no significant difference between the means of the active and passive sites. The mean value at the active sites was 4.12 and the mean value at the passive sites was 4.22, indicating that both groups were satisfied with the color of the picture.

Overall, respondents at both active and passive sites were satisfied with the video characteristics. Ratings were split, with respondents at the active sites rating two of the characteristics higher and respondents at the passive sites rating the other two higher. It was suggested that, when they are used, television monitors be elevated.

Audio Characteristics

Responses to two items concerning audio characteristics at the sites are given in Table 5. For one item, clarity of reception, there was no significant difference between the means at the active and passive sites. In fact, both had identical means of 4.09 for this characteristic, showing a satisfactory reaction.

There was also no significant difference between the means at the active and passive sites concerning volume of the audio coming into the room. The mean value of the active sites was 4.29 and the mean value of the passive sites was 4.17. Again, both groups expressed satisfaction with the audio characteristics.

Evaluation of Presentations

Respondents at the active and passive sites were asked to evaluate the various presentations made in the videoconference session. Topics covered by the speakers were as follows:

- Overview. An overview of the use of microcomputers in the transportation field was the first presentation. It was not intended to be an in-depth presentation, but a general one that would be of benefit to an audience having broad interests and varying levels of knowledge. The presentation was intended to set the stage for the program that was to follow.
- The productive office. This presentation concentrated on the use of word processors and microcomputers in enhancing the effectiveness of the modern office. Examples were given to show how the use of computer capabilities improved the efficiency and effectiveness of office operations, particularly when operating under critical deadlines.
- Strategic planning. In the past few years, strategic planning has become a vital part of many administrative offices in state departments of transportation and other transportation agencies. Sensitivity analysis may be required to evaluate various alternatives. In this presentation, an attempt was made to look at the contributions microcomputers can make to the strategic planning area.
- Ridesharing. The ridesharing presentation was concerned with the manner in which microcomputers can assist in improving the matching needs of ridesharing programs in urban areas. The presentation dealt with the software and type of computer on which the software will operate.
- Traffic engineering. The traffic engineering presentation dealt with the use of microcomputers in traffic engineering activities. These activities included intersection analysis as well as intersection control in real time. Specific examples were given of the use of microcomputers in the field to improve the operational efficiency of specific street and highway facilities.
- Transit operations. This presentation reviewed the types of software available to assist in typical transit operations. Uses of software included routing and scheduling of buses, scheduling of maintenance activities, and other activities to assist a transit manager in improving the efficiency of the operations.
- Design and engineering. Those in design and engineering have long used computers to enhance this area of transportation. However, most of the software has been available for mainframe computers rather than microcomputers. This presentation reviewed the increased capabilities of microcomputers in enhancing design and engineering activities in transportation.
- Construction and maintenance. This presentation dealt with the use of microcomputers in construction and maintenance activities. Perhaps of all the topics under discussion in this TRB session, construction and maintenance has been least affected by microcomputers. However, endeavors are being made to increase the use of microcomputers in the construction and maintenance areas.

While each of the presentations was similar in many ways, there were some differences. For example, the use of pretaped segments and visuals varied among the speakers. Although the analysis did not correlate the specific characteristics of each individual presentation, the ratings that respondents gave the presentation appear indicative of audience acceptance.

As with the questions about environmental characteristics at the remote sites, respondents were asked to rank each category of the presentation on a scale of 1 through 5. An evaluation was made by using the mean value response from respondents for each of four categories: appropriateness of content related to audience needs, speaker's effectiveness, speaker's use of visuals, and speaker's response to questions.

Appropriateness of Content Related to Audience Needs

As might be expected from a program with such a diverse group of topics, interest in the content of different parts of the program varied greatly. For example, mean ratings for appropriateness of individual presentations ranged from 3.25 to 4.09 at active sites and from 3.24 to 4.85 at passive sites. The percentage of respondents who rated the content of the various presentations as satisfactory or better ranged from 35 to 80 percent. Type of site made no significant difference in the response to this question.

Speaker's Effectiveness

Response to this question is probably related to interest of the respondents in the topic area being evaluated. Therefore, not surprisingly, mean ratings for effectiveness of individual presentations ranged from 3.03 to 4.14 at the active sites and from 3.10 to 4.04 at the passive sites. The percentage of respondents who rated the effectiveness of the various presentations as satisfactory or better ranged from 33 to 88 percent. Respondents at active sites rated speaker's effectiveness significantly better than did respondents at passive sites.

Speaker's Use of Visuals

As mentioned previously, the use of visuals varied among speakers. Thus, the mean ratings for the individual presentations ranged from 3.20 to 4.39 at active sites and from 3.37 to 3.94 at passive sites. The percentage of respondents who rated the visuals for the various presentations as satisfactory or better ranged from 43 to 88 percent. Type of site made no significant difference in the response to this question. It was suggested that the visual aids that were shown in the upper right corner of the screen be shown full screen.

Speaker's Response to Questions

The mean ratings given to speaker's response to questions for the individual presentations ranged from 3.67 to 4.00 at active sites and from 3.50 to 3.81 at passive sites. The percentage of respondents who rated response to questions as satisfactory or better ranged from 53 to 85 percent. The responses to questions by seven of the eight speakers were rated higher at active sites than they were at passive sites. In two of these cases, the difference was significant.

General Evaluation

Respondents were queried about their general evaluation of the videoconference. Questions were asked about various characteristics of the videoconference such as the interchange between speakers and the audience, the amount of time devoted to the program, and the comparison of the videoconference with a face-to-face meeting at the TRB Annual Meeting. Evaluation of these characteristics should aid in planning future videoconferencing with interactions at remote sites. Responses to these questions are given in Table 6.

Interchange Between Speakers and Audience

Several items on the questionnaire concerned satisfaction with the interchange between the speakers and the audience. With regard to the appropriateness of questions during the question-and-answer session, respondents differed significantly depending on whether they were at active or passive sites. Active sites had a mean of 3.85, with 82 percent of the respondents reporting satisfaction, whereas the passive sites had a mean of 3.47, with only 53 percent of the respondents expressing satisfaction with the question-and-answer session.

The question-and-answer sessions were very structured and had specific times allocated for them. In the planning stages for this activity, there was some question about the amount of time that should be allocated for discussions with the audience. When asked about the time allotted for questions, 68 percent of the respondents at the active sites and 57 percent of the respondents at the passive sites expressed satisfaction.

Responding to a question about time allotted for follow-up questions, participants at the active and passive sites gave mean ratings that were not significantly different (3.36 and 3.44, respectively). Forty-five percent at active sites and 50 percent at passive sites responded with a rating of 3 or lower for this item. Because of the design of the item, it was not possible to determine if respondents' dissatisfaction resulted from too much or too little time for the question-and-answer period.

