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Summary of Operational Characteristics and Anticipated Evaluation of I-66 HOV Facility

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In late 1982, the final section of I-66 in the Washington, D.C., suburbs in Northern Virginia was opened to traffic after a lengthy and controversial developmental process. The final product of that process is a four-lane, limited-access, parkway-type facility from which heavy-duty trucks are excluded at all times. Peak-period, peak-direction use is restricted to high-occupancy vehicles (HOVs), emergency vehicles, and vehicles bound to and from Dulles Airport. Finally, to maintain safe and efficient traffic flows on the facility, a comprehensive, computer-controlled traffic management system (TMS) will be installed. Basic elements of the system include closed-circuit television, ramp metering, motorist advisory signing, and interface with adjacent traffic signal systems. The Virginia Department of Highways and Transportation, with funding from the Federal Highway Administration, has undertaken a study of this section of highway. The objective is to evaluate I-66 and the HOV restrictions and the TMS. The results of the study will prove valuable in assessing the merits of the concepts used and in planning projects of this nature. A summary of the history, design elements, operational characteristics, and anticipated evaluation of the final section of I-66 is presented.

The approximately 10-mile-long section of I-66 between the Capital Beltway (I-495) in the Virginia suburbs of Washington, D.C., and the Potomac River was opened to traffic on December 22, 1982 (see Figure 1). Estimated to cost $300 million, the facility is heavily traveled by commuters to and from the nation's capital.

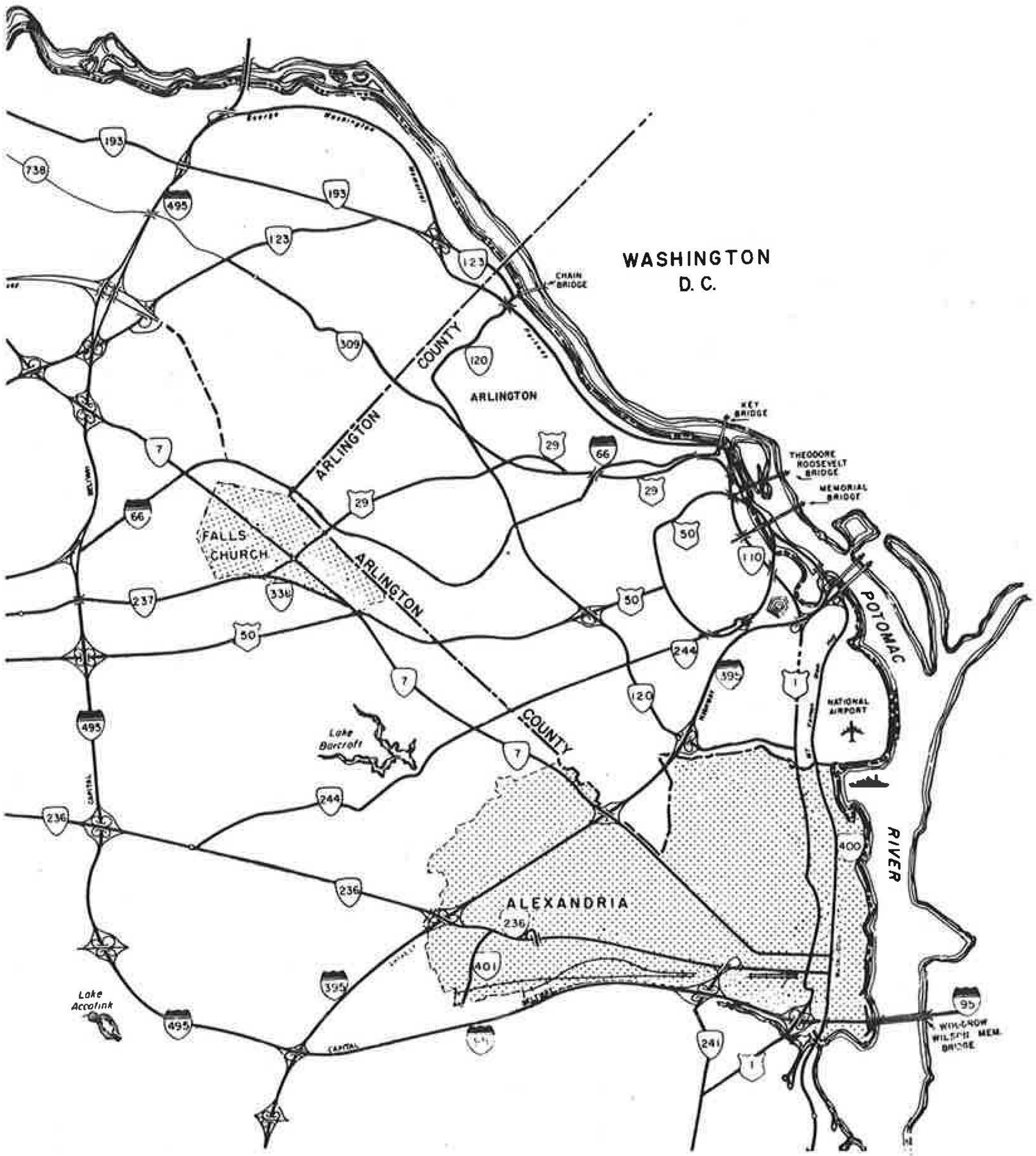
Considerable controversy has surrounded the project, which has evolved into a four-lane, limited-access facility. Heavy-duty trucks are excluded at all times, and high-occupancy vehicles (HOVs)--buses and vanpool and carpool vehicles carrying four or more persons--emergency vehicles, and vehicles bound to or from Dulles Airport are the only vehicles allowed on the facility in the peak direction during peak hours. A detailed plan to enforce these restrictions has been developed. Consideration has also been given to environmental issues in the design of the facility to ensure maximum compatibility with the surrounding area.

