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53 traffic control and operations

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FOREWORD

Papers in this RECORD are concerned with pedestrian programs and motorist services, both of which are of interest to agencies responsible for traffic operations and safety.

Haines, Kochevar, and Surti present an analysis of campus traffic problems with particular reference to a case study of the University of Colorado, Boulder campus. The paper discusses guidelines for developing a traffic plan for a campus area. Data collection techniques and sources of useful existing data are suggested. Through increased modal separation and the establishment of a network of bicycle routes, modal conflicts can be greatly reduced.

Cameron describes a mechanical measurement of sidewalk pedestrian volumes and a pedestrian flow map that led to its development. The author reviews surveys to determine pedestrian volume patterns and suggests that sidewalk closure standards can be established by using Fruin's capacity values and known pedestrian volumes in the same manner lane closures are established from capacity values and traffic counts.

Wilson and Matthias discuss the use of the helicopter and its operating capability for performing medical evacuation, surveillance, and general law enforcement. The paper reports on the multidimensional role of the helicopter to provide definitive treatment and reduce patient transport time (evacuation) and as a deterrent to traffic accidents (surveillance). The paper concludes that use of the helicopter cannot be economically justified when used to perform only 1 type of mission.

Tyler and DeVere report the results of a research program that evaluates California's roadside rest area program. The major objective of the study was to examine the highway travel and stopping patterns of California drivers. The findings of the study deal with long-trip motorists (those who have taken at least 1 trip of 100 miles or more away from home during the previous year). Eighty-six percent of all California motorists have taken at least 1 such trip. The median stopping interval for California long-trip motorists making brief stops is every 73 miles and 75 minutes. The median stopping interval for all rest area users in California is every 58 miles and 68 minutes.

ANALYSIS OF CAMPUS TRAFFIC PROBLEMS

Gordon Haines, Robert Kochevar, and Vasant H. Surti,
University of Colorado, Denver

Because of the large volume of pedestrian and bicycle traffic that occurs on most university campuses, special techniques must be applied to provide for safe and efficient movement of persons traveling through the campus by these modes. Automobile traffic presents potential hazards to pedestrians and cyclists and disrupts the desired park-like atmosphere of the closed campus community. In this report, guidelines that should be followed when a traffic plan is developed for a campus area are discussed. Data collection techniques and sources of useful existing data are suggested. By examining the collected data and following the recommended guidelines, one may develop a comprehensive traffic plan for a campus or similar study area. These techniques are applied in a specific case study of the University of Colorado, Boulder to improve traffic flow on the main campus. Through increased modal separation and establishment of a network of bike routes, modal conflicts are greatly reduced. This is the primary goal that the designers of a campus traffic plan should seek.

•CAMPUS traffic problems require special techniques for solution. Pedestrian and bicycle traffic harmonize with the quiet park-like atmosphere of a campus. Automobiles not only detract from this atmosphere but also are not useful for most intracampus travel. Traffic plans developed for the campus area should provide for safe, efficient movement of persons by limiting automobile-bicycle-pedestrian conflicts and by shortening travel times. The techniques used to solve these problems will become applicable to urban and planned community areas as automobile use is restricted, public transit systems are developed, and bicycle use is encouraged for environmental and energy-use considerations.

GUIDELINES FOR A CAMPUS TRAFFIC PLAN

Providing for modal separation contributes most to the safe and efficient movement of persons. When automobiles, bicycles, and pedestrians move on exclusive rights-of-way, modal conflicts are greatly reduced. Accident rates can be expected to drop significantly because large speed differences no longer exist among modes operating on the same facility and because intermodal conflicts occur only at controlled intersections. Eliminating bicycles on automobile routes and pedestrians on bicycle paths permits higher speeds for the faster modes and increases safety for the slower modes. So, modal separation should be the overall guideline in planning the final system.

Eliminating through traffic, which detracts from the park-like atmosphere of the campus, is also important. Nonessential traffic should be routed around the campus. Shuttle buses may operate on campus on routes shared with delivery and maintenance vehicles. Boarding areas should be clearly signed to encourage their use. Hazardous areas like intersections and crosswalks should be well marked, and precautions like stops or dismounts should be required if they are warranted. At intersections on bicycle routes, curb cuts and radius fillets should be used to lower the number of required stops and dismounts.

Publication of this paper sponsored by Committee on Pedestrians.

Direct routes with few grades should be designed, especially for bicyclists and pedestrians. Locating bicycle parking areas near heavily traveled pedestrian routes will reduce cycle theft. The implementation of a new plan, construction of a new facility, or redesignation of an existing facility for a new use should be publicized through leaflets and through local and campus newspapers. Provisions should be made for special events like sports activities and concerts. Special enforcement procedures also may be required initially.

If standardized design practices are followed for automobile facilities (1, 2), bicycle routes (3), and pedestrian rights-of-way (4), a comprehensive traffic plan for any campus can be developed.

SOURCES OF EXISTING DATA

It is necessary to research the study area to form an inventory of existing data. These data should be studied and deficiencies noted. Then, other data collected to complete the study will be pertinent.

Existing data that should be researched include:

1. Population projections. If available from transportation studies, data on origin-destination (O-D) and generation and distribution of trips are helpful to predict the number of potential users of a system. These projections give a workable set of values on which to base the design.
2. Traffic volumes and flows. These data are usually available from government highway or traffic engineering departments. They show peak periods of use and give an empirical basis for conclusions.
3. Public transit. Existing public transit facilities and service should be studied for routes, ridership, scheduling, and operating costs.
4. Accident studies. Accident records of the area should be studied for those involving bicycles (bicycle-automobile, bicycle-pedestrian, bicycle only). These records, then, should be checked to determine if the accidents could have been prevented through a bikeway plan.
5. Bicycle facility demand studies. Demand for bicycle facilities can be predicted by studying the number of bicycle registrations and the number of bicycle sales.

VOLUME STUDIES AND COUNTING PROCEDURES

If an area has many bicycles, traffic counts must be done to plan a network of bicycle paths. And, most traffic counts must be done manually. The following types of counts may be conducted to obtain desired data:

1. Cordon counts. The major inbound and outbound flows should be studied to obtain the number of bicycles entering and exiting the area to determine peak periods and traffic volumes over various routes.
2. Automobile and bicycle counts. There should be a turning movement count with conflicting movements noted at a major intersection to determine the number of conflicts between automobiles and bicycles.
3. Bicycle and pedestrian counts. A count should be done at an established bicycle and pedestrian conflict area to show conflicting movements and hours of greatest use.
4. Screen line counts. Screen line counts determine the total traffic crossing into the area and show where new routes or new crossings are required. These counts provide a check of O-D data by comparing hourly volume estimates.
5. Bicycle parking lot occupancy counts. Bicycles should be counted at regular intervals to determine their long- or short-term parking use. Space availability per time period can then be computed to show periods of maximum use. When these data are compared with data from the other counts the effectiveness of parking lot placement can be determined.

The results of these studies should be tabulated and presented in a form that can be easily interpreted. The cordon count should be presented either in graph form to show volume changes by time or by flow maps to indicate totals in or out of the area. Turning movement counts should be tabulated and a traffic flow diagram prepared. Tabulated results will show time fluctuations of the specific movements. Bicycle and pedestrian counts should be conducted concurrently to show conflicts per time period. Graphs, if 5-minute periods are used, will indicate time periods of greatest conflict.

CASE STUDY

The University of Colorado, Boulder is in a beautiful location at the base of the Rocky Mountain Eastern Range. But, several features of the traffic patterns in and around the campus detract from the setting. As shown in Figure 1, the campus is adjacent to a major north-south thoroughfare, Broadway, which brings heavy traffic near the campus. This corridor separates the campus from The Hill, which contains small businesses and privately owned student housing and residences. In addition, the campus is split by a route where through traffic is permitted—18th Street and Colorado Avenue. Traffic counts show that over 8,000 vehicles pass through the campus every day on this route.

Primary residence areas for the approximately 20,000 students are the southeast portion of campus in university-owned halls and west of the campus in private housing on The Hill. Approximately 1,000 students reside in Williams Village, a high-rise university complex 1 mile southeast of the main campus to which the university provides shuttle bus service. Classrooms are, in general, located in the northwest portion of the campus except for the Engineering Center and a few other buildings on the east side. Because most activity is in the northwest classroom area, most attention was given to identifying and correcting traffic problems there. The items identified as particularly acute were

1. No modal separation.
2. Excessive automobile traffic through campus.
3. No designated bicycle paths.
4. Too much bicycle traffic through the main east-west corridor, which is heavily traveled by pedestrians.
5. Need for a separate bicycle access route to the University Memorial Center (UMC) from the north to alleviate pedestrian-bicycle conflicts.
6. Lack of curb cuts and radius fillets.

Existing Data

The following components of existing data went into this design study:

Population Projections—Student enrollment within campus sectors and student O-D patterns were obtained from the university planning office. Commuter destination patterns were analyzed for 1970, and a majority of students were found to have destinations in the west sector of campus, the sector considered in this study. (The campus was divided into 3 sectors in the planning office study—east, central, and west.) The west sector includes the UMC and most of the arts and sciences classes. In 1970, 15,800 students out of a total 20,400 were enrolled in classes in the west sector. Two projections were made for 1980 in this study. The first projection assumed an increase of 400 students in the total campus enrollment; the second projection, an increase of 3,000 students. If there were a 400 student increase, there would be a drop in student commuters in the west sector from 5,400 students per day to 4,400 students per day. If there were a 3,000 student increase, there would be an increase of commuters in the west sector from 5,400 students per day to 6,500 students per day. These projections were done after taking into consideration enrollment patterns, campus construction, and other planning items.

Vehicle accesses to the entire campus were projected to increase from 9,000 vehicles per day to 15,400 vehicles per day over this 10-year period.

Pedestrian Movements—A pedestrian study from the planning office estimated there are now 40,000 person trips per day throughout the campus. (This includes class, supply, and maintenance trips.)

Automobile Study—An automobile traffic study was consulted that stated that there are 30,000 vehicle trips per day to and from the Boulder campus. This study claimed 8,000

Figure 1. University of Colorado, Boulder, west sector.

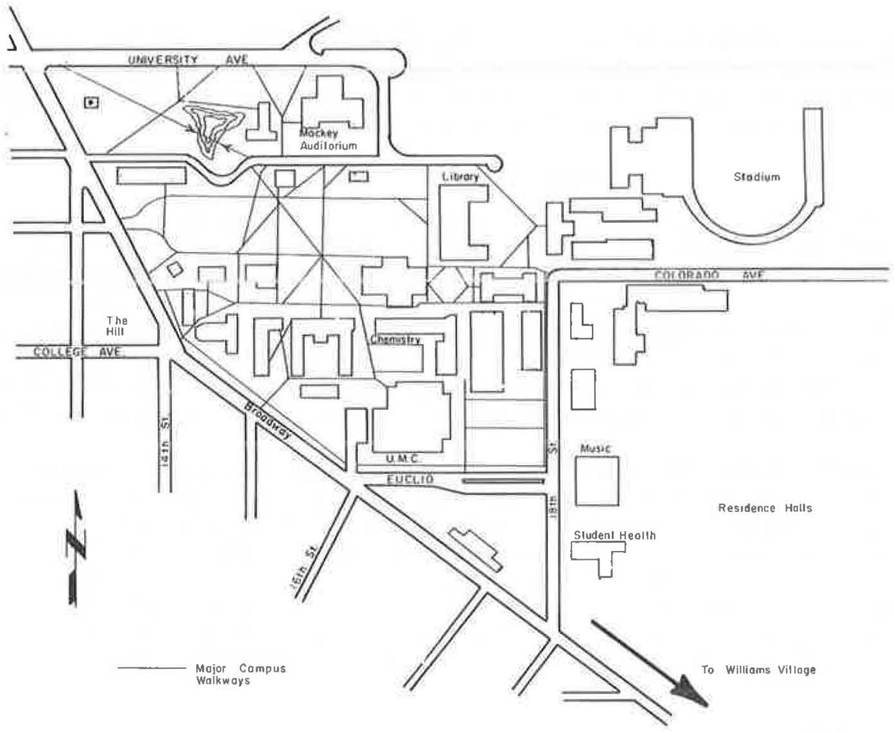
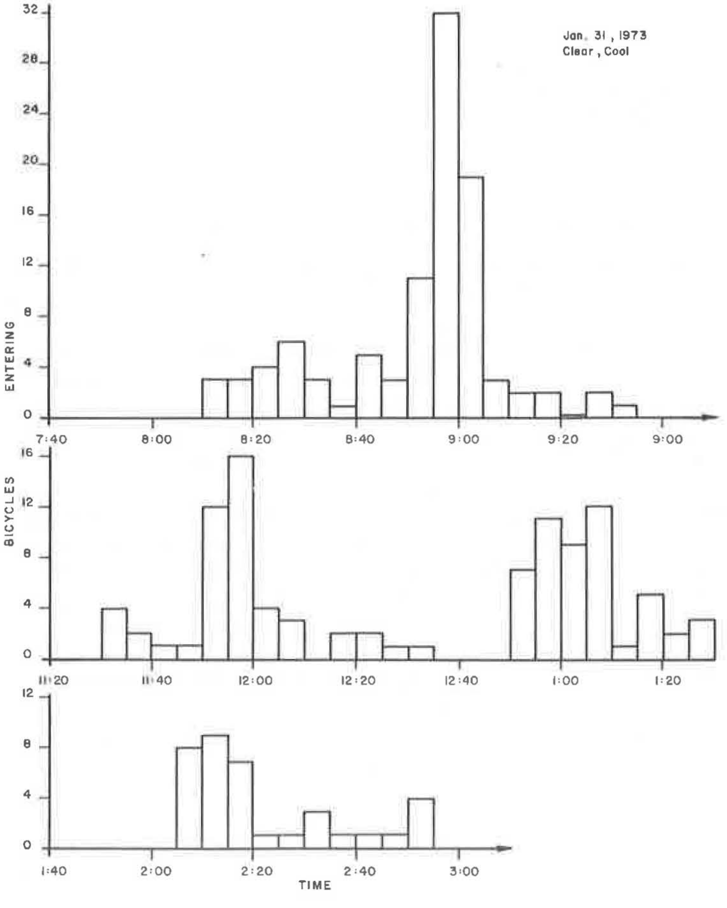


Figure 2. Bicycle cordon count, January 31, 1973.



vehicle accesses per day to the campus—lower than the figure given in the population study of the planning office. It recommended closing the campus streets to through automobile traffic and to allow only service vehicles access.