Respondents at the active sites rated their ability to hear questions higher than did respondents at the passive sites (means of 3.71 and 3.08 respectively), even though the questions could be heard at each site. This was a statistically significant difference. More than one-half of the respondents at the passive sites rated this item with a 3 or lower.

With respect to their ability to hear responses, there was a significant difference between means at the active and passive sites. Respondents at active sites gave a mean value of 4.25 for this category, whereas respondents at passive sites gave a mean of 3.94. Ninety-five percent of those at the active sites rated this item at a satisfactory level.

Respondents at both active and passive sites were asked to respond to a question about their opportunity to ask questions, although there was a category labeled nonapplicable that was intended for use by respondents at passive sites. One of the main objectives of this question was to determine whether the very structured method of permitting questions to be asked would be well received by respondents. Because of the limited time available for questions, questions were queued, that is, they were selected by the monitor for speakers' responses. Respondents did not have the flexibility of an exchange of questions and answers with speakers as one has in a face-to-face meeting. As expected, there was considerable variation as well as a significant difference in the mean ratings on this item at the active and passive sites; active sites had a mean of 3.99 and passive sites had a mean of 2.96.

Satisfaction with Program Format

Because this was the first videoconference conducted by TRB, program planners had many concerns about the format. Therefore, the questionnaire given to participants had several items about the perceived satisfaction of participants with the program format. Table 6 gives the responses of participants at the active and passive sites to questions about length of presentation, number of coffee breaks, and the total length of the program.

Each presentation was approximately 20 minutes long. The respondents at active sites gave a mean value for the length of the presentations of 4.01 and respondents at passive sites gave a mean value of 3.68. This was a statistically significant difference. Although more than 90 percent of the respondents at the active site believed that the length of the presentations was satisfactory, this dropped to about 70 percent at the passive sites.

TABLE 6 General Evaluation of the Videoconference

Question	Active Sites											Passive Sites											Significant Difference Between Means
	Respondents Choosing a Given Rating[a]											Respondents Choosing a Given Rating[a]											
	1		2		3		4		5		Mean Value	1		2		3		4		5		Mean Value	
	No.	%	No.	%	No.	%	No.	%	No.	%		No.	%	No.	%	No.	%	No.	%	No.	%		
5. How satisfactory was the interchange between speakers and your audience group?																							
a. Appropriateness of questions	2	1	5	3	22	14	121	74	13	8	3.85	0	0	6	10	22	37	28	48	3	5	3.47	Yes
b. Amount of time allotted for questions	1	1	25	15	26	16	92	55	21	13	3.65	0	0	8	14	17	29	29	50	4	7	3.50	No
c. Time allotted for follow-up questions	4	3	32	22	28	20	68	47	12	8	3.36	0	0	8	15	19	35	24	43	4	7	3.44	No
d. Ability to hear questions	0	0	23	14	26	16	90	55	25	15	3.71	6	9	15	24	15	24	24	37	4	6	3.08	Yes
e. Ability to hear responses	0	0	2	1	7	4	103	63	52	32	4.25	0	0	2	3	10	16	41	65	10	16	3.94	Yes
f. Opportunity for you to ask questions	0	0	10	6	19	12	92	58	38	24	3.99	2	9	5	22	9	39	6	26	1	4	2.96	Yes
6. How satisfactory was the amount of time devoted to the program?																							
a. Length of presentation	0	0	9	5	7	4	126	75	27	16	4.01	3	2	14	8	32	19	106	62	15	9	3.68	Yes
b. Number of coffee breaks	17	11	28	18	32	20	64	40	17	11	3.23	36	24	32	21	40	27	41	27	2	1	2.61	Yes
c. Total length of program	0	0	7	4	12	7	117	71	29	18	4.02	3	2	22	14	29	18	97	61	9	6	3.54	Yes
7. Considering the amount of money required for travel to Washington, D.C., from your location for a face-to-face meeting, how satisfactory is this type of alternative program?	0	0	2	1	9	5	55	33	103	61	4.53	2	1	9	5	15	9	62	36	84	49	4.26	Yes
8. Considering the amount of time required to travel to Washington, D.C., from your location for a face-to-face meeting, how satisfactory is this type of alternative program?	0	0	5	3	9	5	55	32	101	60	4.48	2	1	7	4	15	9	68	40	80	46	4.26	Yes
9. Overall, how satisfactory was this program when compared to a face-to-face meeting?	0	0	5	3	18	11	103	60	44	26	4.09	2	1	21	13	22	13	89	53	34	20	3.79	Yes
10. How satisfactory was the supplement information (brochures, handouts, papers, etc.) provided at the site?	0	0	9	5	24	14	98	60	34	21	3.95	26	17	13	9	56	36	42	27	17	11	3.07	Yes
11. How satisfied are you with what you learned today?	0	0	4	3	24	14	112	66	29	17	3.98	2	1	21	13	37	23	90	55	13	8	3.56	Yes

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

[a] 1 = very unsatisfactory, 2 = unsatisfactory, 3 = indifferent, 4 = satisfactory, and 5 = very satisfactory.

In response to an item about the satisfaction with the number of coffee breaks, respondents at the active sites gave a lower mean value for this category than did respondents at the passive sites. Respondents at the active sites gave a mean value of 3.23, whereas respondents at the passive sites gave a value of 2.61. Thus, there was a statistically significant difference between responses from active and passive sites. Overall, about one-half of the respondents at active sites and 71 percent of respondents at passive sites rated this item as a 3 or lower.

The total program, including the presentations and question-and-answer sessions, was approximately 3 hours long. There was also a statistically significant difference between responses of those at active sites and those at passive sites to the question about satisfaction with the total length of the program. Almost 90 percent of the respondents at the active sites were satisfied (mean of 4.02); 67 percent of respondents at the passive sites were satisfied (mean of 3.54).

Comparison of Videocommunication Session with a Face-to-Face Meeting

Three questions dealt with comparing the video presentation with a face-to-face meeting at the TRB Annual Meeting. One question dealt with the amount of money required for a face-to-face meeting, whereas another question dealt with the amount of time required to have a face-to-face meeting. The third question in this category concerned the respondent's overall satisfaction with this type of program compared with a face-to-face meeting.

Amount of Money

There was a significant difference between the means for this question at the active and passive sites (4.53 and 4.26, respectively). Ninety-four percent of the respondents at active sites and 85 percent of the respondents at passive sites gave a ranking of satisfactory or higher. Thus, it would appear that, when considering the amount of money required for travel to Washington, D.C., for a face-to-face meeting, the respondents believed that a videocommunication session was a viable alternative for technology transfer.

Amount of Time

Respondents at the active sites gave a mean value of 4.48 to this question and the respondents at the passive sites gave it a mean value of 4.26, which was a significant difference between the means. Ninety-two percent of the respondents at the active sites and 86 percent of the respondents at the passive sites gave a ranking of satisfactory or higher to this question. Respondents believed that, when considering the amount of time required to travel to Washington, D.C., a videocommunication session was a meaningful way to transfer technology.