In addition, a comprehensive traffic management system (TMS) to control and facilitate the flow of traffic will be implemented by the spring of 1983. The elements of this system include an enforcement plan, ramp metering, closed-circuit television (CCTV), variable message signs, incident detection, lighting, and central control. The system will also be implemented on an existing segment of I-395 that contains the reversible HOV lanes. That segment extends from the vicinity of the Springfield interchange just south of the Capital Beltway to the District of Columbia (Figure 1). Both facilities will be under interim control by the TMS for approximately one year as the various elements are implemented. The TMS should be fully operational by early 1984.

The concepts being incorporated into these sections of I-66 and I-395 represent the most recent technology in traffic control and management and offer the potential for the most efficient use of the facility. Accordingly, the Virginia Department of Highways and Transportation, with funding from the Federal Highway Administration (FHWA), has initiated a study to investigate and evaluate the operation of the section on I-66 and the TMS on both I-66 and I-395.

In light of the national interest in the I-66 facility, this paper has been developed to (a) briefly recount the history of I-66, (b) describe the TMS to be used, and (c) outline the evaluation to be undertaken.

Figure 1. Location map.



HISTORY OF I-66

The planning of I-66 took place during a time characterized by a renewed interest in public transit, development of opposition in urban areas to large-scale freeway projects, and an increased concern for environmental quality (1). As a result, the design of that segment of the highway inside the Capital Beltway evolved from an eight-lane Interstate facility to a four-lane, multimodal corridor that uses state-of-the-art traffic control strategies and technology.

Evolution of Roadway Design

Initial Plans

The need for a high-capacity, east-west road linking Fairfax and Arlington Counties with the District of Columbia was first recognized in a 1938 study conducted by Arlington County. This need was reflected in the local zoning and land use policies adopted over the next 20 years to reserve a corridor for the road. Following creation of the Interstate highway system by the 1956 Federal-Aid Highway Act, this corridor was incorporated into that system.

Delays to Planning

Several developments between 1962 and 1970 delayed the final planning and construction of I-66 east of the Capital Beltway. Among these were the public controversy and litigation surrounding the Three Sisters Bridge/I-266 project that was to connect with I-66 and provide an additional Potomac River crossing. The protracted legal negotiations by local commuters seeking the continued operation of the Washington and Old Dominion Railroad, segments of which were proposed to be used for the I-66 right-of-way, also delayed the project. Finally, additional time was needed to coordinate the planning of I-66 and the Metrorail rapid transit system, since a transit line had been proposed for the median of I-66.

During this same period, new federal legislation and administrative directives were adopted that governed highway planning and construction and that affected I-66 specifically. Enacted in 1966, Section 4(f) of the Department of Transportation (DOT) Act prohibits the approval of projects that use parkland unless there is no "feasible and prudent alternative" to such use. The original I-66 design proposed the taking of portions of several parks for

right-of-way. In 1970, Congress enacted the National Environmental Policy Act (NEPA), Section 102 of which requires the preparation of an environmental impact statement (EIS) for major federal actions "significantly affecting the quality of the human environment".

