3A TMC

PROSPECTUS

for

M E T R O P O L I T A N
A R E A
F R E E W A Y
S U R V E I L L A N C E
A N D
C O N T R O L
S Y S T E M

Prepared by

Traffic Research and Surveillance Section

Office of Traffic Engineering

Minnesota Department of Highways

St. Paul, Minnesota

November 1970

SUMMARY

Background

A freeway surveillance and control system is simply a combination of surveillance, communication, and control components inter-related so as to regulate traffic flow.

Surveillance - the continual viewing of traffic in time and space -- provides input to the control system from sources such as television cameras and/or vehicle detectors. The communications system carries information back-and-forth between the surveillance and control components via hard-wire, leased telephone lines, or radio. Control techniques are used to prevent breakdowns due to demand exceeding capacity. These techniques include ramp metering, ramp closure, lane closure, and signing.

Experience in various cities has shown that freeway surveillance and control is an effective traffic engineering tool for optimizing freeway operations and corridor traffic flow. Extensive studies conducted in Detroit, Houston, and Chicago have demonstrated that this type of system is cost-effective from the standpoint of reducing travel time, delay, and accidents. Also, improved operating conditions achieved through surveillance and control techniques may make it possible to postpone or cancel additional construction at certain locations.

Synopsis of Prospectus

This prospectus outlines the need for and nature of a system of freeway surveillance and control for the St. Paul-Minneapolis Metropolitan Area.

Information is presented on the transportation trends in the Metropolitan Area showing heavy reliance on highway vehicular travel and indicating that capacity deficiencies will exit. The role that freeway surveillance

and control may play in the development of a total transportation system is presented. Also included is information on the cost-effectiveness of various urban transportation modes.

The long-range plans and a description of the ultimate system are outlined along with a plan of implementation to develop the system in an organized manner.

Recommendations

Review & evaluation of 11/87 - RBS

Listed below are the more important recommendations for an immediate course of action to efficiently and economically develop the system.

1. Develop adequate Minnesota Highway Department staffing for design, operation, and maintenance of initial stages of the freeway surveillance and control system and for expansion as the need arises.

   initial response - not carried through.

2. Initiate planning, legislative approval, and preliminary design of a building for the freeway surveillance and control center to be located On M.H.D. right-of-way, possibly in the Central Interchange area.

   done - TMC opened 8/72

3. Initiate review of all future construction plans (including bridges) for possible inclusion of duct work for freeway surveillance and control.

   started - follow through?

4. Initiate review of geometrics in all future construction plans to insure adequate ramp storage, sufficient acceleration distance, and adequate sight distance for ramp metering.

   done fairly well.

5. Initiate a program of public information to a) educate drivers, and b) develop public acceptance of freeway surveillance and control.

   ok - needs updating

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INTRODUCTION

Several important theorems have been developed through the experience gained during construction and operation of the Interstate System. These include:

1. Freeways generate their own quota of additional travel demands.
2. It is economically and politically impossible to construct enough freeway capacity to satisfy peak hour and expected future demands.
3. Freeways will receive a diminishing portion of available funds as demands from other needs increase.
4. Freeways will not operate by themselves.

A corollary to these theorems is that optimum use of freeways and all transportation modes must be obtained to maximize the return on the Public's investment. To meet this need, freeway surveillance and control techniques have been developed to optimize corridor travel.

The basic objective of freeway surveillance and control is to decrease congestion and improve the overall quality of traffic flow. In doing so there should be a reduction in travel time and total delay, accidents, vehicle operating costs, driver tension and air pollution.

Freeway surveillance provides input to the freeway control system, and a data base for evaluating operational conditions on a freeway or section of freeway. Ideally, local and arterial streets are included in the system. Surveillance involves the measuring of quantitative traffic stream variables to determine the service quality being provided. The variables most often measured are volumes, speeds or travel times, traffic density and total delay, which when combined with accident data provide an overall system performance evaluation. Conventional vehicle detectors such as loop detectors and radar detectors are used to gather the data.

