FREEWAY AND ARTERIAL INTEGRATED CONTROL SYSTEM

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16. ABSTRACT

A computer system was developed to integrate three pre-existing traffic control systems. These three systems were the traffic signal systems on SR-99 and SR-522 in northern King County and the freeway ramp metering system (FLOW system) on Interstate 5 north of the Seattle central business district. This project continued previous WSDOT research, described in the report "Arterial Control and Integration, Final Report," 1990.

The integration system developed in this effort consisted of a single microcomputer that communicated with both the mini-computer that operated the FLOW system and the microcomputer through which an operator controlled both arterial signal networks. To minimize development efforts and costs and to demonstrate the potential for adding integration capabilities to traffic control systems, the integration system relied extensively on the control systems' existing capabilities.

Tests of the integration system produced mixed results. The basic system design was flexible and met the needs described in the earlier WSDOT report. The control system also showed that it can use the data collected by one control system to adjust the control strategy of another, independent system. Unfortunately, the integration system was not a complete success and therefore was not implemented by WSDOT. The integration system suffered from unreliable inter-computer communications. The communications difficulties were caused by "off-the-shelf" computer networking software that was not sufficiently fault tolerant for real-time control system applications. That is, the integration system experienced intermittent communications failures between the control system computers. These failures disrupted system operation, and that disruption could have significantly degraded traffic operations. A system operator was able to easily fix the communications failures, but the integration computer could not automatically handle them.

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CHAPTER 1

INTRODUCTION AND RESEARCH APPROACH

Traffic congestion is a growing concern in today's urban environment. Metropolitan areas face increasing demand on freeway and arterial networks that already operating at or near their capacity. With resources for providing major capacity improvements declining, the focus of the traffic engineering profession is turning towards ways of managing congestion to ensure maximum efficiency from the existing road network.

A significant part of this management effort relies on computerized traffic control systems to smooth the flow of vehicles traveling both freeway and arterial systems. The increasing computational power available from microcomputers and advanced electronics presents an opportunity to significantly increase the effectiveness of these control systems.

Unfortunately, the power of the electronic devices is often limited by the manner in which they are implemented. Traffic control systems often operate independently. Each traffic control system looks only at traffic volumes and conditions within its boundaries, rather than also considering the effects of traffic volumes and conditions from nearby areas that may significantly affect how that control system will soon have to operate. For example, traffic control systems in City A are not aware of traffic congestion problems occurring immediately to the north in City B. As a result, the traffic plans selected by the automated control systems in City A are not optimal for the conditions in the region of both cities A and B.

Traffic congestion (or its effects) often crosses jurisdictional boundaries, but traffic control systems usually do not extend across those boundaries. To address this problem, engineers are carefully looking at traffic management solutions that are regional in scope, rather than jurisdictional. One potential solution is to integrate traffic management systems that currently operate independently. This project looked at one method for performing that integration. It also developed and tested a low-cost system designed to work in conjunction with the traffic control systems that jurisdictions currently operate within the state.

BACKGROUND

Traffic congestion can be classified as either recurrent or non-recurrent. Recurrent congestion is routine congestion that occurs when demand regularly exceeds the capacity of a roadway section. These reductions in capacity, otherwise known as bottlenecks, are typically due to physical impediments such as freeway interchanges, traffic signals, and lane reductions. This type of congestion can be addressed by measures that include

- controlling the volume of traffic entering the bottleneck area with methods such as ramp metering;
- optimizing the performance of the section by coordinating adjacent traffic signals; and
- removing the bottleneck through design improvements or flow re-routing.

Non-recurrent congestion is caused by temporary reductions in facility capacity. These temporary reductions are primarily due to incidents, short-term construction, or maintenance activities. Estimates are that as much as 60 percent of all urban congestion can be classified as non-recurrent. [1]

When non-recurrent congestion occurs on a facility, a portion of the regular demand for that facility may be diverted to neighboring parallel facilities. This diversion may occur when traffic is physically detoured to an alternative route; traffic information is provided to drivers, allowing them to make their own route determination; or unhappy drivers look for an alternative route. Factors that influence drivers' decisions to use an alternative route include the following:

- the intensity of the congestion,

- the anticipated duration of the incident,
- the perceived travel time benefits of using an alternative route, and
- the availability of the congestion information to the driver.

When traffic diversion does occur, it places additional, unanticipated demand on the alternate facilities. This demand often causes congestion to form quickly on these neighboring facilities. If information regarding an incident, along with the resultant traffic conditions, could be shared among the operators of neighboring facilities, control strategies for these systems could be altered to accommodate the anticipated increase in demand. As a result, control decisions could be made before the demand reached the neighboring facilities, reducing the impacts on these systems.

With the advent of the microprocessor, the operational capabilities of traffic control equipment have expanded considerably. System control and monitoring capabilities, which in the past required extensive mainframe computer hardware, are now commonly available in microcomputer formats. The result has been the availability of "closed loop" systems to all operating agencies, regardless of size or budget.

The widespread use of these systems has given traffic engineers the ability to better optimize the operation of traffic signal control systems on localized arterials or networks within their immediate jurisdictions. However, to provide area wide control, traffic control systems may have to be coordinated across jurisdictional or local system boundaries. Where the bordering agencies or systems happen to utilize common control equipment, coordination can be easily accomplished. However, where dissimilar control equipment is used, the respective operators are typically limited to real-time information from within their own jurisdictions.

Under the latter circumstances, the capability for area wide control is limited, and control decisions are often based on historical trends, eliminating any response to non-recurrent conditions. This inability to exchange traffic information across control system boundaries, while limiting the operational capabilities for all parties, also prevents jurisdictions from sharing the traffic performance and control information that is so readily available with these enhanced systems. This project is designed to address these limitations in modern traffic control systems.

PROJECT OBJECTIVES

This project had three primary objectives. The first objective was to define the structure of existing traffic control systems to determine the methods that might be appropriate for developing a bridge between independent control systems. Issues that were addressed included the limitations/obstructions in achieving this link, the institutional barriers that would have to be overcome, and whether the idea of control system integration is a practical concept to pursue.

Assuming the results obtained from the first objective were favorable, the second objective was to develop a demonstration system that would integrate multiple, independent control systems. This stage of the project addressed issues such as the recommended capabilities of the system, the recommended level of control, and the persons to be responsible for operating the system.

The third objective of this project was to evaluate the effectiveness of the integration system. This stage identified measures of effectiveness for evaluating the benefits provided by implementing the integration system. These measures were then used in an evaluation of the test system.

REPORT ORGANIZATION

Chapter 2 of this report presents background information on the current state-of-the-art in traffic control systems and the potential for integrating these systems. Information obtained from published literature, discussions with state and local jurisdiction staff, and the project team's work experience helps define the environment into which a low cost, integrated control system must fit.

Chapter 2 also includes a discussion of the capabilities of existing traffic control systems, the potential benefits of integrating these independent control systems, several methods for achieving system integration, and a description of, and the rationale for, the method selected for use in this project's demonstration system.