Eight-Lane Concept

In 1968, the Washington Metropolitan Area Transit Authority (WMATA) adopted plans for construction of the regional rail rapid transit system that featured a rail line in the I-66 median. In 1970, public hearings on an eight-lane cross section for I-66 were held. In early 1971, the Arlington Coalition on Transportation, Arlingtonians for the Preservation of the Potomac Palisades, and several individuals filed suit in U.S. District Court, contending that federal and state highway officials had not complied with Section 4(f) of the DOT Act, Section 102 of NEPA, and Section 128 of Title 23 of the U.S. Code, which governs public hearings for highway projects. In October 1971, the District Court dismissed the suit, but on April 4, 1972, the U.S. Court of Appeals for the Fourth Circuit reversed the District Court's decision. The Court of Appeals enjoined further acquisition of right-of-way and construction for the highway until the Virginia Department of Highways and Transportation filed an EIS and determined, pursuant to Section 4(f), that there was no "feasible and prudent alternative" to the use of the parklands. The court also ruled that new public hearings had to be held to consider the social and environmental impacts of the project and the economic effects of the proposed location in light of the planned rapid transit service in the corridor.

In September 1972, the Virginia Department of Highways and Transportation, with FHWA involvement, initiated a study to consider alternatives to the I-66 proposal and to review the various anticipated impacts of the proposed facility pursuant to the decision by the Court of Appeals. The resulting draft EIS/4(f) was released in November 1973.

After consideration of the public hearing comments and the draft EIS, the Virginia Highway and Transportation Commission, on February 21, 1974, adopted a new multimodal facility concept that consisted of an eight-lane cross section with Metrorail in the median.

Six-Lane Multimodal Concept

In September 1974, FHWA requested that the Virginia Department of Highways and Transportation undertake additional efforts to alleviate the impacts of the proposed project. Consequently, the original proposal was modified to reduce the number of lanes from eight to six, and the roadway segment through the Spout Run Parkway area was redesigned. These modifications were submitted to FHWA for consideration by then Secretary of Transportation William Coleman. On August 1, 1975, Secretary Coleman disapproved the proposal.

Four-Lane Multimodal Concept

In response to the decision of the Secretary of Transportation, the Virginia Department of Highways and Transportation and FHWA developed a four-lane multimodal concept (2). A draft supplement EIS/4(f) was completed in June 1976, and public hearings were conducted in mid-July.

On January 5, 1977, Secretary Coleman issued a decision approving construction of I-66 between the Capital Beltway and Rosslyn, subject to the following conditions:

1. Provide, without cost, right-of-way in the I-66 median for construction of a Metrorail line and complete construction of the median to the point that rails can be placed by the WMATA at minimal construction expense;
2. Transfer from Virginia to WMATA funds previously allocated for the construction of I-266;
3. Restrict the use of I-66 between the Capital Beltway and the Potomac River in the peak direction and peak period to buses, carpool vehicles carrying four or more persons, emergency vehicles, and vehicles bound to or from Dulles Airport;
4. Exclude heavy-duty trucks (two axles, six tires, and larger) from the facility at all times;
5. Submit within 60 days a detailed plan for enforcing these traffic restrictions;
6. Do not construct any highway lanes in the right-of-way beyond the four approved;
7. Include design elements and other features intended to minimize and compensate for adverse social and environmental impacts and develop a facility, as far as possible, similar to the George Washington Parkway; and
8. Provide assurances that minorities and minority-owned enterprises will participate in all construction.

Construction of Project

Special Construction Features

Following Virginia Governor Godwin's acceptance of the conditions outlined in Secretary Coleman's decision, the Virginia Department of Highways and Transportation proceeded with the advertisement of the basic roadway construction projects. Construction began in the fall of 1977, and the roadway was opened to traffic in December 1982.

A number of unique practices were used to minimize the disruption caused by construction, including the placement of an information trailer near the project. An on-site environmental monitor was hired to review the contractors' construction practices and suggest corrective measures as needed. Extensive use was made of architectural and landscaping consultants in designing bridges, retaining and noise walls, and other features. A steering committee consisting of citizens from Arlington and Fairfax Counties reviewed the construction plans and made suggestions concerning the design of the roadway.

Multiple use of the corridor right-of-way includes a Metrorail line in the roadway median and a 10-ft-wide parallel bikeway. Surplus right-of-way has been used to create a 4.6-acre linear park, and an additional 10.5 acres will supplement existing parks. At Washington and Lee High School, a parking deck is being constructed over the roadway, and a pedestrian plaza is planned for Rosslyn.

Dulles Access Road Link

In conjunction with the construction of I-66, the Federal Aviation Administration (FAA) is constructing an extension of the Dulles Airport Access Road from its present terminus at VA-123 to I-66 east of the VA-7 interchange. When this segment is completed, traffic going to and coming from Dulles Airport will have a high-speed, limited-access link to downtown Washington, D.C., via I-66 and the Access Road (3).

With completion of the Access Road, traffic with legitimate business at Dulles Airport will be permitted on I-66 at all times. Maintenance of the four-person-occupancy requirement on I-66 for non-airport traffic will require a complex enforcement plan, which is described later in this paper.