In its simplest form, surveillance is merely a visual observation of traffic conditions, with or without remote television cameras. Visual surveillance has been used successfully to detect traffic accidents and breakdowns and has resulted in improved response time and towaway service, minimizing congestion.

Freeway control is used to keep demand volumes from exceeding downstream bottleneck capacities. Control is accomplished by metering and/or closing selected ramps. Metering a ramp leaves a driver with three options: a) divert to an alternate ramp, b) divert to a surface arterial route, or c) wait for access to the freeway. Closing the ramp leaves the driver with alternatives a and b. Exercising control can be most successful if the surface routes have adequate capacity to accommodate the diverted traffic. For this reason, evaluation must include all routes within the transportation corridor.

As a result of research and demonstrations in various cities, freeway surveillance and control systems are rapidly moving from the experimental to the operational status. A complete listing of the history and major events on freeway surveillance and control systems in the United States is presented in the Appendix in an article by A. D. May.(1)

METROPOLITAN AREA TRENDS

The pattern in our St. Paul-Minneapolis Metropolitan Area is similar to other major urban areas. Construction of urban freeways generated additional travel, and as citizens utilized the improved capacity peak hour congestion resulted. While a fair judgment cannot be made until the entire system is completed, peak hour problems will probably continue. Technical Report Number III (2) prepared by A. M. Voorhees for the Metropolitan Transit Commission predicts the following:

1. "Highway vehicular travel is expected to increase still more in the future with more than a 50% growth expected over today by 1985 and a doubling of traffic by the year 2000."
2. "There is evidence that the Twin Cities will be faced with nearly impossible radial corridor highway capacity problems within the forseeable future. Downtown Minneapolis and St. Paul will be less accessible to the labor force and to the rest of the region during peak hours than has heretofore been the case."
3. "Projections indicate large increases in <u>through</u> downtown (Minneapolis) travel which in the years 1985 to 2000 will likely congest all corridors, even if all presently contemplated roads are built and express transit is constructed."
4. "Only the northeast and southeast (St. Paul) corridors would show capacity deficiencies at the inner screen lines. However, the possible impact of transit to relieve these deficiencies is limited since rapid transit lines in these corridors do not divert enough travel from highways to overcome the deficiency."

These trends indicate that serious problems will develop on our highway system if preventative steps are not taken. With travel demands increasing and public resistance to roadway construction intensifying, it is imperative to optimize freeway operations if an acceptable level of service is to be maintained.

The Role of Surveillance and Control in a Balanced Transportation System

The urban transportation system should have proper balance between private automobiles and transit, should make efficient use of the highway system, and should be concerned with meeting an area's long-term transportation needs. Proper application of modal split is one of the key aspects in arriving at a suitable urban transportation system.

Technical Report No. III recommended as an element of the Twin Cities transit system "Rail Rapid Transit constructed in stages with an initial trunk line of 19 miles by 1980, 31 miles by 1990 and an ultimate network of 71 miles." Rail Rapid Transit has tremendous capacity -- generally considered to be in the range of 40,000 to 60,000 passengers per hour per track.

Unless the demands on the system are extremely high, however, the trains will be moving empty seats instead of passengers. There is considerable question as to whether or not the population densities in the Twin Cities are high enough to support rail rapid transit. The average population density for the Metropolitan Area is only about 1,800 persons per square mile, with the Central cities having an average density of about 7,500 persons per square mile. Meyer, Kain, and Wohl [(3)] have concluded that at low and medium densities, bus transit is almost invariably cheaper than rail. They further conclude that "a freeway flyer system, if afforded congestion-free travel, is always the cheapest form of high-performance line-haul transit, even at high population densities." Congestion-free travel on freeways has been hard to achieve to date, but use of freeway surveillance and control techniques should help considerably.