Overall Comparison

Respondents were asked to make an overall comparison of this type of session and a face-to-face meeting. In doing this, they were not asked to consider the amount of money or the amount of time or any other costs associated with a face-to-face meeting. Respondents at active sites gave a mean rating of 4.09 to this question, and respondents at passive sites gave it a mean rating of 3.79. Thus, there was a significant difference between the active and passive sites. Eighty-six percent of the respondents at the active sites and 73 percent of the respondents at the passive sites gave a ranking of satisfactory or higher to this question. Again, a large majority of the respondents at both active and passive sites gave strong approval to this method of technology transfer.

Supplemental Information

At each site, there generally were brochures, handouts, papers, and other items associated with the various presentations. Copies of the papers that were presented in Washington, D.C., were made available at all active sites and some passive sites. Respondents at the active sites gave a mean value of 3.95 to the question of satisfaction with supplemental information, whereas at the passive sites respondents gave a mean value of 3.07. Thus, there was a significant difference between the active and passive sites. It should be noted that 81 percent of the respondents at the active sites gave a value of satisfactory or higher to this question, whereas only 38 percent of the respondents at the passive sites gave it a value of satisfactory or higher. Obviously, some of the difference in rankings was due to the extra effort that went into providing handouts at all the active sites.

Satisfaction with What Was Learned

Respondents at both the active and passive sites were asked to indicate how satisfied they were with what they had learned. Respondents at the active sites gave a mean value of 3.98 and respondents at the passive sites gave a mean value of 3.56, which was a significant difference between the active and passive sites. Eighty-three percent of the respondents at the active sites gave a rating of satisfactory or higher to this question and 63 percent of the respondents at the passive sites gave a rating of satisfactory or higher. Thus, a large majority of respondents at both active and passive sites were pleased with what they had learned from the program.

Knowledge of Microcomputers

Two questions were related to the respondents' levels of knowledge about microcomputers. One question dealt with the respondents' levels of knowledge before attending the program; the other question dealt with their levels of knowledge after attending the program.

There were statistically significant differences in the mean scores of respondents at the active and passive sites concerning their knowledge of microcomputers before attending the teleconference (see Table 7). The mean for the active sites was 3.06 and the mean for passive sites was 2.82. Sixty-four percent of respondents at the active sites and 73 percent of those at the passive sites rated their prior knowledge as average or less.

For both active and passive sites, respondents gave mean values for level of knowledge before and

TABLE 7 General Evaluation of Level of Knowledge

	Active Sites											Passive Sites											
	Respondents Choosing a Given Rating[a]											Respondents Choosing a Given Rating[a]											
	1		2		3		4		5			1		2		3		4		5			
Question	No.	%	No.	%	No.	%	No.	%	No.	%	Mean Value	No.	%	No.	%	No.	%	No.	%	No.	%	Mean Value	Significant Difference Between Means
12. Please indicate your knowledge level of microcomputers prior to attending this program:	7	4	51	30	50	30	48	28	14	8	3.06	9	5	67	39	51	29	38	22	8	5	2.82	Yes
13. Please indicate your knowledge level of microcomputers after attending this program:	0	0	30	18	56	34	64	39	14	9	3.38	1	1	40	23	74	43	48	28	8	5	3.13	Yes

Note: Numbers and percentages in this table reflect the subject population who responded to these questions.

[a] 1 = no knowledge, 2 = some knowledge, 3 = average knowledge, 4 = better than average knowledge, and 5 = very knowledgeable.

after the session that were significantly different (higher after the videoconference). Thus, respondents at both the active and passive sites indicated that their level of knowledge increased through information gained from the session.

COST ANALYSIS

A complete cost analysis was impossible because of lack of information on all costs associated with the program. Many hours of TRB staff and volunteer time were spent on the program for which there are no accurate estimates. In addition, agencies responsible for both the active and passive remote sites incurred costs for which accurate tabulations are not available. Also, the total number of individuals viewing the program is not known. However, even with the deficiencies that do exist in conducting an appropriate cost analysis, some cost data are available that will give at least a cursory view of the resources required for conducting future programs.

As stated previously, it is not unrealistic to estimate the total viewing audience to be about 2,500, which is equal to about one-half of the attendees at the TRB Annual Meeting held in Washington, D.C. Because this was a first for TRB and a reasonable level of effort was put forth in advertising the program, one might expect the attendance at future programs to vary considerably--depending on acceptance of the first program.

The out-of-pocket cost to TRB for the program (paid to WETACOM, Inc., the producer for TRB) was $37,123. The original bid was $33,561, but additional requirements were added during program formation. Information on out-of-pocket costs from the remote sites varied from a low of 0 to as much as $3,900. Several had costs in the $200-to-$300 range. Costs varied depending on whether the facilities were owned by the agencies or available to them on a low- or no-cost basis. Universities often have facilities to accommodate this type of programming and may make these facilities available to other state agencies on a low- or no-cost basis. In addition, some agencies added computer demonstrations, luncheons, handouts, and other activities to supplement the 3-hour program. Obviously, the more activities, the greater the local costs.

In a cost analysis of this type, it is difficult to aggregate the costs that accrue from all agencies involved in the program. No single agency pays for all costs. This, of course, is true if one assessed the cost of the TRB Annual Meeting. Travel costs as well as other costs are borne by the agencies sending their employees to the Annual Meeting. Although the TRB costs for conducting an Annual Meeting might be obtained, it would be difficult, if not impossible, to ascertain all costs associated with the Annual Meeting.

If there were 2,500 viewers of the program, the direct out-of-pocket costs to TRB would be $14.85 per person viewing the program. If the costs at the remote sites were one-half of the TRB outlay (i.e., $18,526), the cost per individual viewing the program would be $22.27. When considering costs of various types of technical programs, these costs are not out of line. In addition, the total cost for increasing the length of the program to two back-to-back sessions (i.e., 6 hours) would not be nearly equal to twice the basic cost. Based on the experience with this program, the basic cost can be reduced for future programs.

As previously discussed, there were minimal differences between respondents at active and passive sites in the acceptance of the program. Thus, one should consider the extra costs for providing telephone service in order to have two-way audio communication. The cost to TRB for telephone service was $3,500, which was about 10 percent of the total contract cost. There were 180 questionnaires returned from the active sites, but it is known that not all of the attendees at the active sites completed questionnaires. If there was an average of 50 participants per site, as estimated earlier, the cost per participant for telephone service at the active sites would be $17.50, which exceeds the average total cost for the 2,500 participants at both active and passive sites.

While this cost analysis is certainly not complete, it does provide some parameters for considering future videoconferencing programs. Information contained here does give a basis for preliminary evaluation of the costs associated with using videoconferencing for technology transfer by TRB.