Bus Service—The university operates a bus service that carries several thousand students per day (4,000 persons per day to and from Williams Village). The bus service is operated through student activity funds; fares are also collected. The 9 buses can transport about 30 riders each. The route is 2.5 miles (4 km) and average travel time is 20 minutes, with a 6.5- to 7-minute headway. The schedule is as follows:

Times	Days	Number of Buses
7:15 a.m. to 5:30 p.m.	Monday through Friday	3
5:30 p.m. to 7:30 p.m.	Monday through Friday	2
7:30 p.m. to midnight	Monday through Friday	1
7:00 a.m. to midnight	Saturday and Sunday	1

Express buses traverse the route in 15 minutes and bypass the UMC. There are 2 express buses in the morning for 2 hours and 1 express bus at noon for 1 hour. Boulder city bus service has a route along Broadway at the west edge of campus but service to the campus community is limited and ridership by campus commuters is low.

Collection of Data

These data did not provide enough information for planning a system, so bicycle and pedestrian traffic counts were made.

The west section of campus was studied and preliminary investigation showed the major entrance and exit points to be

1. University Avenue and Broadway,
2. 14th Street and College Avenue and Broadway,
3. 16th Street and Broadway,
4. 18th Street between Euclid Avenue and Colorado Avenue, and
5. A one-way drive near Macky Auditorium south of University Avenue.

Cordon counts at these locations were conducted on Wednesday, January 31, 1973, and Tuesday, February 6, 1973. These 2 days were chosen for the counts because of the scheduling procedures of the Boulder campus. Courses in the Monday-Wednesday-Friday sequence and courses in the Tuesday-Thursday sequence are conducted at different hours of the day. Different peak periods were expected for the 2 different types of schedules. But, there was no major difference in peak periods. Figures 2 and 3 show the results of the 2 counting days on the one-way drive near Macky Auditorium. Figure 4 shows the results of a morning count at University Avenue and Broadway on Wednesday, May 8. This count was made to show how weather influences use. The 2 earlier count days were conducted in fair winter weather [high temperature about 45 F (280K)]; the May count day had temperatures near 80 F (300K) and the results show much more bicycle use. Although fair winters in Boulder permit bicycle use, much more volume is seen in fall and spring when temperatures are higher.

In all the volume counts, peak periods were from 10 minutes before the hour to 5 minutes after the hour. Because fewer classes are scheduled in late afternoon than in the morning, afternoon volumes were more uniformly distributed. Therefore, afternoon peak hours were studied.

Figure 5 shows the 5 entry points and their 5-minute peak volumes for the winter study days. The greatest inbound morning volume originates northwest of the campus at University Avenue and Broadway. Figure 2, however, shows a greater peak at the one-way drive near Macky Auditorium. Many bicycles that enter at University Avenue and Broadway proceed east down the one-way drive and may have been counted at each location. This would cause the one-way drive to show a higher volume. University Avenue and Broadway is probably the largest entry point.

Figure 3. Bicycle cordon count, February 6, 1973.

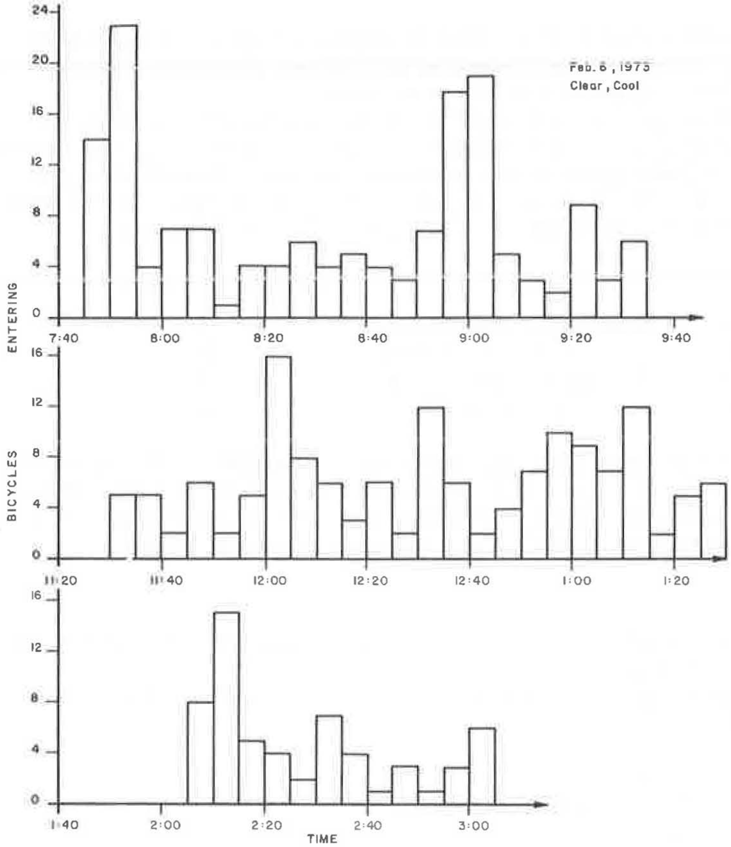


Figure 4. Pedestrian-bicycle cordon count, University Avenue and Broadway.

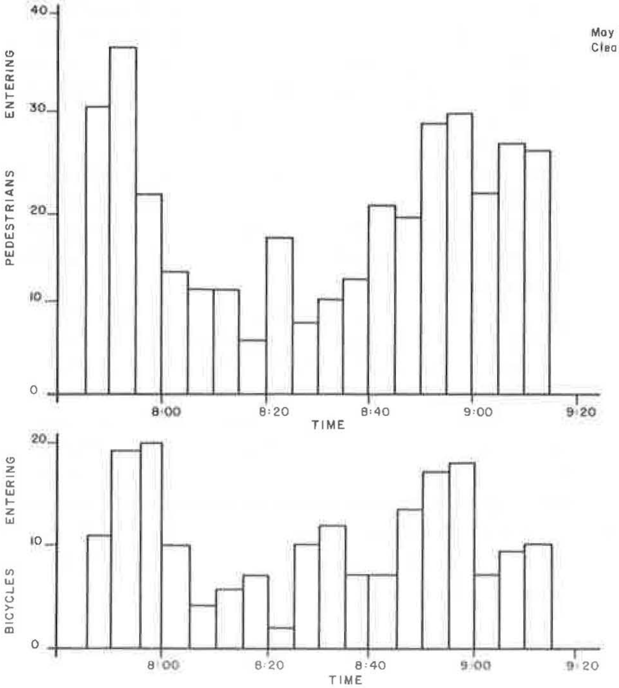


Figure 5. Major entrance locations and peak 5-minute volumes.

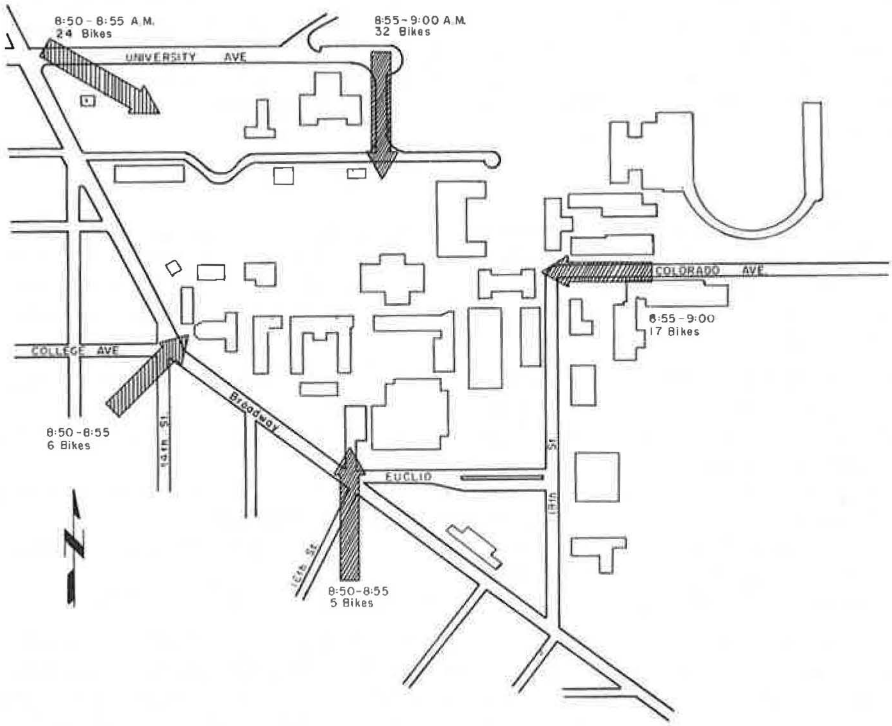


Figure 6. Turning movement count, automobile-bicycle.

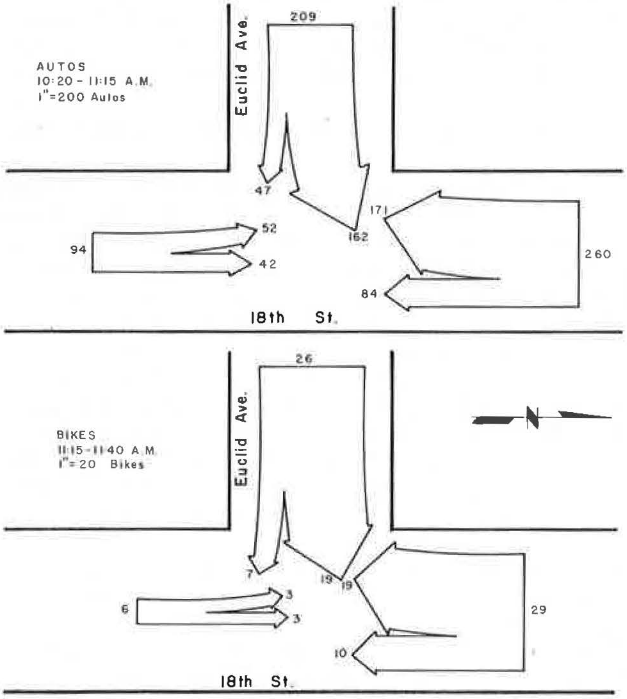


Figure 6 is a flow diagram of automobile and bicycle traffic at Euclid Avenue and 18th Street. Figure 7 is a flow diagram of pedestrian and bicycle traffic north of the UMC near the chemistry building. It is clear from these flow diagrams that conflicts of turning maneuvers exist between the different travel modes. These conflicts are aggravated during peak periods by the crossing of larger numers of pedestrians, bicycles, and autos. The peak periods here were also from 10 minutes before the hour to 5 minutes after the hour.