Chapter 3 describes the transportation network in which this demonstration system was applied and how traffic on these facilities interacts. It also includes a complete description of how the existing traffic control systems function.

Chapter 4 discusses the basic design of the demonstration integration system. This section also provides a detailed description of the integration program, including the structure, the individual system components, and communications requirements.

Chapter 5 focuses on the implementation of the demonstration system. This chapter discusses the problems that were encountered during the implementation process and examines the traffic data the system utilizes. A discussion of the inter-facility traffic flow relationships is also included.

Chapter 6 presents different methods for evaluating the effectiveness of integrated control systems. Included is a discussion of how the goals/purpose of implementing a system of this type can be related to the type of measures of effectiveness (MOEs) necessary to evaluate its effectiveness. The results of computerized simulations, conducted to measure the benefits that would be provided by the integration system, are also discussed.

Chapter 7 presents the conclusions drawn from this demonstration project, recommendations for future work in this area, and recommendations for persons or agencies that wish to develop a similar system in other areas of the country.

The appendices to this report comprise the system specifications for the control system, a recommended modification to the NEMA traffic controller standard to improve jurisdictions' ability to integrate closed loop traffic control systems, and the results of the simulation runs used to estimate the impacts of system integration.

RESEARCH APPROACH

This project consisted of the following six tasks:

- develop an evaluation framework,
- collect before data,
- develop a control algorithm (including software),
- implement and adjust the algorithm,
- evaluate the system, and
- write the report.

Additional work relevant to this project was completed during previous WSDOT research. The WSDOT research report "Arterial Control and Integration, Final Report," March 1990, [2] was invaluable to this project because it described the basic functional model on which the design of the integration system developed in this project was based. Thus, the primary new intellectual work of this project, the design of the integration software and hardware system, took place in Task 3.

The initial evaluation plan for the integrated system, developed under Task 1, consisted of a significant amount of data collection, followed by a careful statistical analysis of the changes in traffic flow produced by the integration system. Problems with system implementation (See Chapter 5) prevented the project team from carrying out the intended evaluation. Instead, the evaluation relied on simulation to estimate the effects of the integration system. The evaluation methodology is described in more detail in Chapter 6.

The integrated control algorithm was developed to run in a microcomputer based, traffic control environment. It was designed to require the smallest number of changes to existing traffic control systems by making use of the existing data collection, communications, and command functions of those traffic control systems. The new system was also designed to be sensitive to the needs of local jurisdictions, so that if the system were expanded to non-WSDOT facilities, the participating jurisdictions could maintain a high level of control over their traffic control systems.

The fourth task of the project included the installation of the integration system on WSDOT hardware. Once it had been installed, the system was tested under field conditions. These tests included collecting real-time data from the control hardware located in the field, but traffic control system messages were sent to a dummy traffic controller, rather than to the controllers in the field. In this fashion, the project team was able to test the functioning of the system without errors in the system creating problems with the control strategies WSDOT actually implemented.

Because problems with the long-term reliability of the computer network (see Chapter 5, Implementation) could not be resolved, the integration system was not fully implemented in the field. This significantly affected the evaluation plan for the project, which was changed to reflect the lack of a fully functioning integration system. The final evaluation framework reflected this limitation, and consequently relied heavily on simulation of the integration system. These results are presented in Chapter 6 and are summarized in Chapter 7, Conclusions and Recommendations.

CHAPTER 2

REVIEW OF TRAFFIC CONTROL SYSTEMS AND SYSTEM INTEGRATION

Spurred by the rapid development in microcomputer technology, the state-of-the-art in traffic control systems has advanced rapidly over the last 15 years. Microprocessor technology has allowed significant advances in this field, particularly in terms of system capability, system structure, and affordability. The last item has resulted in widespread availability of advanced traffic control systems for agencies of all sizes. Many of the system capabilities found in today's microcomputer-based systems were previously too costly for many medium to smaller agencies. System capabilities, which in the past required the installation of costly mainframe computer hardware, can now be found on systems designed around desk-top microcomputers, which can be purchased at a fraction of the cost.

The miniaturization of computer hardware components has allowed intelligence within the control system to be redistributed. A review of past and present system structures reveals little change in the physical placement of control system components. However, the capabilities, and as a result, the functions of the individual components have changed significantly. Past and present system hierarchies, as well as the typical capabilities found in today's micro-based traffic control systems, will be discussed in the following sections of this chapter.

Traffic control systems are typically related with arterial traffic signal systems. In the past this association was likely to be correct. Presently, however, this designation refers to a variety of devices used not only to allocate right-of-way, as in the case of a traffic signal installation, but also for freeway demand management. In the latter case, these systems are used for monitoring traffic conditions, both visually and from a data collection standpoint; facility access control; and providing real-time motorist information in the form of changeable message signs, highway advisory radio, or even in-vehicle, computerized information systems.

CONTROL SYSTEM STRUCTURE

This project dealt with two distinct applications of traffic control systems. The first was the traditional application of an arterial traffic signal control system. This project involved two such arterial systems. The second application was a freeway monitoring and control system. In either case, the project dealt specifically with the control of general vehicular traffic on facilities whose operations are managed by these systems.

While these two systems seem considerably different in application, their architectures are similar. This appears to be the case in most traffic control systems.

In past and present systems there are typically two, and in many cases three, levels of supervision or control. In the three-level approach, the system architecture typically consists of an on-street, location specific level of control (local controller); an on-street, sub-system, supervisory level of control (on-street master controller); and an off-street, multi-system, supervisory level of control (system central computer). The two-level approach typically omits the on-street level of control.

Past System Task Distribution

In past systems, local control consisted of a controller (electro-mechanical or solid state) with limited control capabilities. This component was located at each control site (intersection, freeway ramp). The extent of this level's capabilities was typically confined to a pre-defined, often fixed time, mode of operation. In many instances, the controller component operating at this level was used predominantly as a "dumb" terminal, and the controller acted merely as an interface unit between a higher level of control and the on-street display equipment.

The on-street, master level of control provided most of the enhancements to the system operation. This component provided communications to each of the local control units operating within the system or sub-system. The on-street master controller often held timing plan parameters for each local controller, as well as the schedule that dictated when individual parameters were to be implemented.

The system central computer typically provided a remote means of system monitoring. Many past systems required a direct line of communication between this system component and the on-street components. The central system computer gave the operator the ability to monitor system operations in real time, access on-street databases, and upload and store system data. Many past systems also utilized the central system computer to perform the tasks of the on-street master. In this case, all system timing parameters were held by the central computer. Upon implementation of a specific control plan, the central computer would download all necessary timing parameters to the respective on-street control equipment.

Present System Task Distribution

The architecture of present control systems follows that of past systems. However, because of the enhanced capability of the individual components, the distribution of tasks has changed.