CONCLUSIONS AND RECOMMENDATIONS

Overall, the use of the videoconference at the 1984 TRB Annual Meeting appears to have been well received. Several conclusions appear appropriate after the questionnaire responses to the videoconference were evaluated:

- The videoconference served as a method for increasing communication.
- The presenters were skilled in sharing their ideas.
- There were few differences between responses of those at the active sites and responses of those at the passive sites.
- The videoconference was cost-effective.
- TRB should consider videoconferencing as one of its technology transfer activities to increase the communication to field personnel.

Increased Communication

The videoconference served a different audience than the one that usually attends the TRB Annual Meeting. Therefore, the videoconference in all likelihood provided information to an audience that would never have received information from a TRB conference in Washington, D.C. Few of these individuals had attended a TRB meeting in Washington. Thus, technology transfer involved many individuals who otherwise would not have had the opportunity to participate. In addition, the results showed that the participants learned a significant amount about microcomputers from the videoconference. The participants indicated a significant increase in their levels of knowledge because they attended the videoconference.

It is recommended that future videoconferences continue to address the needs of the different audience identified in this survey. Further, a needs assessment could be made of those who participated at the active and passive sites, determining which of their most pressing information needs could be addressed by videoconferencing. Because the audience is different from that in attendance at the TRB site in Washington, the needs of the videoconference audience may be different from the needs of the audience at the sessions presented at the Washington site.

Skill of Presenters

At this videoconference, respondents were satisfied with the quality of the presentations. Because presenters were selected carefully for the videoconference, it was not surprising that the audience was satisfied. Presenters had been carefully admonished concerning their modes of presentation and their use of visuals.

In future years, it is recommended that careful consideration continue to be given to the selection of presenters at the videoconference. Perhaps a list of criteria should be developed to use in the choice of speakers. Speakers should also be given a list of requirements for or expectations of the videoconference presentation; these requirements may be above and beyond requirements for an ordinary presentation at TRB in Washington.

Active Versus Passive Sites

Overall, there appeared to be few overwhelming differences between active and passive sites. Certainly, there were few differences that changed the evaluation of an item from "satisfactory" to "unsatisfactory." In fact, the videoconferencing was favorably rated when compared with a face-to-face or live presentation. The videoconference was well received by those at both active and passive sites. It does not matter whether the videoconference is active or passive; the critical factor appears to be the availability of the videoconferencing as an adjunct to the on-site conference in Washington.

Cost-Effectiveness

When the number of participants is considered relative to the costs incurred, the videoconference appears to be a cost-effective way for TRB to share information with those in the field. Respondents indicated a substantial reduction in travel costs and in loss of productivity with this type of program. The unit cost appears to make the videoconference a feasible way to share information.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of the videoconference programs planning committee: Bill McCall, Iowa Department of Transportation; Judith A. Pinkey, Minnesota Department of Transportation; Jon Underwood, Texas State Department of Highways and Public Transportation; Thomas F. Foody, Ohio Department of Transportation; and Howard J. Simkowitz, District of Columbia Department of Transportation. Thanks are given to the TRB staff who worked with this committee: Janice W. Bain, K.B. Johns, and W. Campbell Graeub. Also, special thanks are given to the commissioners and directors of the state highway departments in Iowa, Minnesota, Montana, and Texas. Without their assistance of manpower and facilities for the active sites, this program could not have been successful.

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Publication of this paper sponsored by Group 1 Council.

Role of Metropolitan Planning Organizations in the 1980s

BRUCE D. McDOWELL

ABSTRACT

A new study by the U.S. Advisory Commission on Intergovernmental Relations focuses on the adaptations in transit services, finances, institutions, and policy processes occasioned by current financial stress at all levels of government and by the devolution of national responsibilities to state and local governments. It was found in this study, in part, that (a) most metropolitan transportation planning organizations are now locally governed and staffed, (b) their planning is becoming increasingly isolated, less comprehensive, and shorter range, (c) some such organizations are experiencing strong pressure to decentralize or subregionalize, and (d) the desire for these organizations to exercise more effective areawide leadership is not matched with local approval of greater powers for them. It is concluded in the study that informal coordination techniques or new powers granted by state legislatures are the two most likely facilitators of improved metropolitan transportation leadership in the 1980s.

The U.S. Advisory Commission on Intergovernmental Relations (ACIR) has been studying metropolitan transit for slightly more than one year. The project has been sponsored by UMTA and its focus is on the adaptations in transit services, finances, institutions, and policy processes that might be needed because of (a) the financial stress that has been felt at every level of government and (b) the devolution of federal requirements and responsibilities to state and local governments. Presented in this paper is a summary of the findings relevant to the roles of the metropolitan planning organizations (MPOs) officially designated to do the urban transportation planning and programming required by federal laws and regulations.

RESEARCH FINDINGS

The study is based on two original research efforts in addition to a fairly extensive literature search. The first such effort was a questionnaire survey of 56 metropolitan areas. In each of those areas (including one in every state except two), the survey targeted five different types of respondents: MPOs, the transit authorities, cities, counties, and transit unions. Each group expressed somewhat different views, enriching the study more than can be reflected in this brief presentation, although some of the differences between the way MPOs and the others saw the issues will be highlighted. The survey yielded 235 responses out of 302 that were sent, or 78 percent, a good response rate.

The other original research effort involved three case studies: New York, Chicago, and Seattle. These cases greatly enhanced the study team's ability to interpret the questionnaires.

Four of the major findings from this work are as follows:

- Most MPOs are now locally based, but the types of MPOs are still shifting.
- MPO planning is becoming increasingly isolated, less comprehensive, and shorter range.
- Some MPOs are under strong pressures to decentralize or subregionalize, at least in the larger metropolitan areas.
- The desire for more effective areawide leadership in transit affairs does not translate into a desire for a greater concentration of power at the metropolitan level.

An explanation of these findings follows.

Types of MPOs

First, concerning types of MPOs, in 1972 42 percent were still under the thumb of the state department of transportation or highway agency; their work programs were state staffed. The percentage of that type of MPO has dropped to 4 percent at present, leaving 96 percent guided and staffed primarily by local officials.

The most frequent type of MPO now is the general-purpose regional council of governments that performs other areawide functions in addition to its MPO role; 55 percent of MPOs are in that category, although it used to be more. In the mid-1970s about 75 percent of MPOs were of this type when the U.S. Department of Transportation (DOT) was pushing hard to have most of the designated MPOs be the Office of Management and Budget (OMB) Circular A-95 federal-aid review agency (1). However, when DOT pressure dropped off, so did the proportion of these designations. Even though the number of regional councils designated as MPOs is still growing, the total number of MPOs is growing even faster, and the regional councils are getting a smaller proportion of the new designations (Table 1).

The number of freestanding MPOs--those that are organized specifically for the MPO purpose and serve only that purpose--have leveled off and are declining slowly. These MPOs represented 3 percent of the total in 1972 and currently represent 15 percent, although they peaked at about 21 percent in 1980.