Recommended Solutions and Improvements

The deficiencies of the existing traffic plan arise from 2 factors: an insufficient network of bicycle paths and disruption caused by through automobile traffic. The plan shown in Figure 8 would provide adequate corridors for bicycle travel and would alleviate the problems of conflicts between bicycles and other modes. The most significant features of the network are

1. Restriction of through traffic on 18th Street and Colorado Avenue and use of this route as a bicycle path, pedestrian mall, and bus lane;
2. Designation of a separate east-west bicycle lane and restriction of bicycles from the other main east-west route;
3. Exclusion of bicycles from the narrow bridge in the northwest corner of campus;
4. Construction of a peripheral bicycle path paralleling Broadway;
5. Construction of a new bicycle access route to the UMC from the north as shown in Figure 9 to reduce pedestrian-bicycle conflicts; and
6. Restriction of automobiles and automobile parking from the one-way drive.

This plan requires installation of radius fillets at intersections to facilitate bicycle turning movements and construction of curb cuts to facilitate bicycle movements from streets to pathways. Areas that need particular attention are the peripheral route along Broadway, the access route at University Avenue, and the corridor just east of the library. The bicycle paths should be constructed to the standards established in Bikeway Planning Criteria and Guidelines (3). These include a 10 mph (16 km/h) design speed, a 3 percent maximum grade, a minimum radius of curvature of 14 ft (4.3 m) at 10 mph(16 km/h), a minimum vertical clearance of 8 ft (2.4 m), and a minimum width of 3.3 ft (1 m) for each lane of travel. Where both pedestrians and bicycles travel in 2 directions, pathway width should be 8 ft (2.4 m). These paths can be laid by most conventional asphalt spreading machines. Asphalt should be 1.5 to 2 in. (3.8 to 5 cm) thick on a 3- to 4-in. (7.6- to 10-cm) aggregate base. Routes should be clearly marked with standard signs.

A major aspect of the recommended traffic plan for the Boulder campus is the closing of the 18th Street and Colorado Avenue route to through traffic. Also, restricting Euclid Avenue to one-way traffic eastbound is suggested as shown in Figure 10. Colorado Avenue at Folson Street should be closed to all but shuttle bus and maintenance traffic by an automated gate. This would allow use of Colorado Avenue and 18th Street as a bicycle route and pedestrian mall. A center lane could be used for limited motorized vehicle use.

If Euclid Avenue were restricted to one-way eastbound traffic, and the right turn from Euclid Avenue to Broadway northbound were eliminated, bicyclists could move across Broadway more easily when Broadway traffic would be stopped at its red light. Euclid Avenue, in front of the UMC, is wide enough—45 ft (13.7 m)—to allow two 10-ft (3-m) eastbound lanes for automobile traffic, one 8-ft (2.4-m) loading lane on the south side, and two 8-ft (2.4-m) bicycle lanes on the north side as shown in Figure 10. A crosswalk from the loading area to the UMC would be required. Separation between the automobile and bicycle lanes should be by double yellow lines.

Euclid Avenue, east of the UMC, is divided by a center planter into eastbound and westbound lanes. This divider should separate the 2 one-way eastbound automobile lanes and the 2 bicycle paths on the north as shown in Figure 10.

As shown in Figure 11, at the intersection of Euclid Avenue and 18th Street, right turns should be the only movement allowed from both eastbound automobile lanes on Euclid Avenue because 18th Street would be one-way southbound. Full stops by both

Figure 7. Turning movement count, pedestrian-bicycle.

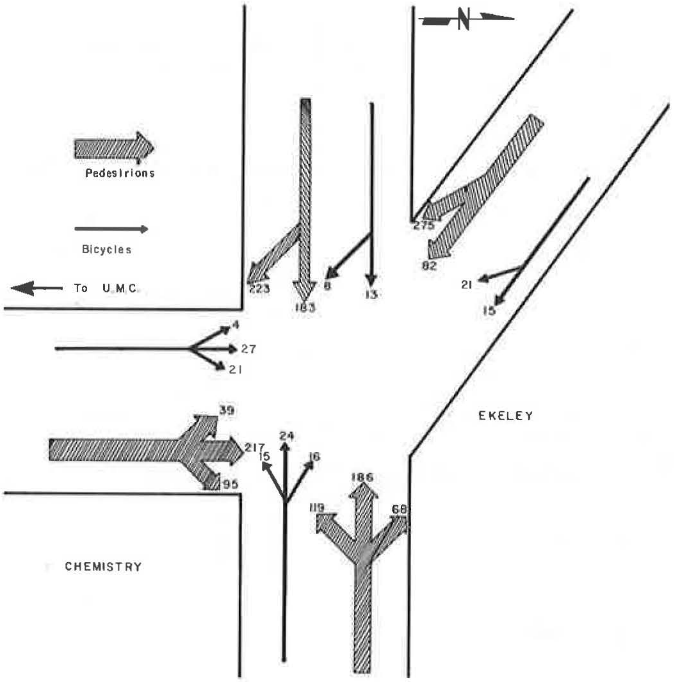


Figure 8. Planned bicycle, pedestrian, and bus routes.

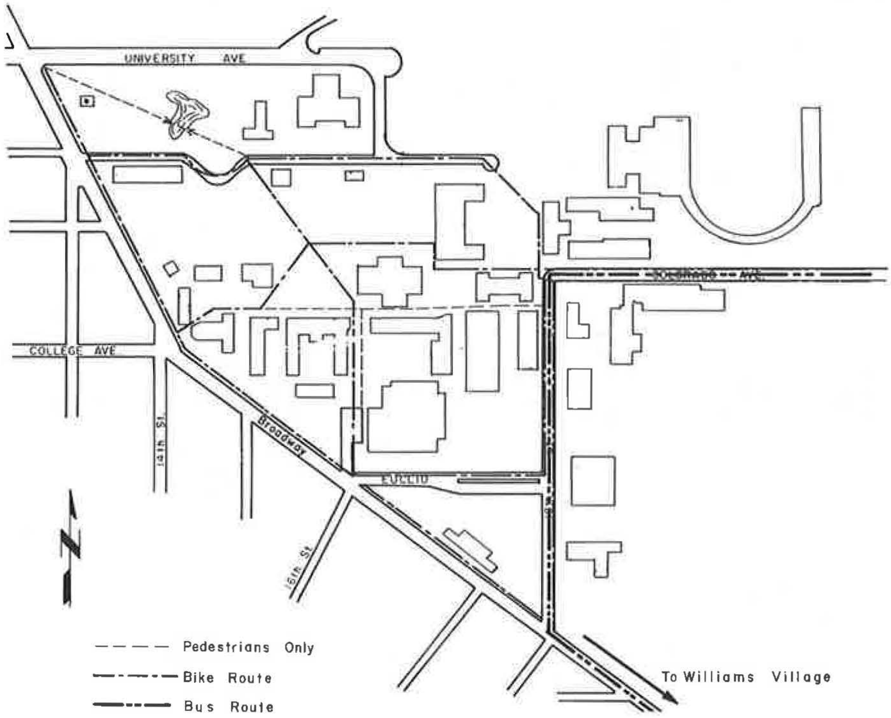


Figure 9. Proposed access to UMC.

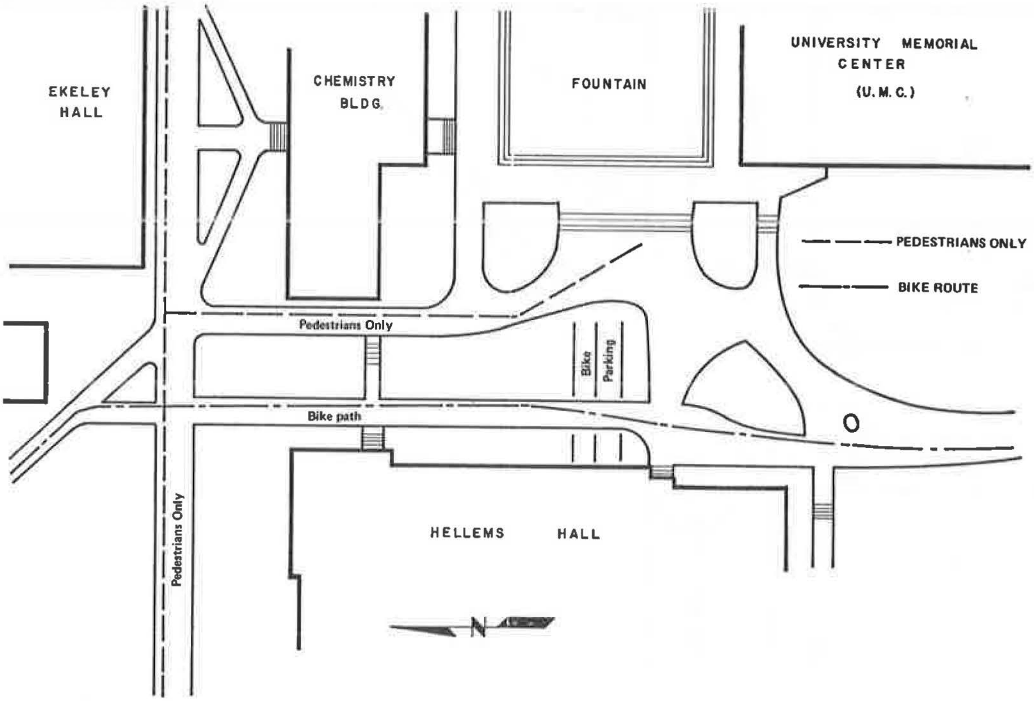


Figure 10. Proposed plan for Euclid Avenue.

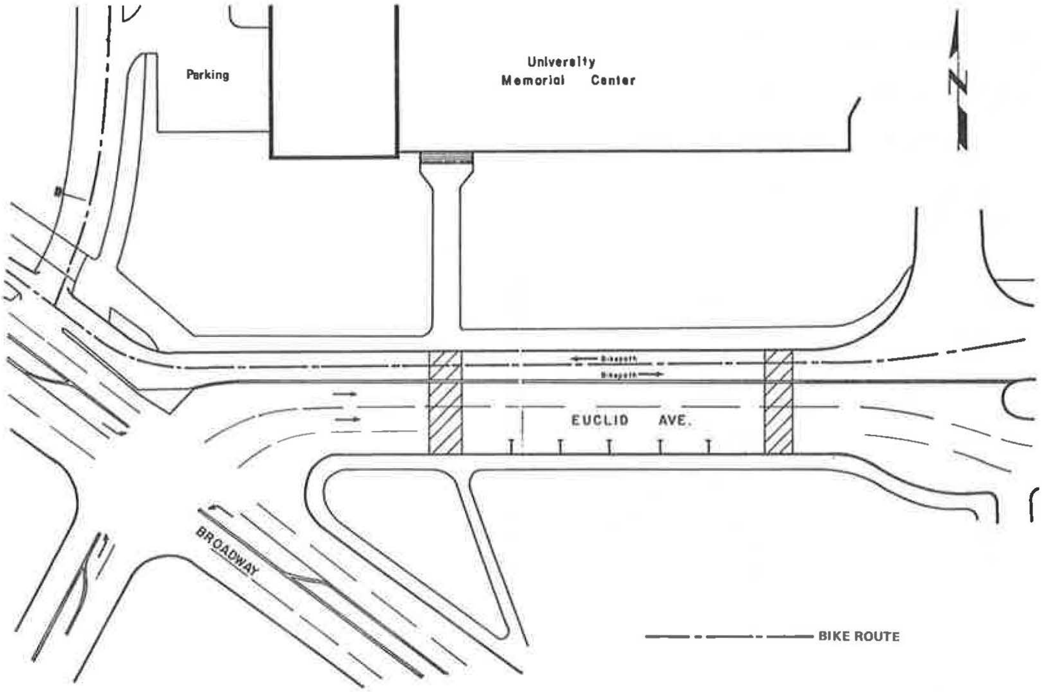
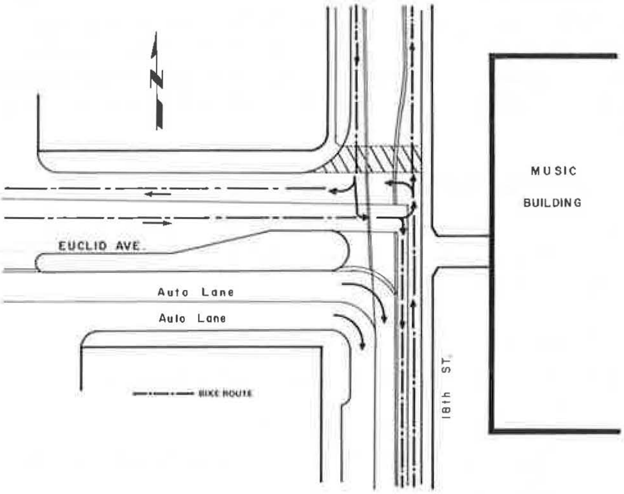


Figure 11. Proposed configuration at Euclid Avenue and 18th Street.



lanes should be required. South of this intersection, 18th Street should be marked for two 12-ft (3.6-m) southbound automobile lanes on the west side and two 6-ft (1.8-m) bicycle lanes on the east side. These bicycle lanes would provide access to the path between the music building and the Wardenburg Student Health Center that leads to several residence halls.