Information on the cost-effectiveness of various transportation modes is presented in Figure I [(4)]. The high cost-effectiveness of the bus-freeway system may be attributed to cost-sharing characteristics between peak and off-peak traffic. The use of mixed traffic on the facility means that bus transit does not need to amortize the entire cost of the traveled way.

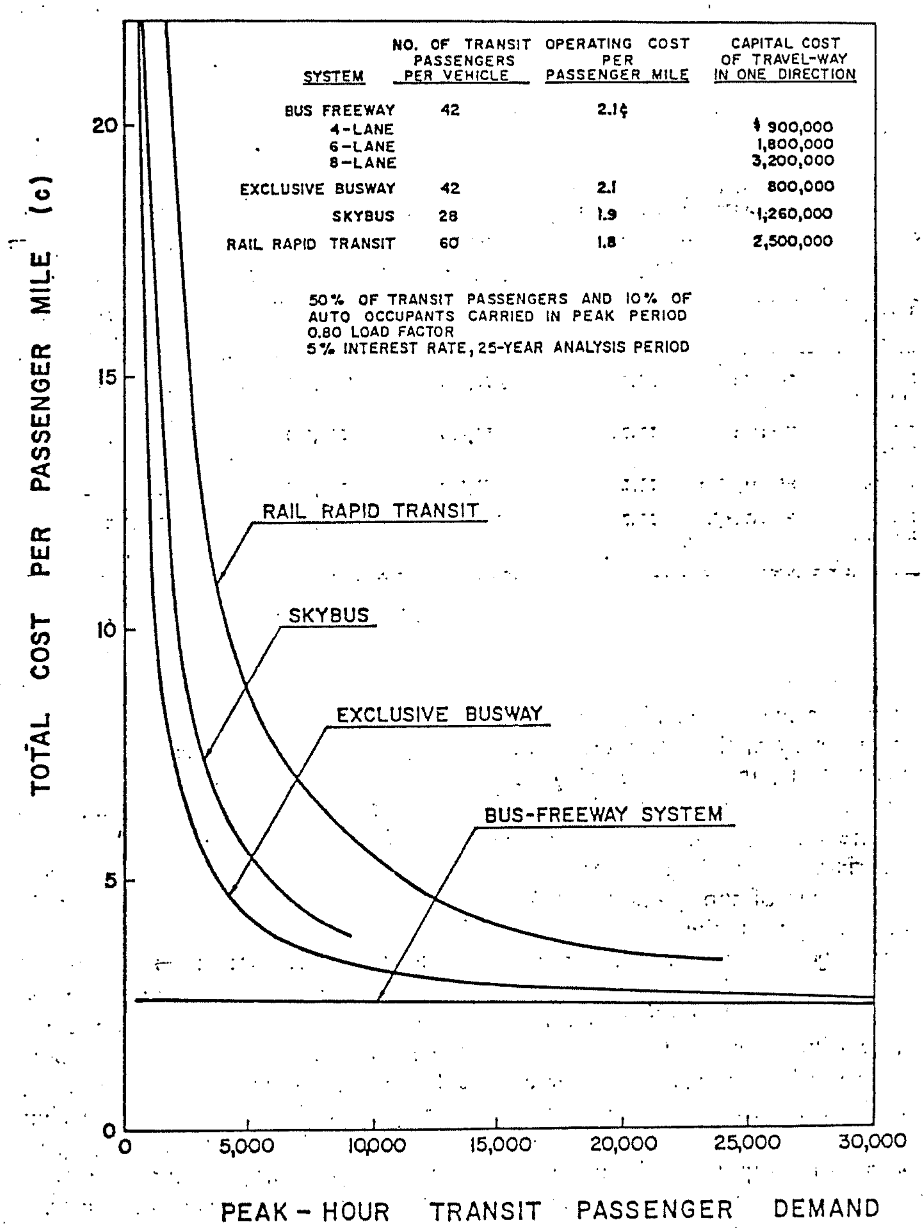

Figure I - Cost Effectiveness of Passenger Movement Capability for Alternate Urban Transportation Modes (4)