The MPOs that are designated within city or county governments are taking up the slack. These MPOs represented 18 percent of the total in 1972 and currently represent 25 percent. This trend probably results largely from the fact that many of the new MPOs are small and the city or the county may be the only government in the area with sufficient staff capacity to do this kind of technical work.

TABLE 1 Types of Section-134 Metropolitan (Transportation) Planning Organizations

	1972 (*2*)		1976 (*3*)		1980 (*4*)		1983[a]	
Type of MPOs	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Regional councils	81	37.2	205	82.3[b]	152	58.9	179	54.6
City or county	38	17.4			44	17.1	83	25.3
Freestanding transportation study organization	7	3.2	30	12.1	54	20.9	52	15.8
State	92	42.2	14	5.6	8	3.1	14	4.3
Total	218	100.0	249	100.0	258	100.0	328	100.0

[a] MPO mailing list, supplied by U.S. Department of Transportation, September 26, 1983.
[b] Regional councils accounted for about 75 percent of all MPOs at their peak in the mid 1970s (*1*, p. 119).

Environment of Metropolitan Planning

The second finding--that MPO planning is becoming increasingly isolated, less comprehensive, and shorter range--is supported by four trends. First, federal aid and federal requirements for metropolitan planning have declined dramatically in the past 3 years. The latest comprehensive study of the federal programs supporting regional planning at the metropolitan and substate levels showed that there were 39 such programs in 1979. Only one of those programs now remains untouched by termination, substantial budget reduction, and major deregulation. This greatly reduced federal impetus for regional planning leaves MPO planning isolated. DOT maintains the only substantial federal support for metropolitan land-use planning.

Especially significant in this federal withdrawal was the termination of the Section 701 comprehensive planning program from the U.S. Department of Housing and Urban Development (HUD) and the Section 208 wastewater treatment planning from the Environmental Protection Agency (EPA). Those two federal grant programs had strongly supported the land-use and comprehensive planning studies done by the regional-council-type of MPOs.

The second trend causing the growing isolation of MPO planning is that, as a result of the general decline in federal support, MPOs sought substitute revenues. They are receiving them mostly from state and local governments; however, these new funds are not for regional planning. They are instead directed toward supporting specific services for local governments--data services, sharing of specialized staff capacities among local governments that could not afford them individually, preparation of local plans by contract, achievement of economies of scale through joint purchasing, and a long list of other similar services. Thus, what is beginning to dominate the regional agenda are specific services to local governments, instead of planning.

The third trend diluting federally required urban transportation planning is that the added funds authorized by Congress for this purpose are being absorbed largely by the 70 new MPOs that have been created since 1980 as a result of the new census. In addition, those funds are having to pick up the land-use planning that previously had been funded by HUD, EPA, and other federal agencies. Therefore, the added money for MPO planning nationwide is not expanding the combined land-use and transportation planning programs of individual MPOs; in many cases, it is not even maintaining them at earlier levels.

The final trend that is deemphasizing areawide comprehensive planning is that much of the new transit planning money comes from the Section 9 block grant (Surface Transportation Assistance Act of 1982, P.L. 97-424) and in most cases does not go to the planning groups. Instead, it goes to the transit authorities. Although these funds may be transferred from the transit authorities back to the MPOs (as a small amount already has been), most of it probably will not take this route. Even when it does, the tendency is for it to buy a specific ser- vice for the transit authority instead of to support general comprehensive planning. Examples of such services include a corridor study, a transit mall design, and other specific transit projects.

Thus, the tables have been turned on the MPOs. They used to receive all the federal transit planning money and then farm out some of it to the transit authorities for specific planning that was in line with the MPO's general planning. Now the added planning money is coming in through the transit authorities and the MPOs will have to serve the transit authorities' direct needs in order to get any of it. Consequently, to the extent that direct UMTA and FHWA funding of the MPOs may not be maintained, the MPOs increasingly can be expected to become servants of the transit authorities. In that situation, it would be increasingly difficult for an MPO to orchestrate areawide policies.

Pressures to Decentralize Transportation Planning

The third basic finding highlighted in the study is that some of the MPOs are under strong pressures to decentralize or subregionalize. In all three metropolitan areas where ACIR prepared case studies, strong central-city versus suburb-equity questions were being raised about transit programs. Many such questions are settled by fair-share formula negotiations that establish major features of the transit system before planning even begins. How much sense does it make to plan the overall area after such formulas have fragmented it?

Moreover, the three principal federal requirements that were gluing metropolitan areas together are no longer there. Specifically, (a) the new federal regulations no longer require that MPOs be areawide; (b) there no longer have to be formal interagency agreements delineating the roles of the different groups involved in the unified planning work program; and (c) the federal requirement for interagency coordination of metropolitan planning resources that used to apply under OMB Circular A-95 has been dropped (1). It is too early to determine whether these loosened regulations will result in any significant changes in established practices, but they could.

In addition, the Section 9 planning funds as well as the Section 9 implementation funds and the urban system funds frequently go into a metropolitan area already subdivided by federal formulas. This was true in all three case study areas, and is also true in a number of other areas where the census-defined "urbanized-area" designations that drive the federal formulas do not match the metropolitan area or MPO boundaries. There also are 35 metropolitan areas that are split by state lines, and federal funding is becoming increasingly oriented to the states.

In the three case study areas, these pressures to decentralize were evident. The New York region, instead of having one MPO (as it did for many years) now has nine. One of those MPOs is subdivided into 3 MPO subregions and 10 Section 9-designated transit block-grant recipients. It is at the smallest geographic area receiving federal funds that the transit project selection process begins. These selections are then fed up through subregional MPO committees to the MPO's executive committee and finally to the MPO's governing board. By that time, the project selections all have been decided. Therefore, if at that point the MPO decides that it wants to apply the regional plan, there is little countervailing federal pressure.

In Chicago, the Illinois-Indiana Bi-State Commission lost its funding and its staff last fall. That organization had been federally required in the early 1970s as a communication bridge between the two substate regions that share the greater-Chicago commuter market. It is not certain yet what is going to happen there, but the area has already suffered a serious setback in its areawide communication process.

In Seattle, there are four subregions within the MPO, and the basic project initiation process goes on within those subregions. Federal money is divided three ways by the urbanized area formulas before the project selection process begins.

This phenomenon is not unique. For example, certain state-dedicated revenues for transit in California are divided among the local governments within the San Francisco and Los Angeles metropolitan areas independent of the areawide plan. Thus, the pressures for subregionalization apply more broadly than in just the three ACIR case study areas.

Areawide Leadership Without Areawide Power?

The last finding highlighted in the study is that the strong desire for greater areawide leadership is not matched by any great desire for further concentration of power at the metropolitan level. The indicators used to measure desire for greater areawide leadership included a survey question about expanding the scope of MPO planning to encompass topics such as transit pricing, taxing, parking, deregulation of services, and enhanced public-private partnerships. About 53 percent of all respondents said that such an expansion would be a good idea.