The level of control most affected by this new distribution is the local controller. In the current arrangement, the local controller contains most all timing parameters. The advantage of this is that the system is less dependent on communications between the various levels of control. In past systems, if communication between two levels of control was interrupted, many of the system capabilities became inoperable. Because of the limited capabilities of the on-street components, no method was typically available to provide system redundancy.

In current systems this redundancy is not needed. In most cases all capability necessary to continue on-street system operations is contained in the on-street components. However, in some cases a decision about a particular plan or strategy and when to implement it is made by a higher level of control. Then this capability is lost during a communications failure. Fortunately, each level of control typically contains a back-up implementation schedule. In the case of a communications failure, the affected level of control has the ability to detect the failure and revert to back-up operations.

Control System Components

The components utilized by each control level can vary considerably, depending upon individual control system design. This is particularly true in the case of the off-street level of control.

The central system computer represents the least "standardized" component of the control system. This component consists of a computer system that may range in size and capability from a desk-top microprocessor to a large mainframe computer. The software used by this component, particularly in the case of freeway control systems, is typically written for the specific installation. For arterial systems, many "off the shelf" programs can be purchased along with the other control level components. Factors that seem to impact equipment selection for these off-street components include the desired control and display capabilities, communications requirements, and the number and location of system operators.

The on-street, local control component is typically the most standardized component of the system. The primary element of this component is the controller. The controller is a microprocessor-based unit that receives field input (typically from vehicle detectors), as well as commands from higher control levels, and transmits output to field displays and higher control levels. In the case of arterial systems, two distinct types or models of controllers are commonly available--those that conform to the traffic signal controller specifications of the National Electrical Manufacturers Association (NEMA) and those that conform to FHWA Type 170 hardware specifications. From an operational standpoint, the principle difference in these two systems lies in the distinction or separation of the system hardware and software. In the NEMA control systems, hardware and software are integrated to form a single control unit and thus are not separable. As a result, a specific model of NEMA controller must be purchased to provide particular capabilities or for certain applications. By contrast, in a Type 170 control system, system hardware and software are separable. Thus by changing the operating software, the same system hardware can be utilized for a number of control applications.

Freeway control systems typically utilize either Type 170 controllers with customized software, or custom built controllers designed by NEMA manufacturers that conform to NEMA specifications.

The on-street, sub-system control component (on-street master) typically consists of a controller similar to the local controller. A Type 170 on-street master controller utilizes the same hardware as the local controller and a software program specific to the application. For the multiple levels of control to operate as a system, communications among the different levels must be established. The control components facilitate system communications by utilizing standard communications media (twist pair copper conductors, leased telephone lines, co-axial cable). This need for communications among the various control components is often the deciding factor in the selection of control equipment for system upgrades and modifications. No standards dictate the use of specific communications protocols. The result is unique communication protocols for each manufacturer's control system and little or no communications capabilities between equipment of different manufacture. This fact limits the selection of control equipment by users who have already invested in and implemented a control system. [3, 4, 5, 6, 7]

INTEGRATED CONTROL SYSTEMS

The difficulty in providing a link between independent control systems is caused by communications. As mentioned earlier, each control system typically comprises multiple levels of control, which provide a hierarchy of information exchanges. Because there is no recognized standard for providing communications among these control levels, each manufacturer has developed its own methods, at its own cost. This development represents a considerable investment for each of the equipment manufacturers, so they seldom publicize the information necessary to make dissimilar equipment compatible. The result is the inability of different brands of control system components to communicate directly with one another, hampering integration of control systems.

This problem is being addressed by others in this field in several ways. In one approach, developers have built custom systems that communicate with common protocols. In this type of arrangement, the development of all the software components of each system level is based upon the specifications of the operating agency. This procedure allows the communications compatibility issue to be addressed in the development stage of system design.

An example of this type of system is the INFORM System. This system, under refinement by the New York State Department of Transportation, integrates the operation of the state's freeway control system, several arterial signal control systems, and the state's motorist information system. In the total system, all components are custom built under specifications developed by the state, and thus the communications aspect is addressed. [8]

Another method of integrating systems is to develop specifications for providing communications among the various control components and persuade the manufacturers of these control components to modify their systems to meet these specifications. This approach has been used in the development of the MIST System.

The MIST System (Management Information System for Traffic), developed by Farradyne Systems, Inc. (FSI) in conjunction with Traffic Control Technologies (TCT), specifies the communication methods to be employed by each component. The MIST system is essentially the third level, or off-street component, of the control system. The MIST component is designed to communicate directly with the on-street, local control component. In this system the on-street master component is not used. Because TCT is a controller manufacturer, there was no problem in establishing communications to its components. It has also been successful in establishing communications with three other models of control equipment. [9]

INTEGRATION BENEFITS

In past signal control systems, the ability of signal controllers to collect and store traffic data was either very limited or nonexistent. Traffic signal controllers were motor driven devices that allocated green time to each movement in a pre-determined pattern, without the use of vehicle detectors or sensor inputs. In these systems no data were available to collect or share.

As computer technology has advanced, so has traffic signal control technology. With today's signal control systems, the operator has an assortment of capabilities at his or her disposal. However, these capabilities remain within the confines of each system, without the mechanism necessary to enable the data to be exchanged.

There are significant benefits to developing a system that provides these information sharing capabilities. They range from simply providing a mechanism for transferring traffic information between different jurisdictions or different sections within the same agencies for record keeping purposes, to providing centralized monitoring and control capabilities for corridor or region-wide control. If this integration system were to provide real-time data exchange capabilities, traffic data from one system could be used to determine control parameters on another system. Where arterials crossed control system boundaries, control system data could be exchanged to enable coordinated operation of these independently operated facilities.

INTEGRATION SYSTEM CONSIDERATIONS

The Seattle area comprises many local jurisdictions. Within their geographical boundaries, the responsibility for traffic signal operations is commonly retained separately by each of the jurisdictions. There are exceptions to this condition, the most common being near Interstate 5. Within the limited access boundaries of Interstate 5, all maintenance and operational responsibility lies with the Washington State Department of Transportation (WSDOT). Traffic signals located at freeway ramp terminals lie within the limited access boundaries and thus are operated by WSDOT.

In a previous stage of this project, representatives from the various local agencies were contacted and questioned regarding their interest in traffic signal control system integration. In summary, most agencies were interested in receiving traffic data and control information from neighboring traffic signal systems in an automated, or "on-line," fashion. Interest, however, decreased when the discussion turned to a regional supervisory system that would provide control over their individual signal systems. Jurisdictional autonomy and control was a common concern. Where arterials crossed jurisdictional boundaries, the ability to know and exchange coordination plan information among the operating agencies was considered desirable. However, the agencies felt that control plan development and implementation decisions should be left to the agency directly responsible for the operation. Many of the agencies responsible for roads near Interstate 5 and Interstate 405 indicated an interest in the ability to receive traffic information from the WSDOT freeway management computer. [2]

CONTROL EQUIPMENT CONSIDERATIONS

In meeting their responsibility for providing traffic signal operations, different jurisdictions and local agencies often develop preferences for specific types or vendors of traffic signal control equipment. These preferences may develop from past experiences with particular products, from the desire for uniformity for maintenance purposes, or from a commitment to provide area or agency wide control and monitoring capabilities. As discussed in the preceding chapter, the operational capabilities of most current traffic signal control equipment are similar among the various makes and models; therefore, equipment features do not necessarily dictate the selection process, and a variety of similar but incompatible control systems are in place.