The I-35W bus-demonstration project, which is presently in the planning stage, shows a great deal of promise in demonstrating the effectiveness of a freeway flyer system. This project, the first of its type, will test a rapid transit system in which buses operate in mixed traffic on I-35W at a guaranteed level of service achieved through the use of traffic surveillance and control. Buses will have undelayed access to the freeway while private vehicles will be "metered" onto the freeway to utilize the "unused capacity" between buses. An improvement in the level-of-service for buses should generate sufficient patronage to substantially increase the "people-carrying" capability of the system. Although recent experience with freeway surveillance and control has demonstrated that peak-hour levels of service can be greatly improved, this type of control system has not as yet been used as a technique to facilitate bus rapid transit operations.

Among the goals of the I-35W bus-demonstration project are to (a) evaluate the use of this type of system as a means of attacking the problem of peak-hour congestion in urban radial corridors, and (b) evaluate where this type of system can be used as a "backbone" mass transit system for medium density metropolitan areas.

Figure II illustrates one possible system of Bus-Freeway routes that utilize constructed and/or proposed Metropolitan freeway links. After the currently planned system for I-35W is completed, other routes can be added as needed for a relatively small capital outlay. Unlike rapid rail systems, routes can be added, modified or discontinued almost at will (and the vehicles assigned to other routes), since a metering system will be needed with or without a bus transit system operating on the freeway. Because the success of any mass transit system is determined by the amount of voluntary use that it generates, route flexibility will be essential to accommodate expansion