Metro Service

During the construction of I-66, provisions have been made within the median to accommodate a Metrorail line. The "K-line" will run at-grade in the I-66 median from its western terminus at Vienna to Fairfax Drive. At Fairfax Drive, Metrorail leaves the I-66 median and continues underground through Arlington Court House, Rosslyn, and across the Potomac.

Four stations are being constructed in the I-66 median: The East Falls Church and West Falls Church Stations are east of the Capital Beltway, and the Vienna and Dunn Loring Stations are west of the Beltway.

Metrorail service as far as the Vienna Station will be initiated in 1986; in the interim, WMATA will operate feeder bus service in the I-66 corridor to the Ballston Station, which is currently the last stop on the K-line.

TRAFFIC MANAGEMENT SYSTEM

Concurrent with the letting of the roadway construction contracts, the Virginia Department of Highways and Transportation contracted with JHK and Associates for the preparation of the traffic enforcement plan required under condition 5 of the Coleman decision. In February 1977, the I-66 Traffic Management Concepts Report was submitted to and subsequently approved by the U.S. Department of Transportation.

The traffic control and management features recommended by the report to achieve these objectives include an enforcement plan, entrance ramp metering, CCTV, electronic surveillance, lighting, and computerized control (4). The report recommended that a similar traffic control system be implemented on Shirley Highway (I-95/I-395) to facilitate integrated traffic control strategies (5).

In April 1978, the Virginia Department of Highways and Transportation contracted with the firm of Howard, Needles, Tammen and Bergendoff, with Sperry Systems as a subconsultant, for the refinement of the traffic management concepts and the development of the plans, specifications, and estimates for their implementation (6). The functions of the elements found on both routes are discussed below.

Enforcement

Management of I-66 will require a complex enforcement strategy with permanent and changeable message signs that advise motorists of the restrictions in effect. A special contingent of state police will be assigned to the road to monitor compliance with the occupancy requirements, truck prohibitions, and ramp metering.

Enforcement areas have been constructed to assist in the identification and citation of violators. West of the Dulles Airport Access Road interchange with I-66, all traffic is subject to the occupancy restrictions, and the pull-offs are located on the main roadway.

East of the interchange, the roadway will be concurrently used during peak periods by Dulles Airport traffic and vehicles subject to the four-person-occupancy requirement. Thus, violators of the occupancy requirement cannot be identified on the main roadway and instead must be apprehended as they attempt to enter or leave I-66 at points other than the interchange. Enforcement areas are located at the I-66 eastbound entrance and westbound exit ramps for this purpose.

A related enforcement issue concerns elimination of commuter traffic that uses the Dulles Airport Access Road in violation of its stated purpose. Currently, eastbound commuters enter the Access Road via a westbound on-ramp, drive to the airport and make a U-turn, and then proceed eastbound to their ultimate destination. Because there is no way to distinguish between legitimate Dulles Airport traffic and "backtrackers" once they are on I-66, the illegal users of the Access Road must be identified before they enter I-66. FAA is studying a number of methods for discriminating between airport users and backtrackers, who constitute up to 50 percent of the peak-period Access Road traffic. The strategies under consideration are areawide electronic surveillance, license plate comparison with selective direct surveillance, and areawide police surveillance. FAA will implement a strategy for eliminating backtracking prior to completion of the Access Road extension to I-66 (7,8).

Ramp Metering

Entrance ramp metering will be instituted on 7 of the I-66 ramps and 20 of the existing I-395 ramps. Under the control of the TMS computer, the series of ramps will be treated as a system; individual metering rates will be set to provide a desired mainline level of service while entrance ramp delay and impacts on adjacent corridor arterials are minimized. Ramps will be placed under control by time of day, and metering will be initiated if the sum of the mainline and ramp demands exceeds a preset threshold. If metering is warranted at one location, it will be automatically initiated at all others in the same direction. Pretimed metering rates and manual override will be available in the event of system failure.

The ramp configurations to be used include standard single lane, high-volume single lane, and dual lane. More restrictive metering will be used at locations with sufficient storage space. All ramps will be equipped with queue spillover detectors. Because heavy Metrobus volumes are anticipated in the I-66 corridor prior to completion of Metrorail to Vienna, two I-66 ramps will have bus-bypass-lane configurations.

CCTV

CCTV will be used in the TMS to monitor ramp-metering operations and roadway use. Other applications include the observation of incidents, the verification of variable-message sign texts, and the confirmation of alarms generated by the detector-based systems.

Continuous surveillance will be provided on I-395 by 25 cameras mounted on high-level poles (approximately 50 ft in height) at 0.5-mile intervals. On I-66, the initial installation of 10 cameras will permit surveillance of the interchanges. Spare capacity for 9 additional cameras will be built into the system to permit continuous surveillance. At the control center, one monitor will be provided for each camera and video recorders will be used to retain the television images.