The selection and installation of traffic signal control equipment designed to provide area or agency wide control and monitoring capabilities represents a considerable investment by the operating agency. The cost of bringing a single intersection on-line can vary from approximately $3,500 to replace a controller to over $20,000 to install a complete cabinet (comprising the controller and other peripheral components). With the installation of central control hardware and software and the necessary communications network, the investment to an agency can easily exceed several hundred thousand dollars. In the Seattle area, the majority of jurisdictions that are responsible for operating their signal systems have made this investment and are operating their signals in this "closed loop" fashion (i.e., all signals are interconnected to form a single system).

Agencies that have already invested in these types of signal systems are unlikely to welcome the idea of system integration if it requires significant modification to their systems. Therefore, for an integration system to be acceptable, it must be able to communicate with a variety of traffic signal systems without requiring significant modifications to these independent systems.

USER CONSIDERATIONS

The preceding discussion identifies some of the parameters that must be considered and addressed before a method of integrating the operation of independent control systems is developed. In summary, for an integration system to be acceptable to operators of independent control systems, the integration system must have the following features:

- the ability to communicate with existing, "off the shelf" traffic signal control systems without requiring substantial modifications to these systems,
- the ability to utilize features already available in signal systems, again without significant modifications to these existing systems, and

- the flexibility to allow each agency to define the data that its control system is to receive, including data content, format, source, and time increment.

An integration system that could accommodate this type of flexibility could provide a wide variety of services or functions that a multitude of operators might define. Depending on the desires of each agency, this system could be designed to provide one user with traffic condition or control data during certain operating hours, and provide a second user with information only when a pre-defined condition was met. Levels of control could also be user defined. One user might elect to receive specific control messages that would result in automatic implementation, while another user might be interested in receiving only control recommendations.

SYSTEM HARDWARE STRUCTURE

The features described above could be provided in a number of ways. Designated personnel could be assigned the task of monitoring each control system and notifying other agencies when a pre-defined condition was met. Data could be retrieved in hard copy format and exchanged. This type of system would have a low initial cost and would require no modifications to existing control systems; could provide the ability to respond to otherwise unknown or undetectable conditions; and could still provide each operating agency complete control over the operation of its own system. The obvious drawback to such a system is the long-term cost of providing the necessary personnel. Response time could also be a problem, particularly if multiple users had to notify several other agencies on the basis of different criteria or circumstances. Because traffic conditions can change quickly and control systems often require time to transition between control plans, the earliest possible notification would be necessary to ensure that the desired control strategy was implemented to meet the forecasted conditions.

Another method would utilize computer technology to automatically perform this function. This type of solution contains several alternatives in itself. In a distributed intelligence system, each control system could be designed to communicate directly with several other systems, transmitting and receiving information as defined by each respective user. With this type of structure, all the integration parameters would be resident within each signal control system. The primary advantage of this type of system structure is that it would provide an automated system. Once established, this system could operate without the need for continuous monitoring. The response time would also be better than that of a manual system. Each jurisdiction would retain complete control over its specific operation; however, each user would be dependent upon the other jurisdictions for information from their systems. The negative aspect of a system of this type is primarily the cost of modifying each of the control systems. Each system would have to provide the operating parameters specified by all potential users. Because the majority of systems are "off the shelf," all modifications would have to be provided by the system manufacturers.

Another alternative of the automated, computerized method follows a centralized intelligence structure. In this configuration, a dedicated "server" computer would provide the majority of the integration functions. All system data would be transmitted to the integration computer from each of the independent control systems. Each jurisdiction would be responsible for determining the type and source of information it was interested in, as well as for defining the conditions for which this information was to be transmitted. Each user would determine how it would use the information received. This type of system structure would provide the same types of benefits as those of the distributed intelligence system. Additional benefits include fewer required modifications to each jurisdiction's control systems. Because each agency would define the functions of its own system, system modifications could be minimized to involve only the desired or available functions.

Negative aspects of this type of integration system structure are the need to purchase additional computer hardware, the development of the necessary integration software programs, and the determination of the central integration system operator. In addition, modifications to existing signal control systems would still be necessary. However, these modifications could be minimized to involve automation or remote access of features already available in the existing systems.

SYSTEM COMMUNICATIONS

Further alternatives exist for determining the appropriate system level or system component in which to implement communications among control systems. As discussed earlier in this chapter, most existing traffic signal control systems contain three levels of control or supervision:

- the local intersection controller,
- the on-street master controller, and
- the central supervisory/monitoring computer.

In the distributed intelligence system, the majority of data collection functions, as well as intersection control functions, would be performed at the local intersection controller level. The on-street master would aggregate data collected from the local controllers, and if requested, transmit these data to the system central computer. The on-street master would also perform system wide control functions.

Communications would occur between each level of control within this defined hierarchy. In other words, local intersection controllers would be capable of communicating through the on-street master controller to the system central computer, and in some cases directly to the system central computer.

Because communication capabilities would be provided at each of the three levels of signal system control, a computerized integration system could theoretically communicate directly with any of these levels. For practical purposes, however, direct communication with each local intersection controller is probably not desirable. Because data collected by each of the interconnected local controllers could be transmitted to and collected and retained by the on-street master controller, the integration system would not have to communicate directly to each local intersection controller. Also, the cost of providing communications capabilities to each intersection would be considerable.

Communicating directly to the on-street master level of the control system seems to be a viable alternative. Because all of the data collected by the local intersection controllers ultimately is stored by the on-street master, this seems to be the logical link for the integration system to utilize. However, there would be hardware and software constraints associated with "off the shelf" control systems.

In most of the existing systems the on-street master controller hardware is designed to provide communications to the local controllers and the system central computer only. In these cases, the features required to provide the third communications access would likely not exist. Modifications to customize this hardware could be considerable. Use of existing communications ports would require the manufacturer's source code, which, as discussed in Chapter 2, is not routinely provided. In addition, use of an existing communication port for integration purposes would likely render other control system features inoperable.

The central system computer provides another alternative communications link. In most existing signal systems the central control component is designed to operate on a "standard," IBM compatible desktop personal computer. In these cases the signal system supplier provides only the software, leaving the user to define the "add on" features of the hardware system. One such "add on" might be a device that could facilitate additional external communication requirements.