A second indicator of the desire for greater areawide leadership was the need to establish a strategic planning process for an area's transit industry to examine the nature of services that should be provided in the future to meet changing conditions. About 83 percent of all survey respondents agreed with this suggestion.

In contrast to these desires for enhanced areawide leadership, however, ACIR found that the typical MPO now is largely a compiler of projects initiated by others as well as a constrainer of those projects. The MPOs apply the overall federal funding cap and try to get the number of projects down within that realistic funding range. Thus, rather than providing areawide leadership, the federally required transportation improvement program (TIP) prepared by the MPO basically confirms what is going on in the fragmented region.

In addition to investigating desires for greater areawide analysis, the ACIR survey tested a number of proposals that would enhance the powers of the MPOs and the transit authorities. A proposal to give MPOs more authority was rejected by about 75 percent of all survey respondents, and a proposal to further consolidate transit authorities was rejected by two-thirds of the respondents.

It can be concluded that MPOs are seen, right now, as playing approximately the right role. The only areas in which there was a majority sentiment (57 percent of the respondents) for giving MPOs more power were the ones in which the city or county government held the MPO designation (25 percent of the cases). This probably says something about political legitimacy; that is, perhaps regional council and freestanding MPOs are not seen as legitimate parts of the political landscape.

The only transit agency reform that received a majority of support in the survey (53 percent) was one that called for separating the transit policymaking function from transit operations. Organizationally, such a setup would resemble the Regional Transportation Authority (RTA) in Chicago--an umbrella funding group for transit that operates relatively little of the service.

Regarding the next steps for improving metropolitan area coordination, the strongest survey support was for the ACIR survey proposal to use informal techniques more fully. Such techniques include temporary task forces, informal meetings and committees, and the sharing of staff expertise among cooperating agencies. This proposal was approved by 68 percent of all respondents. Thus, the primary hope for future coordination improvements in metropolitan transit--as viewed by officials at the local level--appears to rest with strengthened intergovernmental relationships rather than with a restructuring of the formal institutions in the area.

MPO Versus Other Views

Views of the MPOs differed from those of the average survey respondent on several points. Views of the MPOs more strongly favored expanding the scope of MPO planning, using strategic planning techniques, increasing MPO authority, and relying on informal coordination techniques. Therefore, the MPOs will try it both ways. If they cannot get more authority themselves, they will try the informal route.

MPO views were about average (i.e., highly negative) on ideas for further consolidating transit authorities and transferring transit responsibilities to either the county or the state level. These survey proposals drew almost no positive response from any group of respondents.

MPO support was weaker than that of other respondents for the idea of separating transit policy making from transit operations. Such a response was unexpected and remains unexplained unless, perhaps, the transit policy group is seen as an effective competitor for part of the MPO role.

CONCLUSION

The conclusion is that any substantial strengthening of metropolitan transportation powers probably would have to come from outside, not from the region itself. At present, that means that it would have to come from the state legislatures because federal influence is rapidly receding.

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Publication of this paper sponsored by Committee on Intergovernmental Relations and Policy Processes.

Potential for a Full-Service Transit Agency

DAVID CURRY and JESSE GLAZER

ABSTRACT

About 20 ridesharing programs out of a total of about 250 such programs in the United States are currently affiliated with public transit agencies. Such affiliation is a major step toward the advantages of a full-service transit agency, but its pros and cons need to be carefully considered by both the transit agency and the existing ridesharing program. Several aims sought by local ridesharing programs through their affiliation decision are identified and a similar scheme to assist in making affiliation decisions is offered; it is hypothesized that transit agencies will differ substantially in their ability to reach such affiliation goals. Results of a study of 13 ridesharing programs in transit agencies tend to confirm this hypothesis, although little quantitative evaluation information is available. Further study is recommended to remedy this lack of evaluation information and to consider the relative merits of (a) close cooperation between ridesharing and transit agencies and (b) the option of merging these two types of programs.

About 250 ridesharing programs are currently organized and providing services to employers and the public in cities across the United States. Before the 1973 oil embargo, there were no such programs in the country. Now their influence extends into most large employers, many of whom have designated transportation coordinators to help their own staff get to work with more reliability, sociability, and energy efficiency plus reduced effects on traffic congestion.

Concurrently with the increase in the number of ridesharing programs, the cost of public transit has risen rapidly. For example, total U.S. transit expenses increased by 12 percent per year between 1972 and 1980 while ridership increased by only 3 percent per year, resulting in a quintupling of transit deficits, from $0.5 to $2.6 billion. Increasing transit costs and deficits and the slowing or reversal of ridership increases have led to a vigorous search for countermeasures, among which the full-service transit agency is an important example.

A full-service transit agency serves a diversified travel market with correspondingly diversified resources, providing regular fixed-route bus service in areas of higher trip density and demand-oriented service such as ridesharing assistance where that would be a more economical solution. The full-service transit agency concept has also been referred to as the new partnership between public and private agencies in providing transportation services (1,p.13):

> The driving force behind the new private-public agency concept is cost-effectiveness, with the increasing knowledge that the full-blown public approach is proving too costly and inflexible to serve many of the small and unique trip demands that make up so much of today's urban scene. The time-honored business practice of market segmentation is being applied--finding the right product for each segment.
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> The private-public transit agency will support company-based vanpools, contract with private carriers including taxi operators where they are the most cost-effective modes, provide a computerized service to "match" persons interested in carpooling, and orchestrate the many special transportation services provided by social service agencies. It will support parking-management programs, special traffic lanes for all multi-passenger vehicles, and new programs for staggered or flexible work hours to relieve peaks of traffic congestion. It will work closely with the business community on joint financing of facilities and services and on coordinated proposals for new govern-

ment-funded programs. In Norfolk, conventional bus routes are being terminated in low-density residential areas and replaced by private entrepreneur jitneys operating over the old routes but at a fraction of the earlier subsidy. In Michigan, vanpool-driving employees are applying to the Public Utilities Commission for operators' licenses to exchange their vans for full-size buses. This is not being opposed but rather encouraged by the cognizant transit authorities.

Because affiliation with (or initiation of) a local ridesharing program is a major step toward the full-service concept, such affiliations are being considered by a number of transit agencies. About 20 transit agencies include ridesharing in their services, and at least one major ridesharing agency (Seattle-King County Commuter Pool) is in the process of merging with the local transit operator (Seattle Metro). Two other ridesharing programs, in Dallas and Fort Worth, Texas, have been included in the new regional transit agencies that were recently formed around those cities. Therefore, it is timely and relevant to ask, Have such affiliations in the past worked out well enough to justify active interest by both transit agencies and ridesharing programs?