Variable-Message Signs

Disc-matrix variable-message signs will be placed at 9 locations on Shirley Highway and 19 locations on I-66 and on the major approach roads to both routes. The signs will be used to display regulatory information with respect to ramp metering and HOV use. In the event of major delays, advisory and route guidance information will be displayed on the signs located at the route selection decision points.

Incident Detection

Automatic vehicle surveillance and incident detection will be accomplished by using pavement induction loops located at half-mile intervals throughout both highways. The system will be used to determine existing traffic conditions, develop short-term predictions of variations from present conditions, and implement appropriate control strategies such as ramp control and motorist advisories in the event of major incidents. Other applications include providing system evaluation by means of various on-line measures of effectiveness and developing an historic data base for use in updating system parameters and for studies and planning.

Two incident detection arrangements will be used, depending on the volume of traffic. During periods of heavy to moderate flow, the detectors will continuously monitor the traffic density at each station. In the event that the detectors sense an increase in density at one location and a corresponding decrease at a downstream location, an alarm will be sounded at the control panel and an incident status page will be displayed on the control console CRT. Using CCTV, the operator will confirm the incident and implement the appropriate response mechanism.

During periods of light flow, information on incidents will be relayed to the control center by police on patrol, citizens band radio, etc. The system operator will enter the information into the system, view the appropriate television monitor to confirm the incident, and implement the response.

Once incidents have been detected and confirmed, the central control computer's advisory sign algorithm will determine the message to be displayed. Message selection can occur automatically as a function of currently measured traffic conditions or manually by operator intervention.

Direct radio and telephone links between the control center and state and local police, fire and rescue services, maintenance personnel, and towing companies will ensure quick response to incidents and short clearance time. Information concerning the incident will also be provided to local radio and television stations.

Lighting

The need for lighting and the type of lighting to be used on I-66 were established only after considerable study. Continuous roadway lighting will be provided to maintain safe and efficient traffic flows, to aid in the identification and removal of incidents, and to support the surveillance and control system.

On I-66, mainline lighting will be provided by 250-W, high-pressure sodium luminaires mounted in offset fixtures on 45-ft poles. The poles will be spaced 326 ft apart and set back 30 ft from the edge of the pavement. Lighting will also be provided on the I-66 bikeway, where 150-W, high-pressure sodium fixtures will be mounted on 15-ft poles at 165-ft intervals. On Shirley Highway, the existing mercury vapor luminaires will be replaced with high-pressure sodium fixtures to achieve lower lighting costs and increased illumination.

Central Control

Operation of the TMS will be based in a two-story building located on Virginia Department of Highways and Transportation property on Columbia Pike. Control equipment housed in the building will include a central processing unit, disk memories, a keyboard-printer, interactive CRT terminals, a card reader, a line printer, and magnetic tape drives. System operators will monitor a console consisting of panels for map control, video control, alarm and system control, camera control, and sign control.

Behind the console, a dynamic map display will use color-coded, computer-driven lamps to indicate the status of each detector station, metering signal, television camera, and variable-message sign. The map will also be capable of displaying the volume, density, and speed of traffic at each detector station.

The control configuration will consist of microprocessors at each roadside cabinet and a high-performance computer at the control center. Operator input may be through either the control panel or the CRT; those functions that require rapid operator response are incorporated in the control panel.

The center will be staffed by a systems engineer, two operators, two technicians, and one secretary. The contract for the system includes the development and administration of appropriate training courses for these personnel.

The system is designed to transmit and receive real-time data from the signal system control computers located in the adjacent jurisdictions.

Public Information Program

To familiarize the public with the operation and benefits of I-66 and the I-66/I-395 TMS, the Virginia Department of Highways and Transportation, with the cooperation of persons coordinating ride-sharing in the neighboring localities, has developed an educational and promotional campaign.

The goals of this program are to (a) inform motorists of the restrictions in effect on and the proper use of I-66 and I-395, (b) provide information on the operation and the positive attributes of the TMS, (c) supply accurate and timely materials to the media and the public so as to encourage further dissemination of information, and (d) encourage participation in existing and proposed ridesharing programs. Elements of the program will include a slide-tape presentation, newsletters, a call-in television program, free-standing exhibits, pamphlets, and radio and television spot announcements.

EVALUATION OF I-66 HOV FACILITY

In recognition of the uniqueness of the I-66 facility, the controversy surrounding its development, the modern technology involved, and the expected national interest in its operation, the Virginia Department of Highways and Transportation, with funding from FHWA, has initiated a study to evaluate the I-66 HOV facility and the TMS on I-395. This section of the paper describes the purposes and objectives of the study, the schedule for the study as governed by the I-66 project schedule, the data to be collected, and the anticipated analyses.