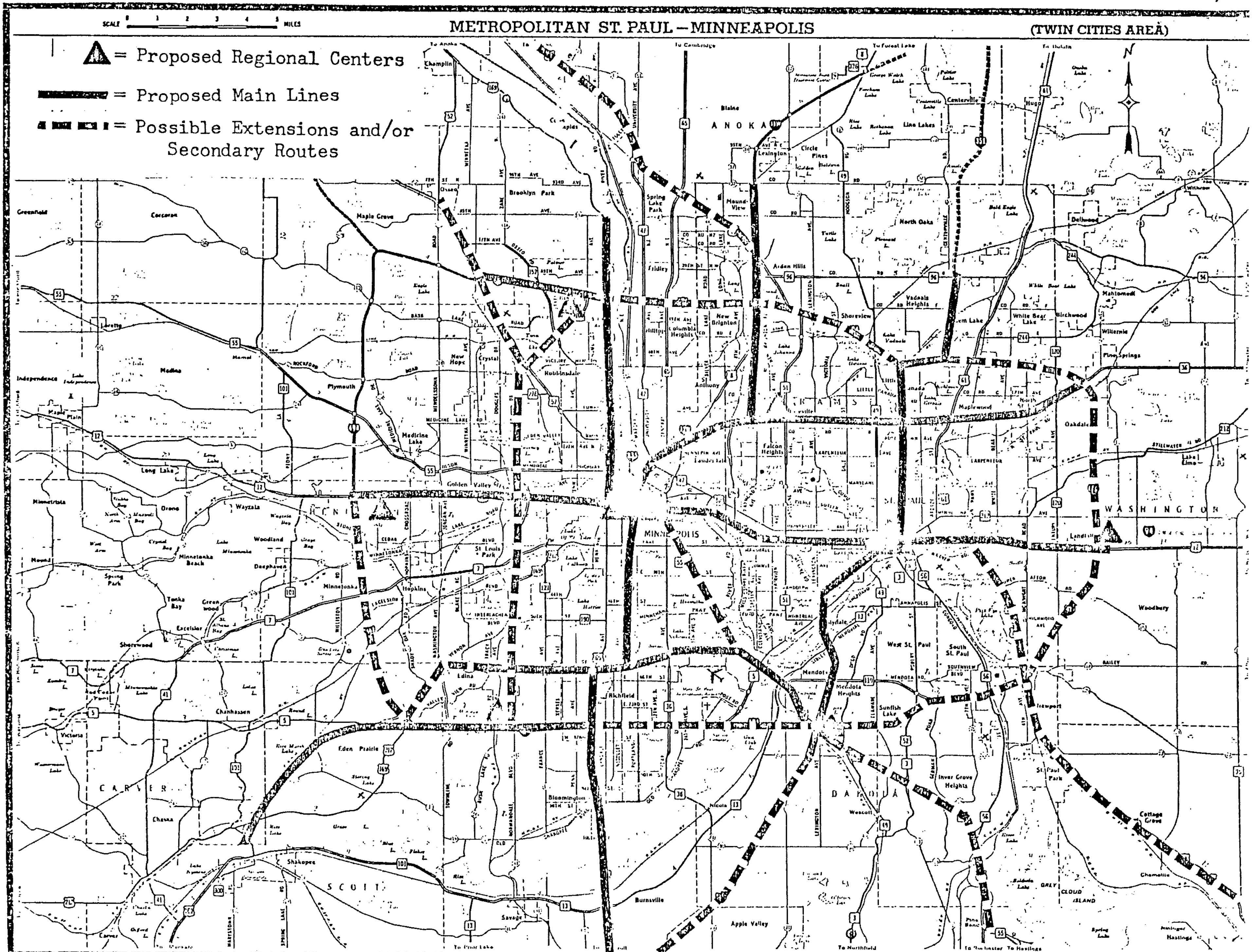

FIG. II BACKBONE BUS-FREEWAY SYSTEM

and shifts in travel demands. If the potential of the Bus-Freeway system is realized, mass transit needs can be met for many years until such time as exclusive ways are needed and/or new technology provides more appropriate means.

MAJOR SYSTEM ELEMENTS

In talking about a Surveillance and Control system and its ultimate development, we are talking about several interconnected sub-systems. These include:

1. Visual and electronic detection system
2. Ramp and arterial control system
3. Lane control system
4. Informational communications
5. Motorist services
6. Central computer and coordination center

The detection system consists of sensor units placed in the roadway at appropriate intervals. These sensors can provide data on volumes, speeds, and densities or lane occupancy, which is fed into the main control center. When congestion levels are imminent, appropriate controls are initiated and the entire network adjusted to optimize flow through the corridor. In addition, strategically located television cameras provide additional information on the cause of the congestion.

If congestion is about to develop, ramp controls can be activated to reduce input into the freeway so as to maintain optimum demand/capacity ratios. When arterial control systems are interconnected, the optimum corridor balance can be obtained by adjusting signal timing to accommodate diversion from the freeway. The reverse is also possible, i.e., allowing more traffic onto the freeway to reduce excessive pressure on arterial routes.

Lane control signals are used to assign vehicles to specific lanes in critical situations or to advise drivers of hazardous conditions. Applicable instances would be a lane blockage due to an accident or stalled vehicle, maintenance operations, and/or severe congestion.

Optimum corridor throughput can be achieved only if drivers comply with the controls and restrictions applied; whether it be on freeway traffic, arterial traffic or both. Toward this end, it would be desirable to communicate to the driver that information he needs to select the best route for himself. Communications would advise of flow conditions and/or hazards ahead, expected delays, and which route would be best to take. Arterial traffic destined for a freeway entrance would be advised of freeway congestion before he enters the ramp and becomes trapped. It is reasonable to assume that driver reaction and compliance will be greatest if he is told why he is not allowed onto the freeway and/or what his alternatives are so he can select his route himself. The Federal Communications Commission recently allocated four frequencies for future use in this type of communications system.