This does not mean that the software would necessarily support this additional channel of communications, and in fact, most systems probably would not. The central system program is typically designed to accommodate the communication devices necessary for providing existing system features. Because the introduction of the integration system would represent a customization or add-on feature to existing signal control systems, modifications to these systems would be required to accommodate not only additional communications requirements, but also access to control, data accumulation, and system monitoring features. [3, 4, 10]

MANUFACTURERS' COMMENTS

Representatives of two independent traffic signal control equipment manufacturers were contacted and questioned regarding these communication alternatives. In both cases they recommended the central system for establishing external communications. Common reasons for this recommendation included the following.

- External communications to the central system computer would not impact existing internal system communications.
- Existing on-street master and local controller hardware and software would not require significant modifications.
- The manufacturers' investment in their internal communications source codes and protocols is considerable. The willingness of the manufacturers to make this information available is unlikely, and at best, costly.
- The central system software is the signal control system component easiest to modify or customize.

When asked about their preference for electronically achieving control system integration, both cited the use of a stand-alone integration computer that would communicate individually to each independent control system. The reasons for this preference included the following.

- This alternative would minimize modifications to each central system program.
- This alternative would better provide for future expansion of the integration network.

Both representatives indicated that their companies would be willing to provide user specified modifications to the central system component of their respective systems to accommodate the requirements of system integration.

CHAPTER 3

SITE DESCRIPTION

Facilities were selected for demonstrating the integration system. These facilities, located within the Seattle metropolitan area, consisted of the three primary north/south travel routes between Snohomish County to the north and the city of Seattle to the south.

The immediate service area of this system lies primarily in unincorporated King County. This 16-square miles area, zoned primarily for residents, has a population of approximately 64,700. [11] These facilities also service southwest Snohomish County, which has an estimated population of 150,000. [12] A map of this area is shown in Figure 1.

Each of these three facilities contains control systems that, before implementation of this project, operated independently of one another. A map of these facilities is shown in Figure 2.

A preliminary analysis of traffic volume data collected at the onset of this project indicated a relationship among conditions on each of the facilities. However, this interaction did not appear to be uniform. The general conclusions of this preliminary study were that conditions on the freeway did impact arterial traffic conditions, and that conditions on either arterial did impact freeway conditions. However, no direct relationship between conditions on the two arterials was apparent. This inter-facility relationship is discussed further in Chapter 7.

The following is a description of each of the control systems.

FREEWAY SYSTEM

The freeway section of the study area is a 4.5-mile section of Interstate 5. This section of Interstate 5 is bounded by the Northgate area to the south and by 236th St. S.W., just north of the King/Snohomish County line, to the north. The average annual daily traffic on this facility is approximately 148,400 vehicles. [13]

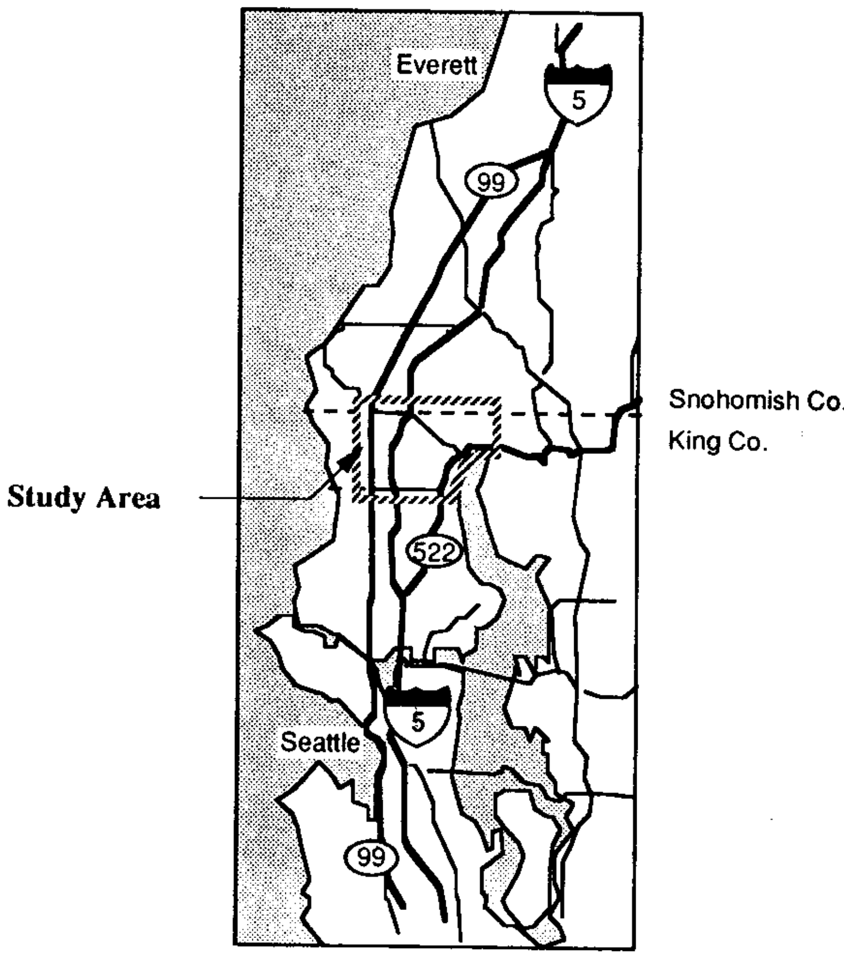
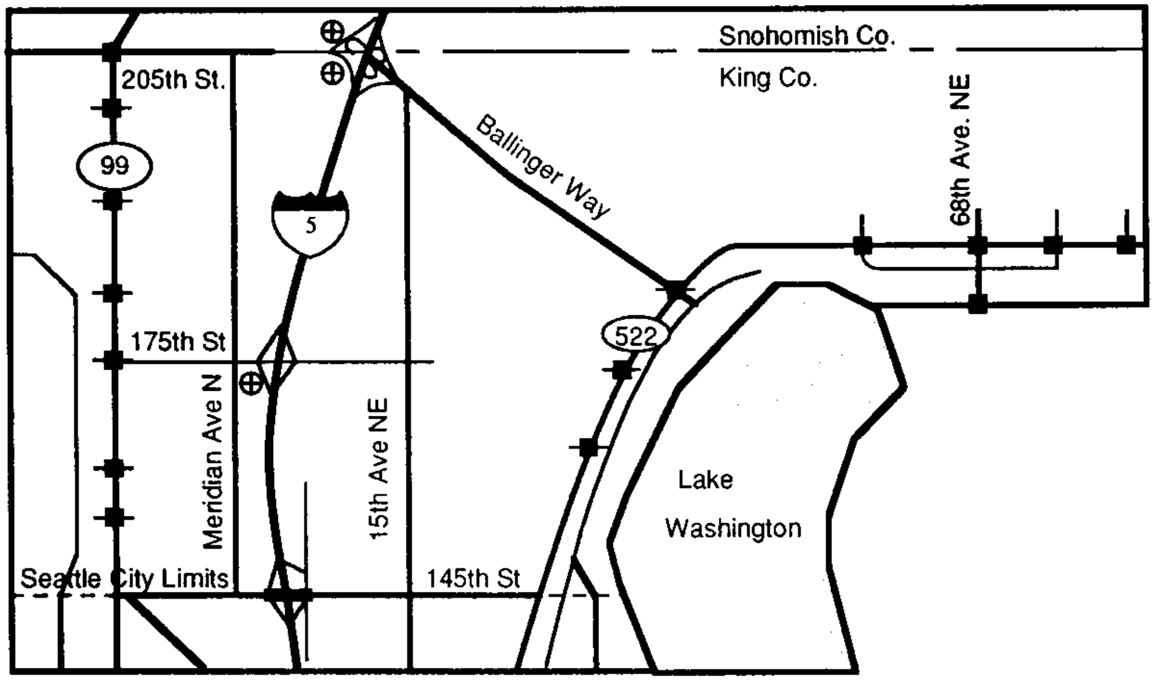