The issues relevant to the choice of organizational form and affiliation for a local ridesharing program are examined in this paper in three ways. First, current affiliation practices and preferences are briefly reviewed. Second, a simple scheme is proposed for assisting in the process of deciding among the different affiliation possibilities of ridesharing agencies. Third, the results of a recent survey of transit agencies with ridesharing programs are presented as evidence of both the feasibility and hazards of such affiliation. This paper is addressed to transit managers and other local decision makers who are considering the best organizational location for a local ridesharing program.

CURRENT AFFILIATION PRACTICES AND PREFERENCES

The distribution of ridesharing agencies by affiliation was surveyed in 1978 (2) and has probably not shifted much since then. The results of that survey show a predominance of affiliations with metropolitan planning organizations (43 percent), cities or counties (22 percent), and state departments of transportation or energy (17 percent), for a total of 82 percent. Transit operators are the next most frequent, with 12 percent, which would indicate that about 30 of today's 250 ridesharing agencies have transit affiliations. This figure is roughly consistent with known ridesharing programs in transit agencies, which serve the following 20 areas and perhaps others:

Baltimore area, Maryland
Birmingham, Alabama
Dallas, Texas
Ft. Worth, Texas
Golden Gate Bridge Corridor, California
Hampton, Virginia
Houston, Texas
Lansing, Michigan
Melbourn, Florida
Minneapolis-St. Paul, Minnesota
Nashville, Tennessee
Norfolk, Virginia
Orange County, California
Phoenix, Arizona
Portland, Oregon
Santa Clara County, California
Seattle, Washington (in process)
Tacoma, Washington
Tulsa, Oklahoma
Winston-Salem, North Carolina

Thus, about 8 percent of ridesharing programs are known to be affiliated with transit agencies, and about 6 percent of the nation's total of some 300 urban transit systems have ridesharing programs. The remaining ridesharing agencies are divided among business or nonprofit corporations, chambers of commerce, and university administrations.

PROPOSED BASIS FOR CHOICE OF AFFILIATION

The choice of organizational form and affiliation for ridesharing programs has always been largely determined by local conditions and preferences, and especially by the amount of interest and support available from different organizations. Hence, the affiliation decision is not usually conducted in an impartial or academic setting, and to speak of objective criteria for the decision may be artificial. In addition, there is as yet no systematic comparison of results available for each major type of affiliation, although examples can be found of outstanding ridesharing programs of each type. Nevertheless, it is possible to identify several goals that are commonly sought in organizing a ridesharing agency, and to consider how well different affiliations are likely to meet those goals. Based on previous work (3,p.48), the goals suggested for consideration are

- High visibility for the program together with an image of solidarity and continuity
- An active client and service orientation, responsive both to local employers and the public
- Facilitation of commitments to ridesharing by employers
- Relative independence and flexibility for exploring new ideas or acting quickly in emergencies
- Ability to participate in relevant transportation activities, particularly coordination with transit planning and marketing and with parking management
- Adequacy and stability of funding
- Encouragement and easy use of donated support
- Ability to interact successfully with legislative bodies

It is hypothesized that the ability of transit agencies to meet such goals on a ridesharing program varies with the policies and capabilities of individual operators. The service of ridesharing promotion and assistance is different in character from the service of fixed-route transit buses with which transit operators are most familiar. However, both have the same goal of providing commuting alternatives to the single-occupant automobile. Transit agencies usually have a high degree of visibility and stability, and many transit operators are keenly attuned to the needs of employers for commuting services. For example, a recent U.S. Conference of Mayors survey (4) shows that 58 percent of all transit operators have programs marketing passes through employers, and 85 percent of these programs have employers reselling the passes to employees at discounts. Many transit agencies also track new developments and employment growth as a guide for modification of bus routes.

Although no complete test of the foregoing hypothesis has been made, a recent study of 13 ridesharing programs affiliated with transit operators has produced much relevant information on the subject (5). In the next section, the results of that study are summarized and comments are provided on the problem areas identified in the study and the study's implications for the hypothesis discussed in this section.

SUMMARY OF RIDESHARING PROGRAMS IN SELECTED TRANSIT AGENCIES

The ridesharing programs considered in the study referred to in the preceding section (5) were sponsored by the following operators, in declining order of the size of their bus fleets: Mass Transit Administration, Maryland Department of Transportation; Metropolitan Transportation Commission in Minneapolis-St. Paul, Minnesota; Santa Clara County Transit District and Orange County Transit District, both in California; Tri-Met in Portland, Oregon; Metropolitan Transit Authority in Houston, Texas; Pierce Transit in Tacoma, Washington; Tidewater Regional Transit District in Norfolk, Virginia; Metropolitan Transit Authority in Nashville, Tennessee; Peninsula Transportation District in Hampton, Virginia; Capital Area Transit Authority in Lansing, Michigan; and the Transit Authority in Winston-Salem, North Carolina. The Regional Transportation Authority's program in Chicago, Illinois, now discontinued, was also included.

The study sought to learn about (a) the benefits and costs to transit operators of the 13 ridesharing programs, (b) what services and incentives were offered, (c) how evaluation was conducted, and (d) what problems were encountered. The principal findings of the study were as follows:

- The major benefits sought and reported by the operators were improved efficiency (through reduced cost per trip in ridesharing modes and reduced peak-to-base ratio of bus service), increased effectiveness (such as offering ridesharing alternatives to employers and areas that cannot be served by fixed-route buses), and enhanced public image (by having a broader family-of-transportation-services outlook and helping to soften the impact of transit service cutbacks). In one program, public costs per vanpool passenger trip were shown to be about 17 percent of bus subsidy costs per passenger trip ($0.25 versus $1.50).
- Typical, first-year costs of the programs were between $50,000 and $150,000, while typical annual costs of established programs varied between $0.12 and $0.35 per capita, averaging $0.24 and ranging as high as $0.78.
- The most essential ridesharing services were carpool and vanpool formation assistance; energetic brokerage of ridesharing to employers (usually assisted by an advisory committee with private-sector representation); and facilitation of company-based employee transportation coordinators (ETCs). Important incentives were park-and-ride (or pool) lots, preferential parking, high-occupancy-vehicle (HOV) lanes (planned to grow to be an HOV lane network in Santa Clara County), HOV bypass on ramps, operation of third-party vanpools or seed vans for trial and later transition, and land-development requirements that encourage ridesharing efforts to mitigate the need for parking.
- Few operators had conducted evaluations of the results of their ridesharing programs, which appear to require some reeducation of the transit staff and board so that they will understand different performance measurement and analysis techniques.
- Problems were encountered either internally (personalities, turfism, resistance to change, lack of independence) or externally (labor union objections, low public response) by about one-half of the programs. However, most problems are solvable or of short duration; there are several sources of technical assistance for coping with problems that arise, including the FHWA National Ridesharing Information Center, UMTA's Public Transportation Network project, and the transit operators participating in this study.