One hazard most unique to freeway driving is the sudden stop from high speeds because of accidents or congestion. The high speed, high volume flow is extremely sensitive to relatively minor disturbances, and consequently a sudden maneuver or braking action can result in violent disruption of flow. Most peak flow accidents are congestion related, either rear end, lane change or sideswipe type during sudden maneuvers to avoid slowed or stopped vehicles. During peak flow, any activity on the shoulder, whether it be a stalled car or a patrolman assisting at an accident, can result in a "gaper's block" and create untold hours of delay as well as secondary accidents. Similar activity during off peak hours is extremely hazardous to individuals involved in the stoppage and to high speed traffic approaching the scene. Whether it be peak hour or off peak, it is essential that stalled vehicles, accident involved vehicles, and accident debris be removed from the scene as soon as possible. At present, patrol staff levels are insufficient to cover each mile of freeway as frequently as would be needed to detect stopped vehicles immediately. Often, response time can be fifteen, twenty or more minutes to any given incident. If medical or emergency repair or fire fighting assistance is also needed, the call often is made after a patrolman arrives and more delay results. In the case of personal injury this delay could be fatal. For this reason, provision of motorist services on freeways is essential. The surveillance system used for the control network will also be used to detect accidents and stalled vehicles. The television system works to the greatest advantage at this time as the observer can immediately determine what response is needed, notify appropriate personnel, and activate appropriate signs to warn approaching traffic. Ideally, a Department owned fleet of emergency service vehicles would be added to the present Patrol force, along with a hot-line link to a HASTE force type medical team.

Because it is not feasible to monitor every lane mile of freeway by television, alternate methods of communication with drivers in need of services are needed. Presently, the most promising system being developed is a motorist aid call system of telephones or specific request panels located at frequent intervals, permitting a stranded driver to summon police, fire, medical or service personnel by lifting a phone or pushing a button. This system would do much to reduce the incidence of pedestrians on the freeway and stalled vehicles parked on the shoulder for several hours, thereby increasing the safety of all concerned.

Predates CB fad + Car phone systems.

The interdependability of the four subsystems requires the coordination and decision making ability of computers. It is anticipated that at most, two control centers will be needed, basically one for each side of the Mississippi River. Anticipated long term use would appear to dictate Department owned facilities, including communication links, supplemented by radio and leased telephone lines on the outlying links. It would also be advantageous to begin placing conduit for major bridge and roadway crossings during initial construction, rather than returning in two, three or four years and disrupting traffic in critical areas. Specific problem areas that can be anticipated at this time include the Hiawatha Interchange area, the Hawthorne Interchange area, the I-494-Minnesota River Bridge crossing, I-35W from T.H. 280 to the Hiawatha Interchange, the north Loop connector (I-335) and I-35E from E. 7th Street to the Capitol Interchange.

Synthesis of a Freeway Surveillance and Control System

It is anticipated that it will take a number of years to structure a complete metropolitan freeway surveillance and control system. The exact time table will depend upon transportation needs. Some of the significant steps in the formulation of the system are outlined below.

The first freeway surveillance and control system in Minnesota was experimental in nature, and consisted of basic equipment controlled by the most sophisticated computer available -- the human brain. This experiment was conducted for two weeks in the summer of 1969 and included ramp meter signals for the I-35E southbound on-ramps at Maryland Avenue, Wheelock Parkway, and Roselawn Avenue. The metering was considered a success and a recommendation was made to install permanent meter signals at Maryland Avenue and Wheelock Parkway to alleviate A.M. peak-hour congestion.

Permanent ramp metering signals for the I-35E southbound on-ramps at Maryland Avenue and Wheelock Parkway, and the I-35W southbound on-ramps at East 31st Street and East 36th Street were placed in operation in October, 1970. These systems are automatic with operation controlled by time clocks and pre-set cycles for metering based on historical data. It is anticipated that additional metering installations will be made as the freeway system develops and as problem areas are analyzed. The individual meters at isolated ramps will eventually be made traffic responsive, adjusting meter rates to optimize local flow conditions.

Another important surveillance and control system will be needed in the summer of 1971 when the I-94 Bottleneck Tunnel is opened to traffic.

It is anticipated that there will be a considerable number of accidents in this area due to the high traffic volumes, limited sight distance, and capacity constraints. A surveillance and control system is needed to warn motorists of traffic stoppages, advise of alternate routes, quickly dispatch emergency vehicles, and to permit maintenance work.