Figure 1. Demonstration System Vicinity Map



⊕ Metered Ramps

Traffic Signal

Figure 2. Demonstration System Facilities

The geometry of the study section consists of three general purpose lanes and an inside high occupancy vehicle lane in each direction. In addition, outside "add/drop" lanes are located between various interchanges.

The primary peak directional flows on this facility consist of significant southbound movement in the morning peak period (approximately 5,000 vehicles per hour) and significant northbound movement in the evening peak period (approximately 6,300 vehicles). During each of these peak periods the reverse flows on this facility are significantly lighter than the peak directional flows. The off-peak (mid-day) flows are more directionally balanced. These traffic flow characteristics were estimated with data collected in conjunction with this project.

Three freeway interchanges are located within the study section, as shown in Figure 2. Freeway access provided by these interchanges is monitored and controlled by the Washington State Department of Transportation's (WSDOT) freeway surveillance and control system. The ramp controls at each interchange are shown in Figure 2.

ARTERIAL SYSTEM

The demonstration system incorporated two independent arterial facilities. Each arterial runs parallel to Interstate 5. SR 99 (Aurora Avenue North) is west of I-5, and SR 522 (Bothell Highway) is to the east.

Both SR 99 and SR 522 are classified as primary arterials. Development along each arterial is typically strip development, with little or no access control. For both arterials, channelization consists of two general purpose lanes in both directions, with a discontinuous two-way left-turn lane in the center.

Traffic conditions on both arterials are primarily peak direction oriented. In the AM peak commuting period, traffic flows are predominantly southbound, while during the PM peak commuting period the northbound flow is primary.

The average daily traffic is approximately 32,000 vehicles per day on SR 99 and 60,500 vehicles per day on SR 522. [13] Traffic flows on each of the arterials are considerable during the peak commuting periods. The average weekday peak directional traffic flows, based upon data collected in conjunction with this project, were estimated as follows:

SR 99:	AM (SB) - 1600 vph	PM (NB) - 1650 vph
SR 522:	AM (SB) - 1950 vph	PM (NB) - 1640 vph

Significant delays occur on each arterial during peak conditions. This delay is primarily the result of demand approaching or exceeding the capacity of the respective arterial. This condition may have affected the accuracy of the vehicle counts. (Collecting traffic data during severe congestion may cause the counters to undercount the actual demand on the facility.)

Each arterial study section consists of seven signalized intersections. All signalized intersections are fully actuated. Both signal systems contain on-street master controllers. In the current level of operation, these on-street masters are used only to send out coordination plan commands, as well as clock updates. All on-street communications between individual intersections and the on-street master are accomplished with state-owned, twisted pair communications cable.

Through leased telephone lines, each on-street master controller communicates directly with the off-street arterial central computer.

The distances between signalized intersections vary considerably on each arterial. On SR 99, the minimum distance between signals is approximately 1,350 feet, and the maximum distance is approximately 4,040 feet. On SR 522 the minimum signal spacing is approximately 1,000 feet, and the maximum signal spacing is approximately 4,200 feet.

The SR 99 traffic signal system contains the signalized intersections located at

- North 155th Street,
- North 160th Street,
- North 175th Street,

- North 185th Street,
- North 192nd Street,
- North 200th Street, and
- North 205th Street.

The SR 522 traffic signal system contains signalized intersections located at

- Northeast 165th Street,
- Northeast 170th Street,
- SR 104 (Ballinger Way),
- 61st Avenue Northeast,
- 68th Avenue Northeast,
- 73rd Avenue Northeast, and
- 80th Avenue Northeast.

Each arterial system operates in the coordinated mode throughout the day (6:00 AM to 7:00 PM). Coordination plans are developed off-line on the basis of previous traffic data. Both arterials operate in a time-based mode, in which coordination plans are changed at preset times of the day.

CONTROL SYSTEM OPERATIONS

The control systems utilized by this demonstration project contained components commonly found in systems designed to provide their respective capabilities. This section discusses the operation of each of these systems, as well as their capabilities, as they relate to the objectives of this project.

Freeway Control System

The Washington State Department of Transportation is responsible for the operation of the freeway systems throughout the state. In the greater Seattle area the Department utilizes a freeway control system, referred to throughout this report as the FLOW system, to provide access control to the freeway system. This system operates throughout the freeway study section defined by this project.

The structure of this system relates to that of the two-level system described previously in this chapter. The two levels of control consist of the on-street, local control level component, and the off-street, central system control component. The mid-level component, referred to as the on-street sub-system level, is not employed by the FLOW system.

The on-street control components of the FLOW system consist of "Type 170" control hardware utilized as ramp meter stations and data collection stations. The ramp meters are located on the freeway on-ramps. These meters control the volume of traffic allowed to enter the freeway. Each ramp meter station contains traffic sensors (typically 6' x 6' induction loops) located in each mainline lane upstream and downstream of the on-ramp merge area. These loops are located on the on-ramp as well. From these sensors, lane volume, occupancy, and speed data are collected and used to determine metering rates.

In addition to the ramp meters, data stations are located at various points throughout the study section. These stations also collect volume, occupancy, and speed data on each main line lane.

Both the ramp meter stations and the data collection stations transmit the collected data to the central system computer. This central mainframe computer provides system wide control capabilities.

Essentially, two types of control strategies are employed in this system, localized control and bottleneck control. Under localized control, each ramp meter calculates its own metering rates on the basis of conditions identified by its own local detectors. These control decisions are made independent of conditions upstream or downstream of its detection zone.

The term bottleneck refers to the deterioration of conditions within an isolated freeway section. This deterioration may be due to demand that approaches or exceeds capacity, an incident, or roadside construction or lane closures. Under bottleneck control, metering rates for each ramp meter are determined by the central mainframe computer. Under this control strategy, meter rates for each ramp meter are set to optimize the flow of traffic along the entire freeway section. This system identifies the formation of a bottleneck within the system and adjusts the metering rates of the upstream on-ramps to alleviate this down-stream condition.