North of the Euclid Avenue and 18th Street intersection, Colorado Avenue should be divided into two 8-ft (2.4-m) bicycle paths on either side of a 20-ft (6.1-m) southbound bus lane. At the intersection, a full stop should be required by motorized vehicles that are southbound on 18th Street. Because traffic would be restricted to buses and delivery and maintenance vehicles on Colorado Avenue, nonbus traffic would be light. A separate bus loading lane would not be necessary. Boarding and unloading should be permitted when the buses stop and a boarding area should be provided for passengers at this location. Crosswalks should be added and all vehicles, including bicycles, should be required to yield to pedestrians.

A cost estimate for the proposed bicycle route installation has been prepared. This cost schedule is for direct costs. No benefit-cost analysis was performed because this project was assumed to be feasible for the area. The prices are estimated rather than exact because they are based on local prices and may vary with contractors and distributors.

Item	Amount (dollars)
Signs	
16—bicycle route, with symbol	68.80
6—no bicycles, with symbol	28.80
2—stop	8.60
1—yield	4.30
21—24-in. by 18-in. sign blanks, octagon and triangle	48.93
3—24-in. by 24-in. sign blanks, octagon and triangle	9.00
24—11-ft channel posts, 3 lb	100.12
Asphalt, 285 yd by 3 yd	5,130.00
Curb cuts, 6—8 ft wide	384.00
Paint striping, 15,000 ft	600.00
Arrow and bicycle symbols	100.00
Labor, 30 hours	112.50
Miscellaneous hardware	25.00
Total	6,625.05

CONCLUSIONS

A traffic plan for any university campus or similar closed community area may be developed by applying the techniques and guidelines used in the University of Colorado case study. The comprehensive traffic plan would facilitate movement of automobiles, bicycles, and pedestrians through the campus. Because of increased modal separation, modal conflicts would be greatly reduced. This is the primary goal that the designers of a campus traffic plan should seek.

ACKNOWLEDGMENTS

The research presented in this paper is part of a project sponsored by the Urban Mass Transportation Administration. The results and views expressed are those of the authors and not necessarily those of the sponsoring agency.

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MECHANICAL MEASUREMENT OF PEDESTRIAN VOLUMES

Ronald M. Cameron, Seattle Engineering Department

A pedestrian flow map developed from manually counted data during 1969 that led to the development of the pedestrian counting device is described. A brief description is given of the counter's development, application, and refinement. The initial studies of pedestrian volumes were made of a downtown employee population, a downtown shopper population, and a mixed population of employees, shoppers, visitors, and residents. The highest daily total at all locations occurred on Friday, and the highest hourly (usually 15 percent of the weekday total) volume occurred between 12 and 1 p.m. for all 3 studies. Saturday volumes were small at the employee station and high at the shopper and mixed stations. General and particular pedestrian volume characteristics that would be considered in design of pedestrian facilities are quantitatively described. The tabulated data represent general pedestrian volume trends and can be used for factoring volumes measured during short periods into comparative volumes. Surveys can be designed to measure the most representative sample; sidewalk closure standards can be established by using Fruin's capacity values and known pedestrian volumes in the same manner that lane closures are established from capacity values and traffic counts. Pedestrian volumes can be measured mechanically because daily and weekly pedestrian volumes recurred in regular patterns. Different types of pedestrian populations have different volume patterns, and the studies indicated the effects of weather and shopping days.

•MUCH attention is now being devoted to the planning, designing, and operation of pedestrian facilities. Navin, Wheeler, Hoel, Fruin, Pushkarev, and Zupan have developed specific design criteria from manual counts of pedestrians, time-lapse photography, and relations between existing sidewalk pedestrian volumes and adjacent types of building floor space (3, 4, 10, 11). Applying these criteria to a central business district (CBD) or any area of pedestrian concentration requires knowing the area's existing pedestrian characteristics.

This paper discusses an alternative method in which an automatic counter is used to obtain pedestrian volumes for use as control data; correction factors are developed for weather, season, area, day of week, and time of day; and these factors are applied to short-term manual counts throughout the study area.

A pedestrian flow map was made of the Seattle central business district in 1969 by

1. Subdividing the CBD into 12 areas such as theater, department store, financial, government, and the like;
2. Determining and graphing hourly average volumes and developing expansion factors;
3. Making short ($^1\!/_2$ to 1 hour) manual counts on weekdays at all the remaining intersections; and
4. Expanding short-term counts from 9 a.m. to 4 p.m. by applying the area hourly correction factor.

Publication of this paper sponsored by Committee on Pedestrians.

Areas that were not in agreement were rechecked and a final map was drawn. The data were collected during the summer, and some seasonal factoring was accomplished by applying retail sales variations to volumes in retail areas. However, reliability of the volumes was questioned because no long-term trends had been measured and evaluated. Also, no corrections had been made for season, day of the week, weather, time of the month, new buildings, building usage change, and the difficulty in manually counting large numbers of pedestrians.

Therefore, an automatic counter was developed and refined during 1971 and 1972. This counter was made up of eight 28-in. by 36-in. (71.12-cm by 91.44-cm) hand-constructed detector pads. The pads were silicon conductor disks sealed in neoprene. They were mounted on 2 stainless steel plates ¼ in. (6.35 mm) thick 3 in. (7.62 cm) apart. The 2 plates were laid on the sidewalk with the 36-in. (91.44-cm) dimension in the direction of pedestrian flow. Leads from the pads ran back to summators in a signal control box. A 4-ft by 14-ft (1.2-m by 4.3-m) rubber carpet was installed over the detectors and glued to the sidewalk. The total rise was less than ⅝ in. (15.875 mm) located 6 in. (15.24 cm) in from the carpet edge to minimize the possibility of tripping. More than fifty 15-minute checks were made during its first operation in a 2-month period, which showed overcounting of 15 to 20 percent because of the pads being too long.

Refinements made after that period included

1. A surplus military radio equipment box for the traffic counter, summators, and dc batteries;
2. New 17- by 23-in. (43.18- by 58.42-cm) detector pads that could be spot-glued to the sidewalk and together with the carpet laid over them would give less than a ½-in. (12.7-mm) vertical rise at any point; and
3. A compact, solid-state 8-channel summator.

Detector pad durability is increased by placing a cushioning material between the pad and concrete. Sidewalk installation must be made on dry sidewalks because glue will not adhere to a wet sidewalk.

Counter units can be installed anywhere traffic patterns permit (doorways and lingering areas should be avoided—direct traffic flow produces the most accurate results). Locating counters 5 ft from a major doorway will avoid multiple counts. Counter units can be installed on various width walkways in less than one-half hour. They produce much pedestrian data for a small cost and computer summarization of the data is the same as that for traffic counts, thereby lowering data reduction costs. Continuing manual checks show that counter accuracy is within 5 percent of volume measurements.

Equipment in the most recent counter includes a Leopold-Stevens traffic counter, a Fischer-Porter 8-channel summator, two 7½ Vdc batteries, 8 Tapeswitch CVP-1723 switching mats (detection pads), and 14 ft of Vertitred gray matting for the overlay.

Until July 1973, two 4-channel summators were connected in parallel to the counter, and there were no missed counts from summator interference. Two 8-channel summators should work as well in locations requiring more than 8 detectors.

Older traffic counters do not recognize the 45 ms signals from the summator; this can be remedied by changing the summator's capacitor C103 from 0.33μF to a 0.47 to 0.50μF ±5 percent value to increase the output pulse to 50 to 55 ms.

Measurements were made at 3 sidewalk locations through June 1, 1973. (Table 1).

The first location was on the west side of 4th Avenue south of Pike Street in the core of Seattle's CBD. This sidewalk was selected for its known high pedestrian volume, its free-flowing pedestrian traffic, and its level, unbroken walkway. There was a signal control case nearby with room for the counter and summators and a source to provide 115 Vac to operate the equipment.

Data for 59 days from April 30, 1971 through July 3, 1971 were collected and indicated definite volume patterns. Volumes on Monday and Friday were the highest. This substantiates the employee classification for this location. Saturday volumes were 63 percent of the average daily volumes; the other 2 locations had Saturday volumes of more than 100 percent. Weekday average hourly volumes are shown in Figure 1, and the percentage each day deviates from the total daily average is given in Table 2. The hourly volume curve at this location was highest during morning and evening peak

Table 1. Survey locations and pedestrian volumes.

Location	Population	Date of Counts	Number of Count Days	Total Average Volumes Daily	Total Average Volumes Weekday
4th Avenue	Employee	May-June 1971	27	10,200	12,250
Pine Street	Shopper	May-Dec. 1972	86	7,900	8,200
Pike Street	Mixed	Feb.-May 1973	69	11,250	12,700

Figure 1. Fourth Avenue, weekday average hourly volumes.

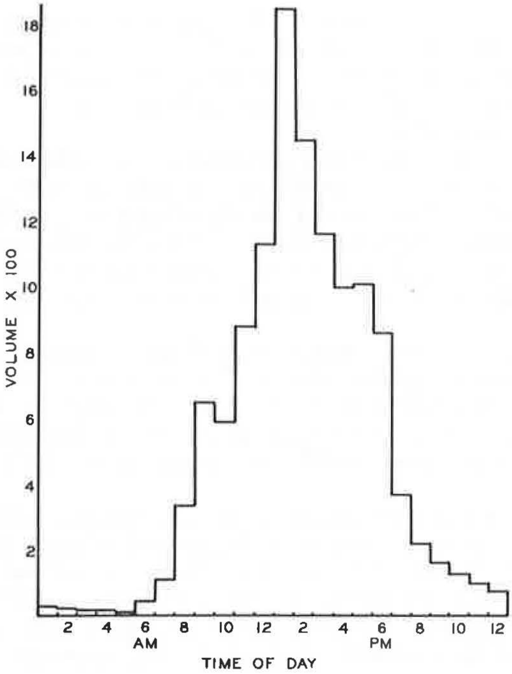


Table 2. Hourly volumes as percentages of total average weekday volumes.

Location	Percentage Deviation From Total Daily Average Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
4th Avenue	130	118	116	111	128	63	22
Pine Street	121	109	105	108	121	107	26
Pike Street	114	114	109	107	122	103	41

periods. Friday afternoon hourly volumes were 15 percent higher than the weekday, which is similar to urban vehicle volume patterns.

Mechanical counts at 2 employee population locations in the summer of 1973 had curves similar to the 4th Avenue location. The noon peaks (12:15 to 1:15 p.m.) had the largest volumes, but morning and evening peaks were also clearly visible. Table 3 gives the hourly volumes as a percentage of total average weekday volumes.

Seattle's downtown department stores have traditionally stayed open until 9 p.m. on Monday nights. The 4th Avenue Monday evening hourly volumes showed no significant difference from other weekday evening hourly averages, which would have been expected at an employee population location. The 2 locations with shopper populations had much higher volumes on Monday evenings.

Weather was the only recognizable factor that affected volumes on 4th Avenue. Day-to-day volumes regularly repeated themselves.

All but 1 of the weekday peak-hour volumes began at 12 or 12:15 p.m. and averaged 15.3 percent of the daily total. The standard deviation of the 41 peak-hour percentages was 1.03. The noon peak-hour volume did not occur on days when there was recorded precipitation during that time. On Fridays and days when it was more than 65 F (291.48 K) and clear, peak volumes continued until 2 p.m.

After some modifications were made to the counter, it was installed in the center of the CBD department store area, less than 2 blocks from the 4th Avenue south of Pike Street survey. This area's pedestrian population is composed mostly of shoppers. This location was selected because of its free-flowing pedestrian traffic and its serviceability.

The Pine Street south of 5th Avenue study was conducted for the longest period of time—May 3, 1972, to December 1, 1972—and provided the largest amount of data and further refinement of the counter.

Total average volumes for Mondays and Fridays were larger than those for other days of the week and their hourly volumes were distributed differently. Friday afternoon volumes were consistently higher than those for other days of the week. Monday evening (6 p.m. to 9 p.m.) shoppers raised the Monday total. The 6 p.m. to 9 p.m. Monday evening volumes averaged 360 pedestrians per hour which was 89 percent greater than the 190 pedestrian weekday evening average.