Study Objectives

Within the framework of the two goals of the study--evaluation of I-66 and the HOV restrictions and evaluation of the TMS--the following specific objectives were established:

1. Evaluate the operating characteristics of I-66 by determining (a) the use of the facility by automobiles, public transportation, bicycles, and pedestrians and (b) the efficacy of the enforcement plan in managing the truck restrictions, the peak-hour and peak-direction restrictions, and the ramp metering;
2. Evaluate the impacts of the opening of I-66

Table 1. General data requirements and period of data collection for each study objective.

Study Objective	Volume	Speed and Delay	Occupancy	Accidents	Neighborhood Attitude Survey	I-66 Transit and Carpool Survey	Modal Split	Survey of Bicyclists and Pedestrians	Incidents	Enforcement	Miscellaneous
Determine use of I-66	D	–	D	–	–	D	D	D	–	–	–
Determine effectiveness of enforcement plan on I-66	–	–	–	–	–	–	–	–	–	D/A	–
Determine changes in regional traffic patterns	B/D	B/D	B/D	–	–	–	B/D	–	–	–	–
Determine impacts of ramp metering on local streets	B/D/A	–	–	–	–	–	–	–	–	–	D/A
Determine environmental impacts	B/D	–	–	–	D	–	–	–	–	–	D
Determine reactions of media, local officials, and the public	–	–	–	–	D	D	–	–	–	–	D/A
Determine effectiveness of marketing and public information	–	–	–	–	D	D	–	–	–	D/A	D/A
Determine levels of safe, efficient traffic flows on I-66 and I-395	D/A	D/A	–	D/A	–	–	–	–	–	–	D/A
Determine effects of TMS on I-395	B	B	–	B	–	–	–	–	–	–	–
Determine efficiency with which incidents are detected and managed on I-66 and I-395	–	–	–	–	–	–	–	–	D/A	–	D/A
Determine effectiveness with which central control facility operates	–	–	–	–	–	–	–	–	–	–	D/A

Note: B = before opening of I-66, D = during interim control by the TMS, and A = after final control by the TMS.

and the improvements to I-395 by determining (a) the changes in regional traffic patterns, (b) the impacts of ramp metering on local streets, and (c) the impacts on energy consumption and air, noise, and light pollution;

3. Evaluate the local response to the opening of I-66 and the improvements to I-395 by determining (a) the reaction and attitude of the media, local officials, and the general public and (b) the effectiveness of the marketing and public information efforts; and

4. Evaluate the performance of the TMS on I-66 and I-395 by determining (a) the levels at which safe and efficient traffic flows are maintained, (b) the effects of the TMS on the operational characteristics of I-395, (c) the efficiency with which incidents are detected and managed, and (d) the level of effectiveness at which the central control facility operates.

Study Schedule

As suggested in the introduction to this paper, three periods of project development can be identified: (a) before the opening of I-66, (b) after the opening of I-66 but during interim control by the TMS, and (c) after final control by the TMS.

Data needed before the opening of I-66 were collected in the fall of 1982. To achieve the objectives of the study concerned with the evaluation of I-66 and the HOV restrictions and to discount seasonal variations, a second round of data collection is scheduled for the fall of 1983. Data for which seasonal variation is not a factor will probably be collected as soon as it is judged that traffic patterns have stabilized after the opening of I-66. A report will be prepared to document the findings of the first two rounds of data collection.

To attain the objectives concerned with the evaluation of the TMS and again to discount seasonal variation, a final round of data collection will be needed in the fall of 1984. A report that documents the findings concerning the TMS will be prepared.

Data Required for the Study

Table 1 summarizes the information to be collected for each objective. A description by study objective of the data to be collected or developed is given below.

1. Use of I-66--Volume, modal split, and occupancy data will be collected in the fall of 1983. A questionnaire survey of carpool, vanpool, and bus users will also be conducted, probably in the spring of 1983. Finally, counts will be made of the number of bicyclists and pedestrians using the bicycle trail.

2. Effectiveness of enforcement plan on I-66--Costs, personnel and equipment requirements, and the number of citations associated with the enforcement plan on I-66 will be obtained along with qualitative information concerning methodology, problems, changes, etc. Enforcement information will be collected during interim control and after final control by the TMS.

3. Changes in regional traffic patterns--Before-and-after volume, modal split, and occupancy data will be collected at 34 stations in Northern Virginia during the fall of 1982 and 1983. In addition, speed and delay data will be collected along all major radial commuter routes. The routes are located clockwise from VA-1 in the east to the George Washington Parkway in the north. Stations are located along these routes and range from sites outside the Capital Beltway to the Potomac River bridges.