This system can operate under a combination of these two control strategies. Individual on-ramps can be operated in localized control. Under this condition, these locations would continue to transmit data back to the control processor, enabling the remaining meters to continue to operate in the bottleneck mode. This is typically done when extreme conditions at an individual ramp are encountered. Because the localized control mode allows the metering rate to be based on demand at the individual on-ramp, an unusually high on-ramp demand can be accommodated under this mode of control. The metering rates downstream of this location can then be adjusted on the basis of bottleneck control. Removing an on-ramp from bottleneck control requires the operator to manually enter a command to the individual station. If system communications are lost, all on-ramp meters revert to localized control.

Communications between the central mainframe computer are facilitated by both state-owned cable systems and leased phone lines. The Department developed the software specifications for each component of this system and thus owns the source code. As a result, communications protocols will not be a problem when system expansion is required.

Arterial Control Systems

The Washington State Department of Transportation is responsible for the operation of two significant signalized arterials within the project study area. Both of these arterials' traffic signal systems utilize similar control equipment, share the same system structure, and are in fact under the direction of the same "off-street" control component.

The arterial signal system controlling these arterials utilizes the three levels of control concept described previously. In this system, Type 170 traffic controllers provide local intersection control, as well as on-street master control. The off-street component utilizes a desk-top microprocessor (IBM compatible) as the arterial central computer.

The software employed at each level of control is "off the shelf" software developed and marketed by a private company. The Department purchased the rights to use this software, but it does not own and, therefore, does not have access to the program source codes.

In this system the local controller contains all control parameter information necessary to operate the intersection in either a free, non-coordinated mode of operation or in a coordinated, system type of operation. From this standpoint the local controller can operate completely independently of the other two levels of control.

Two-way (full duplex) communication occurs between the on-street master controller and each local intersection controller at a frequency of once every two seconds. This communication is facilitated by state-owned, twisted pair communications cable. Each interaction consists of status reports and traffic data reports (volume and occupancy) generated by the local controller and transmitted to the on-street master, and coordination plan implementation commands and clock updates generated by the on-street master and transmitted to the local.

In this system the on-street master controller performs primarily as a data and communications buffer between the local controllers and the arterial central computer. Although coordination plan implementation commands are issued by the on-street master controller, each local controller has the ability to implement a back-up schedule in the event of a communications failure. However, all traffic responsive operational commands are issued solely by the on-street master. A communications failure renders these features inoperable.

One on-street master controller is located on each arterial. Both on-street master controllers communicate directly to the arterial central computer via leased telephone circuits. Communication between the arterial central computer and the on-street master controllers consists of status reports and accumulated traffic data reports transmitted by the on-street masters to the arterial central, and control commands, manually requested by an operator, from the arterial central to the on-street masters.

As discussed in Chapter 1, the primary objective of this project was to provide a link between the freeway's FLOW system and the arterial control system. The integration of these two systems should allow data sharing and the exchange of control parameter information between the two systems. The following chapter discusses other work to integrate the operation of independent control systems.

CHAPTER 4

SYSTEM DESIGN

As discussed in Chapter 3, preliminary studies indicated a probable relationship between traffic conditions on the three facilities. Because these were the three primary north/south route choices for motorists in the corridor, a significant incident on any one of these systems could divert traffic from that facility onto one or both of the other facilities. To accommodate this atypical demand, a system was desired to detect an incident on any of the facilities and, given the increased demand the incident would create on the other two, change the control strategies on the affected facility(s). Thus, any required change to a system's normal control parameters could be made before demand increased, minimizing problems related to a large influx of traffic, particularly on the arterials.

INTEGRATION SYSTEM DESIGN PARAMETERS

The project's integration system electronically links the freeway surveillance and control system and the two arterial traffic signal control systems. This link incorporates features that provide the centralized monitoring and control modification capabilities required to address the conditions described above. The parameters used in developing this system were as follows.

- The integration system should allow automated monitoring of traffic data from each of the three control systems. This capability should utilize the data collection ability already available in each of the three systems.
- The integration system should be able to analyze these data "on line," determine the need for control parameter modifications, and change the control parameters of the appropriate system by utilizing each system's pre-existing capabilities.

- The integration system should operate on a low cost hardware system (microcomputer).
- The integration system should utilize data collection and system control features already available within each of the independent control systems with minimum modifications to these systems.
- The integration system should allow individual jurisdictions to maintain control of their own facilities.

This project's integration system was intended to accommodate these goals. Designed to operate on a desktop computer, the integration system provides area-wide control capabilities by communicating directly to multiple, independent control systems. The integration system gathers information from each independent system and has the ability to determine when new control plans should be implemented. However, the choice of control plans was left to each jurisdiction, and the system was designed to implement those plans only under conditions agreed to by the cooperating jurisdictions.

INTEGRATION SYSTEM HARDWARE REQUIREMENTS

The integration system developed for this demonstration project consists of three primary components. The complete system architecture is shown in Figure 3. This figure illustrates the primary elements of the integration system, as well as the peripheral components of the on-street control systems.

Two of the components, the freeway system central mainframe computer (FLOW system central) and the arterial central computer, are fundamental elements of existing independent control systems. These two systems were operating before the start of this project. The third component of this project, the integration computer, was added as part of the integrated traffic control system. This component acts as the link between the two existing control systems.

The integration system was designed to minimize computer hardware requirements. Utilizing an IBM compatible desktop microcomputer, the integration