Saturday totals were greater than 100 percent of the total average daily volume in the retail core. This contrasted sharply with the Saturday volume of 63 percent of the daily average for employees at 4th Avenue and Pike Street. Figures 2 and 3 show that Saturday totals were comparable to weekday totals but that hourly distributions were different. Saturday volumes developed later in the morning and built to a peak near 3 p.m. Theater goers and after-dinner window shoppers could have caused Saturday evening volumes to be higher than Monday evening volumes.

When weekday hourly volumes on days with recorded precipitation were compared with total weekday hourly averages, it was discovered that only between noon and 4 p.m. were volumes less than the average hourly volume during rain. Generally, there were 10 to 12 instances of recorded precipitation for each hour, which was a small sample for determining volume precipitation correlations. Volume decrease percentages for 1-hour periods were

Time	Percent
12 to 1 p.m.	7
1 to 2 p.m.	17
2 to 3 p.m.	7
3 to 4 p.m.	3

The highest volume of the day occurred in the afternoon immediately after it stopped raining or after it let up had it been raining during the noon hour.

A review of the daily hourly volumes revealed that before noon and after 4 p.m. pedestrians were unaffected by rain; rain affected shopper-pleasure trips between noon and 4 p.m. more than it affected business-work trips; the first rain after a period of dry weather had more effect on volume than did continuing rain day after day; and days with

Table 3. Percentage deviation of volumes on each day from total average daily volumes.

Time	4th Avenue	Pine Street	Pike Street
12 to 1 a.m.	0.3	0.2	0.7
2 a.m.	0.2	0.1	0.4
3 a.m.	0.1	0.1	0.2
4 a.m.	0.1	0.0	0.1
5 a.m.	0.1	0.0	0.1
6 a.m.	0.4	0.1	0.3
7 a.m.	0.9	0.5	0.9
8 a.m.	2.7	2.1	2.4
9 a.m.	5.3	3.9	4.1
10 a.m.	4.8	4.1	4.4
11 a.m.	7.2	6.0	5.8
12 noon	9.2	9.1	7.4
1 p.m.	15.1	14.3	11.6
2 p.m.	11.8	12.7	10.5
3 p.m.	9.5	11.2	9.2
4 p.m.	8.2	10.0	8.9
5 p.m.	8.3	9.4	9.1
6 p.m.	7.0	7.6	8.7
7 p.m.	3.0	3.3	4.9
8 p.m.	1.8	2.0	3.0
9 p.m.	1.3	1.6	2.5
10 p.m.	1.1	0.9	2.0
11 p.m.	0.8	0.4	1.6
12 midnight	0.6	0.4	1.1

Figure 2. Pine Street, weekday average hourly volumes.

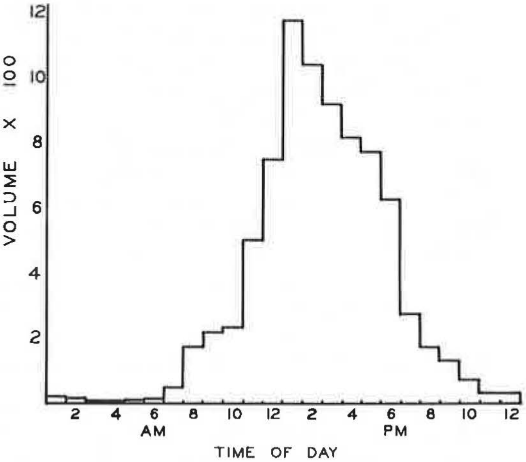


Figure 3. Pine Street, Saturday average hourly volumes.

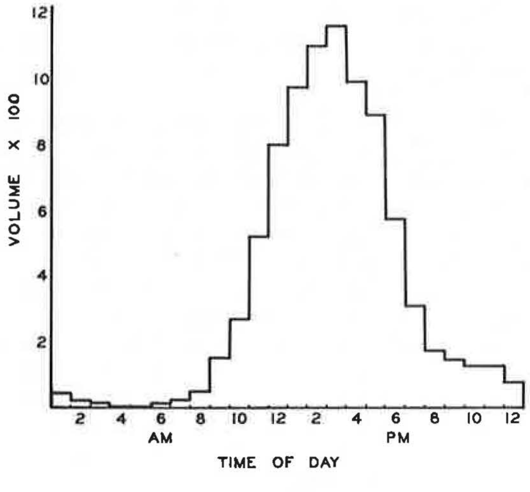
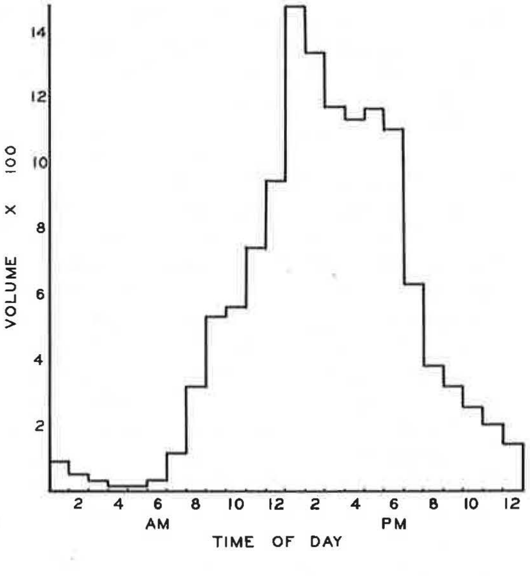


Figure 4. Pike Street, weekday average hourly volumes.



more than 0.05 in. of rain generally had 5 percent less volume.

A study of 3 special shopping days gave the following information:

1. A sale was held on a Thursday after 1 of the 2 largest department stores had been closed for 2 weeks because of a fire. The total day's volume of 11,054 was 40 percent more than the total average daily volume and 30 percent more than the average Thursday volume. The peak-hour volume of 1,642 (14.9 percent of the day's total) occurred between 12:15 and 1:15 p.m. with a peak-hour factor of 0.946.
2. An all-week downtown advertising campaign was held during the middle of October before a downtown sale on Friday, October 20. The sale day volume of 11,636 was 48 percent higher than the total average daily volume and 22 percent higher than the average Friday volume. The peak-hour volume of 1,454 (12.5 percent of the day's total) occurred between 12:15 and 1:15 p.m. with a peak-hour factor of 0.977.
3. The highest volume recorded was 13,232 on the Friday after Thanksgiving. This was 68 percent greater than the total average daily volume and 38 percent higher than the average Friday volume. The peak-hour volume of 1,879 (14.1 percent of the day's total) occurred from 1:15 to 2:15 p.m. with a peak-hour factor of 0.985.

Weekday peak hours occurred between noon and 2 p.m. usually between 12:15 and 1:15 p.m. The peak-hour volume averaged 14.5 percent of the daily volume with a standard deviation of 1.184 for the 68 recorded peaks. The only weekdays that did not have peak hours fitting these criteria were days when there was precipitation recorded during the peak period. Saturday peak hours were distributed throughout the afternoon and averaged 14 percent of the Saturday total volume.

Volumes recorded in the latter part of August before school openings were greater than other daily totals but not so large as the 3 shopping days.

The third location was on Pike Street east of 3rd Avenue (less than 1 block from the 4th Avenue location), again in the CBD core. This location serves bus patrons on major bus routes, shoppers to the department store area 1 block to the north, shoppers and visitors to the public market 2 blocks to the west, and employees of the office area 1 block to the south. It is located next to the large dime stores. The pedestrian population was composed of shoppers, employees, visitors, and downtown residents.

This sidewalk location was selected for its general pedestrian volume characteristics, its free-flowing large volumes, and its serviceability. A volume difference comparison to the employee location less than 1 block away was also possible.

Measurements were taken during the week before Christmas 1972 and from February 5, 1973, to June 1, 1973. Fridays had the highest daily volumes of any day with 122 percent of the 11,250 total average daily volume. Sunday volumes were 41 percent of the total daily average here in contrast to 20 percent at other locations. Monday evening shoppers raised the Monday evening average volume to 482 pedestrians per hour from the 441 pedestrians per hour average—an increase of 9 percent. The evening hourly average of data collected in the week before Christmas was 26 percent more than the average 441 pedestrians per hour, and precipitation was recorded every hour.

Pre-Christmas weekday volumes approached 15,000—one-third more than those of the spring survey. The highest hour volume was 1,833 from 12:30 to 1:30 p.m. on Friday, December 15, 1972. (There was a trace of precipitation recorded.) The highest 15-minute volume during this hour was 502 pedestrians and it was exceeded 4 times during April and May 1973 during lunchtime peaks. Saturday hourly and total volume trends were comparable to the retail location volume patterns.

Figure 4 shows that average weekday hourly volumes increase through the morning to the noon peak and gradually drop off through the afternoon.

CONCLUSIONS

Pedestrian sidewalk volumes follow cyclical patterns depending on population classification and weather. They can be measured mechanically to provide a reliable, economical data base for planning and designing pedestrian movement systems.

There are many possible uses for mechanical measurement data including:

1. Developing warrants for minimum walkway area openings during construction closure periods;
2. Developing warrants for sidewalk furniture control;
3. Evaluating walkway use;
4. Planning pedestrian malls, bus zones, and public transit stations;
5. Determining pedestrian accident factors to increase highway safety; and
6. Determining high pedestrian densities (e.g., for people entering parking garages) to change traffic signal timing.

Peak pedestrian flow rates occurred in surges of less than 15 minutes making it impossible to evaluate service level by Fruin's criteria—pedestrians per foot width per minute (10). The 15-minute volume summaries do not show the maximum values reached during surges. Recording the volumes in 5-minute increments should provide sufficient data to evaluate service levels. The average of the 15 highest 15-minute recordings at Pike Street east of 3rd Avenue was 940 pedestrians per 15 minutes, which reduces to 7 pedestrians per foot width per minute. This average value, according to Fruin, would be at service level B (10, p. 6, Fig. 5). Further study should evaluate level-of-service values for periods of time summarized by automatic count.

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AIR MEDICAL EVACUATION AND SURVEILLANCE SYSTEM

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The helicopter and trained paramedics operating in the rural areas of Arizona in 1969 and 1970 in a multidimensional role as an airborne force to provide definitive treatment and reduce patient transport time for highway accidents (the evacuation mission) and as a deterrent force to reduce traffic accident potential (the highway surveillance mission) were demonstrated and evaluated. When they were used in patrol and surveillance operations, there was a statistically significant reduction in driver behavior characteristics that are accident-related. The helicopter must be evaluated with regard to its total operating capability of performing medical evacuation, patrol and surveillance, and general law enforcement. It cannot be economically justified when used to perform only 1 type of mission.

•A HIGHWAY accident is a multidimensional problem composed of man, machine, roadway, environment, and their interrelationships. The traffic accident fatality rate per 100 million vehicle-miles has decreased by a factor of 3 in the last 40 years and has stabilized between 5.2 and 4.7 for the last 10 years. However, in 1971, 54,700 persons lost their lives, 2 million persons were injured, and 170,000 of the injured suffered permanent physical injury (1). Arizona had 1.6 million registered motor vehicles in 1971 and over 13 billion vehicle-miles of travel (VMT). This VMT represents an increase of more than 10 percent since 1970. The fatality rate in 1971 was 5.73, which was somewhat higher than the national rate. There were 751 traffic deaths and over 28,000 traffic injuries in 1971 (3).

This unfortunate situation has developed although vehicles, highways, training, and law enforcement have improved throughout the nation. More effort must be devoted to giving accident victims more chance of survival and recovery and less chance of permanent injury.

One contribution of the Air Medical Evacuation System (AMES) has been in accident prevention but its most important contribution has been in its postaccident activities that improve the rate of survival for those involved in highway accidents.

The experience of the U.S. Army indicated that air evacuation of the wounded was a most significant factor in reducing the death rate from 4.5 per hundred wounded in World War II, to 2.5 per hundred wounded in Korea, to less than 1 per hundred wounded in Vietnam. During World War II, no wounded were evacuated from the battlefield by air; in Korea, 15 percent of the wounded were evacuated from the battlefield by air; and, in Vietnam, 90 percent of the wounded were evacuated by helicopter to sophisticated medical facilities (6). It was thought that this method, which caused a dramatic decrease in the military death rate, might be applied to assisting the victims of motor vehicle accidents.

CONCEPT

It was planned that AMES would be used for roads and recreation areas with high accident histories. There would be helicopter rescue teams on ground alert, others on airborne surveillance, and computer-assisted dispatchers. When an accident occurred, one of the AMES teams would be directed to the scene.

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At the scene of the accident, a specially trained 2-member team would rescue, sort, and treat the injured by need. The injured would be evacuated to the nearest medical facility capable of providing definitive treatment. The AMES team would have direct radio communication with a medical consultant who could advise on emergency treatment measures to be taken at the scene or en route to the hospital. After the casualties had been delivered to the hospital emergency room, the AMES helicopter would return to the accident site, to another patrol route, or to the base.