4. Impacts of ramp metering on local streets--On-ramp volumes will be collected before implementation of the TMS on I-395 and during interim and final control by the TMS on both I-395 and I-66. Qualitative information concerning problems experienced at the metered ramps will also be obtained. Finally, a field inspection of each metered ramp in peak-period operation will be undertaken if deemed necessary.

5. Impacts on the environment--In addition to measuring fuel consumption and emissions on I-66, overall changes in the environs will be calculated from the before-and-after data. In addition, information on noise and light pollution will be obtained through a survey of neighborhoods adjacent to I-66 and from newspapers, citizens' groups, complaints, etc.

6. Reaction of media, local officials, and the public--Information on local reaction to the opera-

tion of and concepts involved in the highway improvements will be obtained through the I-66 user and neighborhood surveys, newspapers, citizens' groups, complaints, possible legal challenges, institutional problems, etc. This information will be collected throughout the study.

7. Effectiveness of marketing and public information--Information on the effectiveness of the marketing and public information campaign to inform the public of the operational characteristics of I-66 will be obtained from the I-66 user and neighborhood surveys, the level of compliance with the operating restrictions, and newspapers, citizens' groups, complaints, etc. This information will be collected throughout the study.

8. Safe and efficient traffic flows on I-66 and I-395--Traffic-flow conditions will be determined from the volume-to-capacity (V/C) ratios and speed and delay data on I-66 and I-395 during interim control and after final control by the TMS. Safety will be determined through the collection of accident data on both facilities throughout the last two periods of project development. Finally, qualitative information concerning the performance of the TMS elements will be obtained.

9. Effects of TMS on I-395--Unlike I-66, which is a new facility, the segment of I-395 on which the TMS will be installed is an existing roadway; therefore, a "before TMS" phase exists. Accordingly, V/C ratios, speed and delay data, and accident data were collected for I-395 in the fall of 1982.

10. Incident detection and management on I-66 and I-395--Information for interim and final TMS control concerning the detection of, response to, and management of incidents on the facilities during the week will be generally qualitative; however, elapsed time between the incident, detection, response, and management of the incident will be obtained where possible. Again, qualitative information on the performance of the TMS elements will be obtained.

11. Operation of the central control facility--Qualitative information for interim and final TMS control will be used to evaluate the control center's operation. Items such as repair records, repair costs, operating costs, and equipment failures will be documented when possible.

Anticipated Analyses

Following is a description by study purpose of the major analyses to be undertaken initially. As the study progresses and these analyses are performed, there may be a need for additional analyses.

Operating Characteristics of I-66

A description of the use of I-66 will be developed. In addition to determinations of daily, peak-period, and peak-hour traffic volumes, profiles of hourly volumes will be developed for the average weekday, Friday, Saturday, and Sunday at four stations along the facility. The profiles will also be developed for the on-ramps. The modal split between automobiles and buses will be determined for the morning and evening peak periods and peak hours at the four stations. In addition, automobile and transit occupancy rates will be calculated for each of the two peak periods and peak hours. A summary of the use of the bicycle trail will be developed from counts at five locations. Finally, a questionnaire survey of peak-period carpoolers, vanpoolers, and transit riders will make it possible to develop a profile of the I-66 user, including socioeconomic characteristics, trip characteristics, prior mode and route used, and opinions on unique aspects of the roadway.

Impacts of I-66

Changes in regional traffic patterns for an average weekday will be evaluated by comparing peak-period and peak-hour volumes, modal split, and occupancy at 34 stations located along 11 major radial commuter routes before and after the opening of I-66. In addition, before-and-after travel speeds along these radial routes will be compared. Before-and-after volumes at the on-ramps to both I-66 and I-395 will also be compared to determine possible diversion and impacts on local streets caused by ramp metering.

Finally, environmental impacts will be measured by calculating before-and-after emission and fuel consumption statistics at the 34 stations or along the radial routes, as appropriate, for the average weekday during peak periods and peak hours. Changes will be noted. In addition, a questionnaire survey in neighborhoods adjacent to I-66 will solicit information on the noise barriers, lighting, and general impacts of I-66.

Local Response to I-66

Information on local reaction to I-66 and on the effectiveness of the marketing and public information campaign obtained through the means previously mentioned will be reviewed, analyzed, and summarized.

Performance of TMS on I-66 and I-395

The performance of the TMS will be measured by calculating V/C ratios during peak and off-peak hours at locations along the two facilities and comparing them with acceptable ratios. Average speeds during peak and off-peak hours will be calculated and compared with acceptable speeds. Finally, selected accident statistics will be calculated for comparison with typical accident levels. In the case of I-395, the statistics cited above will be developed for the facility prior to the installation of the TMS so that a before-and-after performance evaluation can be made.