COMMENTARY ON PROBLEMS MENTIONED IN STUDY

It is worthwhile to expand on the internal and external problems with ridesharing programs that were identified by their transit operators during the foregoing study.

Internal problems usually relate to organizational and personal inertia. Ridesharing promotion is different from provision of conventional transit service and will call for adaptations on the part of the transit staff. Also, some of the existing transit staff may view the ridesharing program either as competition for scarce funding or as a threat to their current position or advancement potential. Finally, the desirability of integrating ridesharing with transit marketing and administrative services should be tempered by the need of the ridesharing program to have its own outreach staff who are (a) trained in promotion of ridesharing and transit options to employers and (b) fully responsible to the ridesharing director.

Internal competition per se is not unhealthy in an organization. To the extent that such competition is for providing the most efficient mix of transit and ridesharing services in each corridor and area of the region, a wider choice of modes is made available to commuters, and total ridesharing and transit usage is likely to increase. Probably a loose coupling of the ridesharing unit to the transit organization--such as reporting to the general manager or an assistant general manager without close day-to-day supervision--will best foster the development of a creative, customer-oriented ridesharing service that can be integrated without losing the advantages of internal competition.

The possible external problems mentioned by respondents were labor union objections and public awareness. None of the agencies studied has had significant labor problems, and only two had to develop special modifications of their labor agreements as a result of their ridesharing programs. It is very significant that so few labor problems have been encountered because most transit managers fear the repercussions from labor if vanpooling appears to erode the transit market. Indeed, a full-service transit operator should be providing the types of affordable service best suited to the public demand, which may require reducing bus service in areas where it becomes too expensive or replacing it with ridesharing options.

A more frequently mentioned external problem was maintaining public interest. This problem is common to all types of ridesharing programs and cannot be ignored. It is necessary to maintain commuter awareness of the ridesharing services to make using the services extremely easy and to facilitate ridesharing incentives where possible, otherwise the demand for these services will diminish and program productivity will decrease.

CONCLUSIONS

In terms of the organizational affiliation goals of ridesharing programs that were identified in the third section of this paper, the authors believe that results of the study of 13 ridesharing programs in transit agencies confirm their basic hypothesis: the ability of transit agencies to meet the goals of a ridesharing program varies with the policies and capabilities of individual transit operators. Specifically,

- Many respondents achieved high visibility through their transit agency affiliation. Others felt that their program was subordinated to the transit interests of the agency, with a loss of vigor in marketing ridesharing. Program continuity was good in all cases except Chicago, where the ridesharing program was cancelled in 1983.
- Contacts with the public and local employers were generally enhanced, with some transit agencies facilitating ridesharing at employer locations that were off of transit routes instead of extending transit service to them. In other cases, transit and ridesharing promotions were unrelated.
- Employer commitments to ridesharing tended to be difficult to obtain and were usually limited to distribution of ridesharing information; however, this is a problem common to all ridesharing agencies.
- Independence and flexibility were often hampered by being a small part of a large transit agency. The offsetting advantage was better coordination with transit decisions; however, many respondents believed that their ridesharing potential was being underused.
- Adequacy and stability of funding both were problems with some transit-sponsored ridesharing programs and not with others, much as for independent ridesharing programs. However, more adequate and stable funding are key reasons that Seattle-King County Commuter Pool recently agreed to a merger with Seattle Metro, which suggests that the ridesharing program of a large transit agency does not have to be underfinanced.

No information was sought in the survey on donated financial support or on the ability to interact with legislative bodies.

In conclusion, the authors believe that there are enough potential advantages for ridesharing programs due to affiliation with transit agencies that they should consider such affiliation carefully. However, the advantages are not assured, so they should be the object of negotiation and prearrangement instead of being based on an assumption that everything will work out well.

The case for advantages for the transit agency is less conditional. All of the transit operators that were contacted perceive significant benefits of some kind from their ridesharing programs. Nevertheless, the extent of the benefits, especially in terms of greater patronage per dollar spent, is not well-known and can be presumed to vary considerably. Adoption of a ridesharing program is a necessary but not a sufficient condition for creating a full-service transit agency; that is, the potential is there, but requires understanding and effort to be realized.

FURTHER STUDY NEEDS

There are two areas in which further work is recommended.

Benefits of Ridesharing to Transit Operators

The first and perhaps the most important question asked by a transit manager is "What are the benefits of a full-service transit approach to my agency?" There is still scant evidence with which to provide a quantitative answer in terms such as the effects on deficit per passenger, total patronage, or peak-to-base ratio.

The only way in which this evidence can be developed is through careful evaluation studies of selected operators who have incorporated an in-house ridesharing program. Ideally, such a study should begin before the ridesharing program is initiated or expanded so that baseline data can be gathered to permit before-and-after comparisons.

Such an evaluation study would not be easy or inexpensive to carry out. It would necessarily involve the operations and planning staffs to collect and analyze the data needed. The study could be affected by external events, such as changes in gasoline prices, that would complicate the analysis and raise the need for a control transit agency that did not have a ridesharing program. The period of the study should be at least 1 year, preferably 2 years, to allow the ridesharing program to get established (typically a 6- to 12-month process) and its effects to begin to develop. The measured benefits should include effects on ridesharers, transit users, and the community as well as on the transit agency. UMTA and/or the American Public Transit Association (APTA) are probably the most likely sponsors of such a study.

Cooperative Efforts with Existing Ridesharing Programs

In most urban areas, there is already a ridesharing program in operation. Thus, the usual decision facing most transit operators, if they have decided that ridesharing could complement transit services, is "Should I undertake a more cooperative effort with the existing program or consider a merger?" Speaking more broadly, transit operators both with and without a ridesharing program face the question "How can I improve the effectiveness of present cooperative efforts between transit and ridesharing services?"

Many transit operators are already cooperating with their local ridesharing agency. For example, the transit general manager in Kansas City would not consider starting an in-house ridesharing program because of his close working relationship with the existing ridesharing program. In other cases, the ridesharing and transit programs may operate in a competitive mode. The correct action will depend on local circumstances.

To assist in making such a decision, much could be learned from the experiences of those transit operators who have already undertaken joint cooperative actions with an independent ridesharing program. The authors suggest that there is another potential role for UMTA and/or APTA here: to conduct a study of several of these cooperative efforts compared with several examples of in-house ridesharing programs of transit agencies. The principal study objectives could be to describe

- The type of cooperative efforts that are conducted in both situations and
- The comparative cost and effectiveness, or advantages and disadvantages, of such efforts for both in-house and independent ridesharing programs.

As an example, some transit agencies restrict the geographic scope of their ridesharing programs to areas not currently served by transit routes or even to areas not likely to be served by transit. The evidence now available suggests that less restrictive policies would produce fewer vehicle trips and, in the long run, more efficient transit service. However, restrictive policies are unlikely to be abandoned without convincing statistics on such effects.

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Publication of this paper sponsored by Committee on Intergovernmental Relations and Policy Processes.