Primarily, the system was to provide quick response to an accident particularly in rural and remote areas. Secondarily, AMES was to be an alternate means for highway patrolling and law enforcement; an aid to improved accident investigation; a base for civil defense and disaster systems; and a model for use by other states or communities.

OPERATIONS

The AMES mission was derived from a combination of the assigned missions of the U.S. Army Air Ambulance Operations, the U.S. Air Force Rescue and Recovery Service, and the definition of the AMES concept originally established by the study team. The 3-part mission of AMES was to

1. Rescue in the shortest possible time persons injured in motor vehicle accidents or other accidents within Arizona, especially in rural and remote areas;
2. Preserve the lives of injured persons through competent emergency first aid at the accident scene; and
3. Transport the injured from the accident site to the nearest medical facility capable of providing definitive treatment.

Although AMES was developed primarily for evacuation missions, general law enforcement operations and accident prevention operations that resulted from surveillance operations were also tested. Operational plans, therefore, included all AMES missions.

The range and speed limitations of the helicopter and the need to reach casualties as quickly as possible limit the distance over which it can operate effectively. The environmental conditions that limit the operational effectiveness of AMES are the size (341 by 396 miles) of Arizona and its topography. Helicopters considered for the AMES mission had an operational radius of approximately 150 miles at a constant altitude of 5,000 ft. The realistic average range of the AMES helicopter would be 150 miles although there might be a wide variance in range for a given time. It then became apparent that 1 centrally located AMES group could not serve the entire state because the maximum area the helicopter could cover would be only about 71,000 square miles of the state's total of 113,600 square miles.

EVALUATION

This portion of the planning activity involved developing procedures to measure the effectiveness of the AMES operations in accomplishing specified objectives.

Some of the benefits expected of the AMES program during the original study conducted by R. L. Sears included a reduction in patient incapacitation from injuries received in motor vehicle accidents (days lost from normal activity because of hospitalization, immobilization, or pain and diminished functional or cosmetic results because of delays in treatment); a reduction in motor vehicle accident mortality rates; and a reduction in the number of motor vehicle accidents (6).

It has been generally accepted that people die or are subjected to more serious injury because of delay between injury and competent medical treatment. Air medical evacuation and specially trained paramedic teams offer real potential for reducing this problem.

Determining which remedial program, or combination of programs, to implement in a state like Arizona should be based on the relative cost and effectiveness of various programs. The AMES demonstration provided cost and operational data for a particular level of implementing a helicopter evacuation system. From these data, estimates were made for the cost-effectiveness of different levels of AMES implementation.

Cost-effective implies that the benefits derived from a system must be measured in dollars. It is difficult to assign monetary values to the cost of a life or to assign a value to mental suffering. In a classical analysis of cost-effectiveness comparative, not absolute, cost-effectiveness figures are used. If these same relative values are used in measuring the effectiveness of all systems being studied, the relative worth of each system can be judged with some validity.

To determine the reduction in patient incapacitation, the following data were collected on each injured person evacuated to a medical facility by an AMES helicopter:

1. An estimate by the attending physician of any time delay in definitive treatment that may have resulted in 5 or more days of increased hospitalization;
2. Difference in time between arrival of the AMES helicopter at the scene of the injury and the estimated arrival of a ground ambulance at the same scene;
3. Difference in time between the arrival of the AMES helicopter at the receiving hospital and the estimated arrival of a ground ambulance at the same hospital; and
4. Difference in time between the arrival of the AMES helicopter at the receiving hospital and the estimated arrival of a ground ambulance at the hospital nearest the scene of the injury.

To determine whether an AMES mission saved a life, the same data collection procedure was used. If the difference between the mission time of AMES and the estimated mission time of a ground ambulance would have resulted in death according to the physician, then the AMES demonstration was credited with the possible saving of a life. The number of possible saved lives was another measurement of the benefit of early arrival on the scene of injury or at a hospital and would assist in the determination of acceptable air or ground ambulance response times.

Highway patrolling by AMES was limited by helicopter capabilities and costs to 8 or 10 hours of flight per week. The natural variability in accident frequency over relatively short stretches of road, at restricted times, is such that any observed change during the hours of patrolling could not be attributed solely to AMES. The observed rate might have occurred purely by chance. AMES effectiveness was analyzed by considering causation factors as discussed in the surveillance section.

The following are tasks, other than those involving medical evacuation, that were also performed by AMES:

1. Location and rescue of lost or trapped persons;
2. Transfer of patients between hospitals when movement by ground ambulance would be hazardous to their survival;
3. Delivery of critically needed medical supplies—drugs, whole blood, or blood products;
4. Transfer of premature infants to special nurseries; and
5. Traffic control, fugitive searches, and general law enforcement.

The value derived from each mission depended on the time required to accomplish the mission, the cost of accomplishing the same mission by some other means, and the possible savings in human suffering. Although the frequency of any 1 type of mission might be small, the total benefit proved significant because the helicopter flew many types of missions. Care was taken to avoid including, in a final tally of benefits, missions that could have been accomplished economically and within allowable time limits by other means.

A cost and operation effectiveness evaluation was conducted to develop the following:

1. A cost model of an air medical evacuation system;
2. A measure of system use for different types of missions; and
3. A measure of the operational effectiveness of the system.

DEMONSTRATION

Actual flight operations were conducted for a period of 9 months. The categories of flight missions were

1. Evacuation,
2. Transfer of patients, including premature infants that required special care,

from 1 hospital to another;

3. Search for missing vehicles, missing persons, and criminal suspects;
4. Surveillance of major roads for traffic violations, unsafe conditions, and unusual happenings; and
5. Other (training, public relations, demonstration, and support).

Data for evacuation and transfer missions are given in Table 1. The largest number of missions flown (81) was for highway accidents and the largest number of hours flown (134) was for hospital transfers. Highway accident flights averaged 1 hour and hospital transfer flights averaged 2.28 hours. Average flight time for the 213 evacuation/transfer missions was just under 1.5 hours. Total cost for evacuation and transfer was slightly less than 26 percent of the total cost of the program. Average cost per patient evacuated was $288. The highest costs for transporting of sick and injured persons were in hospital transfer operations. Many of these people had been injured in highway accidents and were in such critical condition that they had to be moved to special care centers in Phoenix or Tucson. A total of 225 persons were carried in the AMES helicopters. The distribution of these persons by type of mission is given in Table 2.

A summary of all missions (824) flown during the AMES program is given in Table 3. The flight phase of the program involved 1,185 hours of flight time and cost $251,220. According to distribution of flight activity by type of mission, over 63 percent of all flights and over 64 percent of all flight time involved surveillance. Medical evacuations and hospital transfers accounted for just under 26 percent of all flights and all flight time. Search and other missions accounted for the remainder.

The operating cost of the total system depends on the number of flight hours per month. To operate a system equivalent to the demonstration project would cost $212 per hour for 150 flight hours per month. If flights were increased to 200 per month, the cost per hour would be $200. But the real value of the AMES role in medical evacuations lies in time savings. An average of 41 minutes per patient was saved compared to the time necessary for conventional ground ambulance service.

The high initial investment, personnel requirements, and operational characteristics of helicopter systems combine to make this type of program unsatisfactory if its only purpose is evacuation.

SURVEILLANCE

Objective

The original objective of the AMES surveillance program was to determine the helicopter's effect on accident rates. But, because of the limited number of patrol hours and the random occurrence of accidents, an emphasis on this effect would have had little significance. It was decided, then, to concentrate on the following:

1. Determining the cost of patrolling by helicopter in comparison to the cost of patrolling by present means, and
2. Analyzing traffic incidents that are illegal or hazardous or both and determining whether the helicopter has an effect on them.

Accident Causes

The cause of an accident is difficult to define. Many factors, such as the use of alcohol or inattentiveness of the driver, can contribute to the cause. So, the following incidents that are illegal or hazardous were selected as evaluation criteria:

1. Excessive speed—Although it is debatable that excessive speed is the major cause of accidents, it is a factor in accident severity. Excessive speed was defined as 10 mph or more over the posted speed limit. The AMES patrolling might measurably reduce speeds on patrolled roads as a result of motorists seeing a helicopter marked Arizona Highway Patrol; widespread publicity that certain roads will be patrolled by helicopters; and motorists being stopped by ground patrol units and charged with violations that had been reported by helicopter patrols.
2. Following too close—This always represents a potential accident. Following

Table 1. Evacuation and transfer missions.

Type	Missions Number	Missions Percent	Hours	Cost[a] (dollars)
Evacuations				
Highway	81	38	81	17,172
Nonpatient	42	19.2	47	9,964
Nonremote, nonhighway	24	11.7	29	6,148
Remote[b]	11	5.2	15	3,180
Transfer	55	25.8	134	28,408
Total	213	99.9	306	64,872

[a] $212 per hour.

[b] Areas inaccessible to ground ambulances because of terrain or absence of roads.

Table 2. Patients evacuated and transferred.

Type	Missions	Persons Number	Persons Percent	Persons per Mission
Evacuation				
Highway	81	116	52	1.42
Nonremote, nonhighway	24	25	11	1.04
Remote	11	12	5	1.09
Transfer	55	72	32	1.30
Total	171	225	100	

Table 3. All missions flown.

Type	Missions Number	Missions Percent	Hours	Cost (dollars)
Evacuation	158	19.2	172	36,464
Transfer[a]	55	6.7	134	28,408
Search	21	2.5	30	6,360
Surveillance	520	63.1	765	162,180
Other	70	8.5	84	17,808
Total	824	100.0	1,185	251,220

[a] Transfer missions were flown only during the last month of the demonstration.

too close was defined as traveling within 30 ft of another vehicle when the operating speeds were more than 50 mph. If a vehicle closed to pass another and the passing maneuver began within these limits, it was not included.

3. Illegal passing—This was defined as passing on the left in a no-passing zone. Vehicles that completed passing within the first 100 ft of the solid line were not included.
4. Unsafe passing—Unsafe passing was defined as passing with less than 100 ft clearance of an oncoming vehicle or cutting off the passed vehicle.
5. Improper lane position—This was defined as encroaching on the centerline or the shoulder or as traveling on the wrong side of the road.
6. Driving too slow.
7. Littering.
8. Stopping on roadway.
9. Obstructing right-of-way—This was defined as parking to fully or partially block a right-of-way.
10. Driving while under the influence of alcohol.
11. Driving with equipment that needs repair.
12. Driving with inadequate vision.
13. Pedestrian or livestock on roadway.
14. Other (e.g., improper turns, improper stop).

Although it was doubtful that the helicopter could reduce the number of incidents in several of the criteria, they were included because they represent duties that would be performed by a ground patrol vehicle and because they are readily identifiable from the air.

Selection of Patrol Routes

The first step before beginning helicopter patrols was determining routes, their length, and the patrol schedule. Routes were determined by considering their proximity to the helicopter base; accident history, geometric characteristics, and traffic volume of the routes; limitations of personnel availability; and cost.

Based on these determinations US-87 and I-10 were selected. In 1968 the summer average daily traffic (ADT) for these routes was 1,800 and 9,000 respectively. US-87 is a 2-lane route through hilly terrain and has one of Arizona's highest accident rates (2.86 per 100 million vehicle-miles). I-10 is a 4-lane divided highway and has a low accident rate (approximately 1.2 per 100 million vehicle-miles).

The length of route to be patrolled was determined by the number of flight hours possible before refueling would be required, location of the base of operation, flight pattern, evacuation capabilities during a patrol, and desired sample size. The helicopter is limited to about 3 hours of flight time before refueling is required. Therefore, a short surveillance period (1 hour on station) was selected to allow a maximum flying radius in case an evacuation occurred during a patrol mission. A loop was flown in both directions along the roadway during the patrol. In this manner approximately 80 miles of road were patrolled on a 1-hour round trip.

The time of day and day of week for patrolling were determined by helicopter crew availability and by the past accident history of the routes. The schedule provided that a surveillance mission was not to be flown unless there was a standby helicopter. If an evacuation mission occurred during the mission and the surveillance helicopter was not to perform the evacuation, the surveillance helicopter was to return to base.

On US-87, the procedure was to fly the helicopter intermittently for 4 patrols on alternating days of the weekend. A helicopter would fly on Friday and Sunday of 1 week and then on Saturday of the following week. Data were collected by ground observers on all 3 days. In this manner the effect of the helicopter could be determined by examining the criteria under patrol and nonpatrol conditions.

Data were collected on I-10 by ground observers before helicopters flew patrols over this route. After sufficient data had been collected, concentrated patrols were flown over similar hours and days of the week as on US-87.