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Peak-Period One-Way Operation of an Urban Expressway

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The evaluation of an experimental urban traffic control strategy designed to reduce recurring congestion on the Arlington Expressway in Jacksonville, Florida, is described. The 60-day experimental project involved the daily conversion of a 2.8-mile section of the expressway to one-way operation toward the downtown area during the morning peak period and one-way operation out of the downtown area during the evening peak. The one-way operational plan, which provided temporary additional capacity for the peak direction, was developed by the Jacksonville Traffic Engineering Department and approved for implementation by the Florida Department of Transportation (FDOT). The effectiveness of the one-way strategy was measured by using before and after studies. The primary objectives of the evaluation were to identify existing points of congestion and quantify the delay incurred, to measure travel-time savings realized by motorists who used the one-way operation, and to compare user benefits with the negative effects experienced by motorists forced to divert to alternative routes. The results of the before study identified a four-lane bridge (Mathews Bridge) as the primary capacity constraint for peak-period traffic entering and leaving the downtown Jacksonville area. The one-way operation, in effect, doubled the capacity of this bridge to serve the peak directional flow and eliminated the recurring congestion that had developed on its approaches. During the morning westbound one-way operation, stopped delay at the Mathews Bridge toll plaza was reduced 78 percent in the peak half-hour. During the evening eastbound operation, average running speed on the expressway improved by 56 percent. Motorists entering and leaving the downtown area opposite to the peak directional flow experienced increased trip length and travel time as a result of the requirement to use alternative routes, but these increases were not unreasonable. Analysis of the systemwide impacts on fuel consumption showed a marginal net benefit. After the evaluation, FDOT approved indefinite continuation of the one-way strategy.

In July 1981, the Jacksonville Transportation Authority (JTA) and the Jacksonville Traffic Engineering Department approached the Florida Department of Transportation (FDOT) with a plan for easing morning and evening traffic congestion on the Arlington Expressway, a four-lane, limited-access facility that links downtown Jacksonville with residential areas located to the east across the St. Johns River. The plan involved daily conversion of a 2.8-mile section of the expressway to one-way operation toward downtown during the morning peak period and one-way operation out of the downtown area during the evening peak.

The FDOT acknowledged the need to improve peak-period conditions on the expressway and recognized the potential for a low-cost, high-benefit freeway management strategy that would be of widespread interest should the concept prove to be successful. Accordingly, FDOT approved an experimental demonstration period of 60 days, during which an evaluation of the one-way operation would be conducted. The Research and Studies Section of the FDOT Bureau of Traffic Operations was assigned the responsibility for developing and implementing the evaluation. This paper documents the results of that study.

The material presented here primarily addresses the impact on those traffic operational characteristics that could be satisfactorily measured through comparative studies conducted in the weeks just before and during the 60-day experimental period.

ONE-WAY OPERATION

Project Location

Downtown Jacksonville is located in the central portion of Duval County and is situated on the St. Johns River, which separates the downtown area from numerous suburbs to the east and southeast. A total of five bridges span the river within a distance of 4 miles (see Figure 1).

The Arlington Expressway is an easterly extension of State and Union Streets, which are prominent one-way arterials that accommodate downtown travel in the westbound and eastbound directions, respectively. The expressway is designated as Alternate US-90 and FL-10A. Full control of access on the expressway begins at Liberty Street and extends eastward over the river by way of the Mathews Bridge to Southside Boulevard, a total length of 5.7 miles. Located at the eastern terminus of the Mathews Bridge is a toll plaza at which motorists crossing the bridge in either direction must pay the required toll.

On the west side of the river between Liberty Street and the Mathews Bridge are three interchanges. Two serve low-volume surface collectors in residential areas on the fringes of the central business district (CBD), and the third provides a connection to Alternate US-1 and Haines Street. Haines Street provides access to Jacksonville's Gator Bowl and the surrounding riverfront industrial area. Alternate US-1 south of the Haines Street interchange becomes the Commodore Point Expressway and crosses the St. Johns River via the Isaiah Hart Bridge, located approximately 1 mile south of the Mathews Bridge. Like the Mathews Bridge, the Hart Bridge is a toll facility and has a similar toll schedule.

On the east side of the Mathews Bridge, there is a major interchange at University Boulevard, approximately 1100 ft east of the toll plaza. Between University Boulevard and Southside Boulevard, the Arlington Expressway is flanked by frontage roads with slip ramps that provide ingress and egress. Only two additional north-south streets, Cesery Boulevard and Arlington Road, provide connections between areas separated by the expressway on the east side of the river.