The target date for operation of the I-35W Bus-Demo project is late summer in 1972. A Bus-Demo feasibility study (5) conducted by the Texas Transportation Institute presented a preliminary design for the surveillance and control system including the following:

1. 275 Detector Installations
2. 29 Signal Installations
3. 10 TV Installations
4. Control Center
5. Control Equipment

This study indicated that the tentative location of the control center was immediately north of the common freeway section of I-35W and the Crosstown Highway in rented office space. Cost data were presented for transmitting data via leased telephone lines.

It is our feeling, however, that it would be more desirable and economical to construct our own control center on Minnesota Highway Department right-of-way, and utilize our own interconnect system, at least for the first several miles from the Center. The building for the control center should be constructed so that it could be expanded vertically. Since the I-35W and Crosstown Highway common section may be rebuilt in the future, we feel that it would be desirable to select another location, possibly in the Central Interchange area. This would provide a strategic location from which to branch out and include other systems, including the I-94

done

Bottleneck Tunnel system. Access to the control center could be via special slip-ramps, or the use of a pedestrian bridge.

Installation of the aforementioned systems should lead to a natural expansion of freeway surveillance and control to cover the entire Metropolitan Area in the future, as the need arises. The system would be built up ramp-by-ramp, corridor-by-corridor as dictated by traffic demands and transit needs. It is anticipated that the control center in the Central Interchange area would serve the system west of the Mississippi River. Another control center may eventually be needed east of the river to serve the St. Paul area. We feel that this center should be located in the Capitol Interchange area, possibly in the Highway Department Building or another state-owned building nearby.

no longer necessary

The scope of the surveillance and control system will have to be widened ultimately to more completely meet motorist's needs. At the final stage, the Metro Area Freeway Surveillance and Control System will include electronic detectors in each lane every one-half mile plus other critical system detectors, a system of entrance ramp controls, main line lane control signals in critical areas, closed circuit television surveillance in areas with high accident potential, motorist aid call system, a system of dispatching emergency vehicles, and a communications system by which motorists could be informed of flow conditions and optimum routes.

RECOMMENDATIONS

On the basis of findings from other states, our own experience to date with freeway surveillance and control, and the information presented in this prospectus, the following recommendations for an immediate course of action are offered:

1. Develop adequate Minnesota Highway Department staffing for design, operation, and maintenance of initial stages of the freeway surveillance and control system and for expansion as the need arises. It will be especially important to develop expertise in computer programming and operation, and electrical capabilities for system maintenance.
2. Initiate planning, legislative approval, and preliminary design of a building for the freeway surveillance and control center to be located on M.H.D. right-of-way, possibly in the Central Interchange area. It is imperative that action be taken quickly on this if the proposed turn-on date (late summer-1972) for the I-35W bus-demonstration project is to be met. done
3. Initiate review of all future construction plans (including bridges) for possible inclusion of duct work for freeway surveillance and control. done
4. Initiate review of geometrics in all future construction plans to insure adequate ramp storage, sufficient acceleration distance, and adequate sight distance for ramp metering. done?
5. Initiate a program of public information to a) educate drivers, and b) develop public acceptance of freeway surveillance and control.

REFERENCES

(1) A. D. May, "Freeway Surveillance and Control Systems in the United States", Traffic Engineering and Control, September 1970.

(2) Technical Report #3, "Development of a Long Range Transit Improvement Program for the Twin Cities Area, November 1969. A. M. Voorhees and Associates, Inc.

(3) J. R. Meyer, J. F. Kain, and M. Wohl; "The Urban Transportation Problem", 1965.

(4) J. C. Glennon; "Balanced Transportation Through Efficient Use of Existing Facilities," Traffic Engineering, August 1970.

(5) V. G. Stover and J. C. Glennon; "A System to Facilitate Bus Rapid Transit on Urban Freeways", Texas Transportation Institute, December 1968.