Informing the motorists of the patrols was done by posting signs on the patrolled routes and by using newspapers, radio, and television. Portable signs were used on

US-87 and were placed only when the helicopter was scheduled to patrol. Permanent signs were used on I-10 after the background data were collected.

Ground data were collected from a fixed point on both routes. The ground observer sections were located at approximately the one-third point on the route with visibility of more than ½ mile in each direction.

The ground observers fixed intervals for speed determination by using a stopwatch. These sections were about 0.2 mile. Clocking was done on only those vehicles that appeared to be traveling unusually fast. When a speeding vehicle was passed, both vehicles were counted. When several vehicles were traveling at apparently the same high speed, all vehicles were counted. The helicopter observer gathered the same data as did the ground observer except that the helicopter observer determined excessive speed visually.

Surveillance Patrol Results

All of the evaluation criteria, separately and combined, were examined by using the analysis of variance technique (4, 5). A 2 by 3 grouping of the experimental data was made based on the helicopter flying status and volume. The statistical analysis of the evaluation criteria before and during airborne surveillance was made by using an error of the first type (the error of rejecting a true hypothesis—probability that the statement, "the AMES effect reduced the criteria," is false) of 0.10.

US-87—Data were collected on US-87 for 31 hours, including 13 hours when helicopter patrols were flying. This route is predominantly used for recreational travel. The directional split of traffic, as a percentage of total westbound traffic (toward the Phoenix metropolitan area), was 34.3 percent on Friday, 58.5 percent on Saturday, and 79.4 percent on Sunday. The range of this directional emphasis was 70 percent. A count made on the trucks, buses, and trailer-car and boat-car combinations was 14.3 percent of the total volume observed. This route also serves several recreational areas north of the Phoenix area.

The F value for rejecting the hypothesis that the variance or standard deviation of the criteria are equal when the helicopter is and is not flying is F 0.10, 1, 22 = 2.95. Based on this test the hypothesis can be rejected because the helicopter patrol did have a significant effect in reducing

1. Excessive speed, F = 4.69;
2. Illegal passing, F = 4.23; and
3. All criteria, F = 4.95.

I-10—This 4-lane divided highway is predominantly traveled by intercity traffic between Tucson and Phoenix and through-state traffic on this southern Interstate route. The volume of traffic observed was relatively constant and had no major directional emphasis. A total of 30 hours of data were collected before signs were placed and helicopter patrols begun. Ground observers collected 22½ hours of data while the helicopter was patrolling. And, a special 1-hour patrol was made over a 2½-mile section that was near the ground observation location. This special patrol resulted in a marked decrease in the number of speeding vehicles. This indicates that the helicopter has a zone of influence much larger than that of ground enforcement vehicles. Four and one-half hours of data were collected when the signs were in place and the helicopter was not patrolling. Statistical analysis of these data indicates that the signs themselves have no effect as a deterrent.

The F value for rejecting the hypothesis is F 0.10, 1, 47 = 2.82. The helicopter had a significant effect in reducing

1. Excessive speed, F = 18.55;
2. Improper lane position, F = 2.84; and
3. All criteria, F = 15.17.

SUMMARY

If a vertical takeoff is required, there is no substitute for the helicopter. For straight traffic control, however, a fixed-wing aircraft can orbit a point as well as a helicopter and at about $^1/_{10}$ the cost.

Ground patrol units are the most economical means of traffic control and surveillance and are a necessity for enforcement. But, they have several important disadvantages. For example, only a small segment of roadway is visible to them at a time; in rough terrain visibility perpendicular to the roadway is restricted; and enforcement and surveillance take place in this restricted segment, which can vary from a few feet to several miles.

Operating speeds of the helicopter are about $2^1/_2$ times as fast as those of a ground unit on normal patrol. Under almost all circumstances the helicopter can patrol a route faster than any other mode. The helicopter's landing and fast evacuation capabilities can be made available in combination with trained medical personnel. There were several missions during the project when the helicopter was the first official vehicle at an accident scene. The pilot was available to direct traffic movement or to aid the observer-paramedic in treatment. Ground units are limited in enforcement and movement when the traffic is heavy. This is particularly the case on 2-lane routes. But, violators can be detected but not stopped by a helicopter. This, and high operating costs, are the main disadvantages of the helicopter.

A ground unit and helicopter combination was used in issuing warning tickets on both routes. On the Interstate, the primary violation was excessive speed. On US-87, the helicopter aided the ground patrol units in detecting and apprehending illegal passing and centerline violators. In a 1-hour period 12 of these violations were detected from the helicopter over an 8-mile area, and all were apprehended by 1 of the 4 ground units in the area. The advance notice given to patrol units was a key factor in apprehending all violators detected. Under similar heavy traffic conditions, if ground units detected these violations, apprehension would not always be possible.

The AMES performed the functions of both a ground ambulance system and the Highway Patrol operation. Cost models for AMES, a Highway Patrol operation, and a ground ambulance operation were developed on the basis of 24 hours per day for a year.

On the basis of time, a helicopter operates at an average of twice the speed of a ground ambulance or Highway Patrol car. AMES performed 171 medical missions in 154.5 hours, less time than it would have taken a ground ambulance for the same missions. This time saved cannot be measured in dollars, but the 41 minutes saved per patient constitutes the real value of AMES in its medical evacuation role.

It is estimated that the AMES is equivalent to 3 times the capability, in terms of area serviced, of the Highway Patrol operation or ground ambulance operation. Operating 3 Highway Patrol groups would cost $205,617. Six ambulances would cost $329,835. The total annual cost of these 2 systems is $535,456. The annual AMES cost would be $379,000.

These comparisons show that use of a helicopter, when it is operated in a rural area, can be justified on a cost basis as a supplement, not a replacement, for existing law enforcement and ambulance services.

CONCLUSIONS

A major time savings was demonstrated by AMES when used in medical emergencies in rural areas. The greater the distance is from a base of operation, the greater the savings are in time. When used only in evacuation, AMES costs of operation are over 3 times those of ground ambulances. But, in a multiple role, the cost-effectiveness of AMES can be justified by providing a valuable supplement to existing law enforcement and ambulance services. The multiple use of surveillance and evacuation was demonstrated successfully. Functioning in a patrol and surveillance role, AMES significantly reduced driver behavior characteristics that cause accidents, especially excessive speed and illegal passing.

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MOTORISTS' ATTITUDES AND BEHAVIOR CONCERNING CALIFORNIA'S ROADSIDE REST AREAS

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This paper reports the results of a research program conducted to assist in evaluating the highway travel and stopping patterns of California drivers. The findings of the study deal, in large part, with long-trip motorists, defined as those who have taken at least 1 trip of 100 miles or more away from home in the previous year. Eighty-six percent of all California motorists have taken at least 1 such trip. The demographic profile of the California long-trip motorist closely parallels the profile of California highway users in general. The median stopping interval for long-trip motorists is every 73 miles and 75 minutes; the mean stopping interval is 81 miles and 85 minutes. The roadside rest area user tends to stop more often than the average long-trip motorist. The median stopping interval for all rest area users is every 58 miles and 68 minutes, and the mean is every 61 miles and 73 minutes. Sixty-four percent of all California highway users have stopped at a roadside rest area at 1 time or another; long-trip motorists are more likely to stop at such an area than short-trip motorists. Roadside rest area users have taken considerably more long driving trips (14) than the average California motorist (7) within the past 12 months. Other findings of the study concern motorists' attitudes and opinions concerning roadside rest areas, reasons for using them, comparison of the rest areas with the "ideal" stopping opportunity, and related issues.

•THE MAJOR objective of this study was defining the highway travel and stopping patterns of California drivers. The data collected provided the basis for an evaluation of the roadside rest program in terms of its present services and those that it ideally should have. Answers to 3 fundamental questions were sought.

1. Are the existing stop facilities on the California highways frequent enough?
2. What types of facilities are needed and how should they be equipped?
3. Can existing facilities meet the needs of motorists?

RESEARCH DESIGN AND METHODOLOGY

Research Process

Extensive briefings were held by Opinion Research Corporation and executives from interested state agencies, the California Highway Commission, and the Safety Roadside Rest and Highway Planting Committee to ensure that the study encompassed all areas of specific interests. At the same time, the research team reviewed all available information pertaining to roadside rest areas. Draft questionnaires were developed and were pretested under actual field conditions. When questionnaires had been reviewed and approved by the Roadside Rest and Highway Planting Committee, field work began. All interviewing was conducted between August 18 and September 8, 1972.

Publication of this paper sponsored by Committee on Motorist Services.

Phase I

Personal interviews with 1,552 people in a probability sample of Californians 18 years of age and older who use the state's highways were conducted to determine the frequency with which Californians make long driving trips (100 miles or more); the purpose of long driving trips; the average distances of such long trips and length of time involved; the actual stopping patterns followed by travelers on long trips; stopping opportunities that may be preferred to those currently available; and the reasons for differences between actual stopping patterns and desired stopping opportunities, if such differences exist.

Phase II

Personal interviews with 1,025 individuals in a representative sample of roadside rest area users were conducted at 5 California rest areas. The 5 rest areas chosen were representative of typical locales in the state. The primary objective of this phase was to observe in detail the behavior and attitudes of travelers at roadside rest areas.

Phase III

Personal interviews with 525 individuals in a representative sample of California nonresident travelers were conducted at 4 heavily traveled border-crossing points, 1 at each of the common boundaries with Oregon, Nevada, Arizona, and Mexico.

The objectives of this phase were to measure the use of California roadside rest areas among nonresident travelers in California and determine why other nonresident highway travelers did not use California roadside rest areas. Additional objectives of the study were to determine use patterns of California roadside rest areas in terms of frequency of stops and length of time spent; the degree to which trips are planned with roadside rest areas in mind; the degree to which specific facilities (rest rooms, telephones, and the like) available at roadside rest areas are actually used; the degree to which travelers use roadside rest facilities as a rest opportunity; and the extent to which roadside rest facilities are used for atypical reasons like overnight stops.

RESULTS

Profile and Traveling Patterns of California Motorists

Eighty-six percent of California motorists have taken long driving trips in the past year. In this report, long driving trips are trips where the motorist traveled 100 miles or more away from home. The demographic profile of California long-trip motorists closely parallels the profile of California highway users in general. California motorists most likely not to have taken long trips are those from the lowest income categories, the less well-educated, and those 55 years of age and older. California highway users take an average of 7 long driving trips a year. The mean number of long driving trips taken by all California motorists is 6.8 trips per year. This average figure is inflated by those motorists who take many more long trips than the typical motorist. This is reflected in the median figure of 3 long trips per year for all California highway users. The mean more closely relates to volume of use of the state's highways and other facilities. The median can be thought of as more closely representing what a typical California highway user is doing. Roadside rest area users and nonresident motorists take considerably more long driving trips per year than the average California motorist. On the average, nonresidents take about 16 such trips, roadside rest area users 14, and the California motorist 7.

Passenger cars are used by most motorists. But roadside rest area users and nonresident travelers are considerably less likely to travel in passenger cars than are California motorists. They are more likely to travel in recreational vehicles or to tow boats and other types of trailers.

Five roadside rest area users in 10 travel with children between 6 and 17 years of age. This is substantially larger than the proportions of California long-trip motorists and nonresident travelers who travel with children in these age categories. More than 1 California long-trip motorist in 10 travels with a dog or other pet. But, roadside rest area users are more likely to travel with a dog or other pet than either California motorists or nonresident travelers. Nonresident travelers are the least likely to travel with a dog or other pet.

Table 1 gives the travel statistics for a typical day for California long-trip motorists, roadside rest area users, and nonresident motorists.

Current Stopping Places

Table 2 gives the places where California motorists currently make brief stops. California motorists are more likely to stop at gas stations or restaurants than at any other kind of stop, although many do stop at various other places. California long-trip motorists spend widely differing amounts of time for different types of brief stops. Stops of more than 3½ hours in length were not considered brief stops and have been eliminated from the figures to present a more accurate average. On the average, more than an hour is spent at pay amusement areas and national, state, and local parks. More than a half hour, but less than an hour, is spent at restaurants, historical landmarks, and vista points. On the average, 20 minutes or less is spent at grocery stores, drug stores, gas stations, and the shoulders of the road.

Reasons for Brief Stops at Other Than Roadside Rest Areas

The major reasons for stopping at gas stations are to buy gas and oil and to use the rest rooms. The 2 most frequent reasons for stopping at restaurants and drive-ins are to buy a meal and to use the rest rooms. The most frequent reason for stopping at national, state, or local parks is to enjoy the scenery or to view specific attractions. The key reason for stopping at historical landmarks or vista points is to look at the scenery. The major reason for stopping at pay amusement or entertainment areas is to enjoy their specific attractions.

Motorists stopping by the side of the road do so to relax, look at the scenery, and switch drivers. Those California motorists who have never used the state's roadside rest areas may be more likely than those who have used them to make shoulder of the road stops to eat food brought with them, change a tire, repair the vehicle, and the like.

Desired Additional Stopping Places

Two in 10 California long-trip motorists would like to make stops that they do not or cannot actually make. Long-trip motorists are much more likely than short-trip motorists to feel that there are times when they would like to make stops but do not or cannot make them. The need for additional stopping places is mentioned most frequently by motorists who tow trailers, travel in recreational vehicles, or are roadside rest area users. The reasons given for wanting to stop are given in Table 3.

Reasons for not stopping when a stop is desired relate to the lack of a stopping opportunity for 4 long-trip motorists in 10. About 2 in 10 do not stop because they are in a hurry, have already stopped too many times, or do not want to take the time. About the same proportion do not stop because they find no turnoff or safe place off the highway. One in 10 does not stop because someone else in the vehicle does not want to stop.

Ideal Stopping Place

Table 4 gives the characteristics of the ideal stopping place according to California long-trip motorists. More than 6 California long-trip motorists in 10 describe the ideal stopping opporutnity as having clean rest rooms.

Fifteen percent of all California long-trip motorists spontaneously mention that the state's roadside rest areas already are ideal stopping places. Roadside rest area users describe the ideal stopping place somewhat differently than do motorists who have never used these areas. Roadside rest area users are significantly more likely to mention clean rest rooms, shade and shade trees, water fountains, picnic areas, a scenic location, a parking area, and safe access and exit. California motorists who have never used a state roadside rest area are significantly more likely to mention that the ideal stopping place would have a restaurant or a gas station.

Table 1. Travel statistics for a typical day.

Item	Mean	Median
Miles covered		
California long-trip motorists, 1,337	307	256
Roadside rest area sample, 1,025	381	354
Outbound nonresident sample, 525	446	406
Driving hours: minutes		
California long-trip motorists	5:34	4:25
Roadside rest area sample	7:39	6:54
Outbound nonresident sample	8:30	7:44
Number of stops		
California long-trip motorists	3.5	3
Roadside rest area sample	5.6	5
Outbound nonresident sample	5.2	5
Miles between stops		
California long-trip motorists	81	73
Roadside rest area sample	61	58
Outbound nonresident sample	80	73
Hours: minutes		
California long-trip motorists	1:25	1:13
Roadside rest area sample	1:13	1:8
Outbound nonresident sample	1:29	1:23

Table 2. Stopping places currently used.

Stopping Place	California Long-Trip Motorists[a] (percent)
Gas stations	90
Restaurants, drive-ins	72
Grocery or drug stores	33
Shoulder of the road	25
National, state, and local parks	23
Historical landmarks or vista points	20
Pay amusement areas	11

[a] Based on a sample of 1,337.

Table 3. Reasons for additional stopping places.

Reason	California Long-Trip Motorists[a] (percent)
Relax	35
Look at scenery	25
Use the rest rooms	18
Get something to eat	9
Get something to drink	7
In case something was wrong with car	4
Sleep for night	4
Cool off	4
Get gas	2
Change drivers	2
Other	11

[a] Based on a sample of 288, those who desired more stops.

Table 4. Characteristics of ideal stopping places.

Characteristic	California Long-Trip Motorists[a] (percent)
Clean rest rooms and facilities	65
Shade trees	47
Drinking water	39
Picnic facilities	37
Grass, lawns, flowers, streams	24
Scenic	19
Restaurant	15
State roadside rest areas are ideal	15
Gas station, place to have car serviced	14
Food and drink stand	14
Clean	11
Parking area	9
Safe access and exit	10
Phones	8
Quiet and restful	8
Place to cook	5

[a] Based on a sample of 1,337.

Table 5. Motorists' perceptions of California roadside rest areas.

	California Highway Users		
Perception	Total[a] (percent)	Long-Trip Motorists[b] (percent)	Short-Trip Motorists[c] (percent)
State roadside rest areas are a useful and necessary part of the state highway system.	74	77	61
State roadside rest areas make an important contribution to safety on California highways.	73	76	57
We do not have enough roadside rest areas in California.	47	50	32
A state roadside rest area would not be a safe place to stop after dark.	28	27	36
I would not stop at a state roadside rest area if I were traveling alone.	19	19	25
I sometimes plan in advance to stop at particular state roadside rest areas.	18	19	15
Turnoffs for state roadside rest areas are hard to spot in time to take them.	12	12	13
Before today, I didn't know where any California roadside rest areas were.	11	8	30
We have enough roadside rest areas in California.	10	11	4
State roadside rest areas are unnecessary because there are gas stations, restaurants, and other places to stop.	7	7	8
I wouldn't care for the people who stop at state roadside rest areas.	3	2	4

[a] Based on a sample of 1,552. [b] Based on a sample of 1,337. [c] Based on a sample of 215.

Perceptions of the California State Roadside Rest Areas

The percentages given in Table 5 are of California motorists who agree with the 11 statements about California roadside rest areas.

Roadside rest areas are perceived differently by those California motorists who have used them and by those who have not. Roadside rest area users are more enthusiastic and are considerably more likely to believe that they are useful and necessary, that they make an important contribution to safety on the highways, and that there are not enough of them. Those who have never used state roadside rest areas are more likely to say that they would not be safe places to stop after dark, that they would not stop at them if they were traveling alone, that they do not know where any are located, or that they are unnecessary because of other commercial places to stop.

Men are more likely to believe that California needs more roadside rest areas. Women are more likely to have some fears about their personal safety at roadside rest areas.

Use of California Roadside Rest Areas

More than 6 California motorists in 10 have used California roadside rest areas. Six in 10 of nonresident travelers also have stopped at a California roadside rest area at 1 time or another. Three California long-trip motorists in 10 use at least 1 rest area on a long trip. The proportion of use rises to nearly 4 in 10 among nonresident travelers on a given trip. From the interviews with motorists at roadside rest areas, it is apparent that the state's roadside rest areas are serving the entire range of California motorists. But roadside rest area users are somewhat more likely to be from 25 to 54 years of age, be better educated, and have higher incomes than motorists in general. Roadside rest areas also have a slightly higher proportion of white people, although virtually every racial and ethnic group was represented in the special sample of travelers interviewed at 5 rest areas.

More than 7 out of 10 vehicles observed in the special users sample were registered in California. Even so, the sample of 1,025 included vehicles from 36 states.

Although 85 percent of California long-trip motorists travel in passenger cars, only 63 percent of the vehicles in roadside rest areas are passenger cars. A substantial proportion of recreational and other special vehicles are among those using roadside rest areas. In addition, roadside rest area users are more likely to tow trailers than are long-trip motorists in general. Because these special vehicles require more space and because motorists in these vehicles spend a much longer time in the rest areas than do motorists in passenger cars or trucks, the roadside rest area load factor accounted for by special vehicles is substantial.

Motivations for Use or Nonuse of Roadside Rest Areas

Table 6 gives California motorists' reasons for stopping at rest areas rather than at other kinds of places. A substantial proportion of the reasons why motorists do not use roadside rest areas on any given trip relates to self-induced pressures to complete the trip quickly. This is even true among California long-trip motorists. Of those in this group who have not used roadside rest areas, 2 in 10 say that their trip is too short to stop; 2 in 10 say there is no need to stop; about 2 in 10 say they try to drive straight through; 1 in 10 says he or she is in too much of a hurry to stop. Between 1 and 2 in 10 long-trip motorists do not use roadside rest areas because they only stop at gas stations or they only stop for something to eat. Fewer than 1 in 10 long-trip motorists have never seen a state roadside rest area.

Use of Specific Roadside Rest Area Facilities

Table 7 gives the uses made of roadside rest areas by the 3 groups. The most frequent are to use the rest room, relax and take a break from driving, and get a drink of water.

Table 6. Reasons for using California roadside rest areas.

Reason	California Highway Users[a] (percent)	Reason	California Highway Users[a] (percent)
Relax	50	Children can play	5
Use rest room	36	Not crowded	5
Not commercial	26	Handy	4
Easy access	23	Shady	4
Nice scenery	12	Change drivers	4
Get a drink of water	12	Facilities for pets	3
Clean	12	Nap or sleep	3
Quiet	12	Quick	1
Convenient location	9	Other	9
Safe	8	Don't know, no answer	4
Make car repairs	5		

[a] Based on a sample of 994, those who have stopped at a roadside rest area.

Table 7. Use of specific roadside rest area facilities.

Use	California Highway Users[a] (percent)	Roadside Rest Area Sample[b] (percent)	Outbound Nonresident Sample[c] (percent)
Used the rest rooms	80	91	81
Relaxed	72	71	68
Got a drink of water	65	55	53
Looked at scenery	46	27	39
Disposed of trash	40	32	36
Had something to eat	38	40	23
Went for a walk	35	23	25
Read map or asked directions	21	22	30
Cleaned windshield, checked tires	20	14	18
Switched drivers	19	13	20
Walked pet	11	11	6
Changed tire or repaired vehicle	5	5	8
Slept overnight	4	5	10
Took a nap	3	6	11
Used the telephone	2	3	7
Disposed of sewage (recreational vehicle)	2	1	4

[a] Based on a sample of 372. [b] Based on a sample of 1,025. [c] Based on a sample of 202.

Table 8. Average length of time spent in roadside rest areas.

	All Stops			Stops of Less Than $3\frac{1}{2}$ Hours		
Sample and Type of Vehicle	Number	Mean (min)	Median (min)	Number	Mean (min)	Median (min)
Roadside rest area sample	1,025	55	21	969	29	19
Passenger car without trailer	566	35	18	553	26	18
Passenger car with trailer	78	66	29	75	35	28
Campers, vans, motor homes	251	93	32	220	34	29
Trucks	53	35	17	52	31	17

Table 9. Facilities or conveniences not in the rest area that would make it a more convenient and comfortable place to stop.

Facility or Convenience	California Highway Users[a] (percent)	Roadside Rest Area Sample[b] (percent)	Outbound Nonresident Sample[c] (percent)
Everything is satisfactory	34	41	46
More shade, windbreaks	21	12	7
Specific rest room facilities such as showers, electrical outlets, and the like	7	11	13
Vending machines and snack machines	7	6	5
Cleaner rest rooms	6	4	6
More drinking fountains	5	4	2
Emergency telephone	5	2	1
More grass, flowers, water	4	7	1
Refreshment stand	4	2	3
More picnic facilities	4	1	1
More and larger rest rooms	3	4	3

[a] Based on a sample of 372. [b] Based on a sample of 1,025. [c] Based on a sample of 202.

Actual Length of Time Spent in Roadside Rest Areas

As given in Table 8, the average length of time for all stops by vehicles using roadside rest areas is 55 minutes and for brief stops ($3\frac{1}{2}$ hours or less) is only 29 minutes. The difference is largely accounted for by the fact that a number of motorists use California roadside rest areas for overnight stops. Two in 10 of the motorists interviewed in the special sample of roadside rest area users stayed overnight at 1 or more of the California roadside rest areas. Among the special sample of outbound non-California residents, an almost identical proportion (21 percent) also used the California roadside rest areas for overnight stops.

Suggested Changes for Roadside Rest Areas

When asked to name facilities or conveniences that are not available now, but that would make the rest areas more convenient and comfortable places to stop, more than 3 in 10 California motorists who have used the state rest areas can think of nothing that needs to be added. Table 9 gives the principal changes motorists suggest for the California roadside rest areas.

Future Planning for the Roadside Rest Area Program

In understanding California motorists' behavior and attitudes toward the state roadside rest program, one should keep the following key points in mind:

1. Eight in 10 use the bathroom facilities;
2. Seven in 10 take the opportunity to relax;
3. More than 6 in 10 get a drink of water; and
4. More than 4 in 10 enjoy the scenery and the view.

Key reasons why motorists prefer to use state roadside rest areas, instead of other kinds of places where they might stop, include:

1. The opportunity to take a break from driving and relax;
2. The existence of rest room facilities;
3. There is no charge for using rest areas; and
4. They can bring their own food to eat at the picnic facilities.

The California motorists' description of the ideal stopping opportunity includes clean rest rooms, shade and shade trees, water fountains, picnic facilities, and landscaping and scenic features.

All data indicate that clean, well-maintained rest rooms are important to the acceptability of roadside rest areas to California motorists. In addition, California motorists attach much importance to the presence of shade, windbreaks, drinking fountains, picnic facilities, and so forth. Ideally, all rest area facilities should be blended into an overall design that has a relaxing, restful atmosphere.

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James K. Williams, Transportation Research Board staff

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