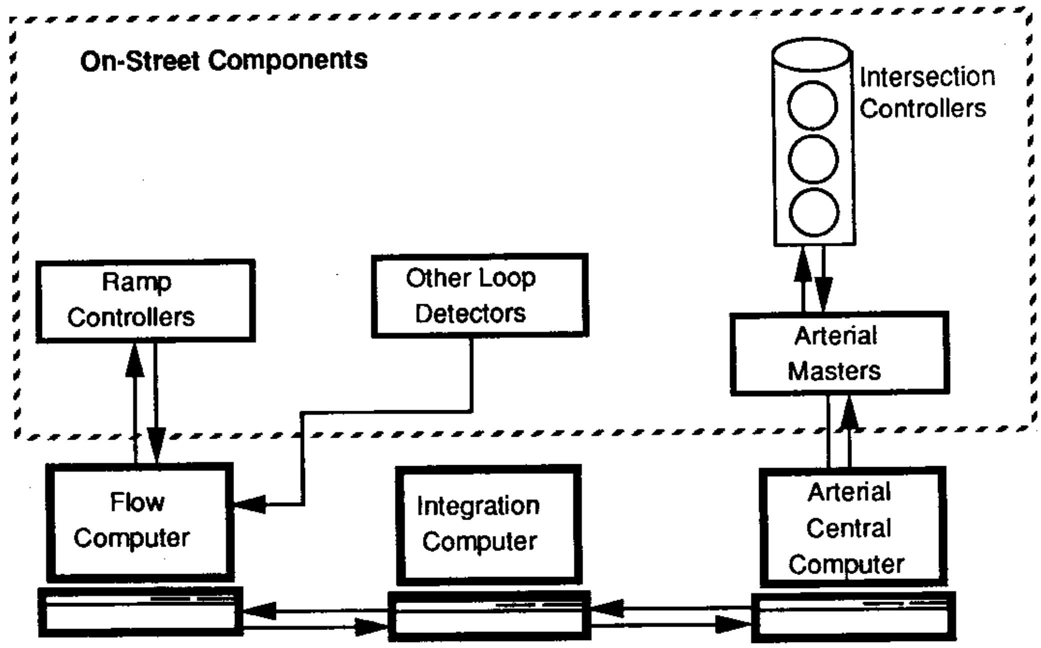


Figure 3. Integration System Hardware Configuration

system conducts all its functions with standard hardware capabilities. The computer used for this project was an IBM AT. The computer was equipped with 512 kilobytes of RAM, 40 megabytes of fixed drive storage, and two external floppy disk drives. External interface devices included two serial communications ports and a single parallel port. No hardware modification or customization of this computer were required, with the exception of the LAN card installation discussed later.

INTEGRATION/CONTROL SYSTEM INTERACTION

The integration system was designed to interact directly with external control systems. This required establishing direct communications between the integration computer and the FLOW system central computer, as well as between the integration computer and the arterial central computer. This communications capability allows interaction of control capabilities and data collection across independent systems. The following sections describe the interactions that occur between these systems, as well as the communications methods used for this project .

Flow System

As discussed earlier in this report, the WSDOT FLOW System consists of a central mainframe computer and multiple subsystem field computers, referred to as data stations. The principle functions of the FLOW system are to collect and analyze freeway data and, from these data, determine proper ramp metering rates.

In this system the data stations (typically Type 170 controllers) act primarily as data accumulators. Their primary functions are to collect and transmit vehicle data (volume, occupancy, and in some cases speed) to the FLOW system central. These data are obtained with vehicle detectors (induction loop type) located in the roadway surface. The data are transmitted to the FLOW system central in 5-second intervals.

The FLOW System central receives and aggregates the data from each field computer. Metering rates for each on-ramp are then calculated on the basis of both localized and downstream freeway conditions when the ramp meter operates in the "bottleneck" mode. Under "local" operations, the data stations, which also operate as ramp metering controllers, calculate the metering rates on the basis of localized conditions only.

The FLOW system central computer is able to aggregate and write data to a buffer. The operator specifies the data stations to be included in the data set. The central computer provides a total directional volume and an average lane occupancy for each station. For this demonstration system, 26 freeway data stations were selected (13 northbound and 13 southbound), all located within the study area. In addition, four arterial data stations were used, two on SR 99 and two on SR 522. The central mainframe computer collects data from these stations at a frequency of once every 5 seconds and then aggregates these data into 5-minute intervals. These data are then written to a buffer location.

The FLOW system central also has the ability to read data sent to a buffer from an external source. This function can be used in conjunction with a command to a data/ramp metering station to drop out of the "bottleneck" mode. When this occurs, the selected on-ramp reverts to the "local" mode, resulting in a less restrictive operation (higher metering rate).

Communications - Flow System/Integration Computer

By using these available buffers, the integration computer can send and receive data to and from the FLOW system central. The physical connection between the two computers is a standard RS-232 hardware link. Customized code was written for the integration program, as well as for the FLOW system central, to facilitate this connection. Data received from this buffer include

- time of day,
- data station identification,
- total 5-minute volume, and
- average occupancy over the 5-minute interval.

The FLOW system central automatically updates this buffer every 5 minutes.

In addition, the FLOW system computer continuously scans a buffer to find an externally generated control string. This function is included in the custom communication code mentioned previously. The control string contains the integration computer's recommended mode of operation (bottleneck or local) for each ramp meter station. Upon detecting this control string, the FLOW system computer deciphers the code and changes the operating modes of the specified ramp metering stations.

Once a control string has been sent, the integration computer continues to resend the control string to the buffer in 5-minute intervals until a "revert to normal operations" command is sent.

The FLOW computer continues to scan the buffer for updated control commands. If the FLOW computer has received and implemented a control command but has not detected an updated command for more than 10 minutes, the FLOW computer will automatically reset its operations to normal (bottleneck).

Arterial Central Computer

The arterial central computer is responsible for monitoring the operations of the two signalized arterials. In its normal mode, the arterial central does not direct the operation of either arterial. Instead, it acts only as a system monitoring, data collection, and storage data device.

Arterial operations are directed by the on-street control devices. For each of the two arterials, these devices consist of a single, on-street master controller and local intersection controllers located at each signalized intersection.

Two primary modes of intersection control are used at the two arterials. These modes are referred to as "free" operations and "coordinated" operations. Under free operations, each intersection operates under isolated, fully actuated conditions. Cycle length and movement timing allocations are based entirely upon conditions at intersection and within the constraints of predetermined timing parameters.

Under coordinated operations, each intersection operates within a predetermined coordination plan. Each plan comprises a common cycle length, movement timing allocations, and an intersection offset. All of these timing parameters for each intersection are stored at the respective local controller. Each local controller has the ability to store up to 15 coordination plans.

The primary role of the on-street master controller in arterial operations is to determine which coordination plan should be implemented. In the case of these two arterials, the plan is determined solely by time of day.

With the arterial central computer, the operator is able to manually override the control directives of the on-street master controller. In other words, the operator, through the arterial central computer, can implement a coordination plan that would not normally be implemented under the on-street master's regular operations schedule. However, this plan must still reside at each of the local controllers. Free operations can also be implemented in this manner. When operations are manually overridden, the implemented control plan remains effective until the override function is removed or a new plan is manually implemented.

The arterial central manual override function was modified specifically for this project. The modification was required so that the function could be automatically implemented on the basis of externally generated commands. These commands exist as externally generated files written to the arterial computer's hard drive. Each file includes an identifier that specifies the intended on-street master, a coordination plan (or free operation) to be implemented, and the appropriate offset.

The arterial central computer scans its hard drive each minute to find these files. When one of these specially named files is detected and the command is executed, the file is deleted from the drive. The implemented command remains effective at the on-street master until the arterial central detects a new file that commands the system to revert to normal operation.

Each local controller is also able to record volume and occupancy information. These data are obtained from detectors (induction loops) in the roadway. Data from loops assigned as system detectors are collected and summarized at a pre-defined interval. At the end of each interval this summary is transmitted to the on-street master controller. Up to 16 detectors can be assigned as system detectors for each local controller. However, no more than 32 system detectors can be assigned for each on-street master controller. These system detectors are designated at the on-street master as either in-bound detectors or out-bound detectors. Thus, a maximum of 16 in-bound detectors can be assigned, and a maximum of 16 out-bound detectors can be assigned for each on-street master controller.

A new data collection function was written into the arterial central program specifically for this project. This function allows the operator to program the arterial central computer to automatically upload the system detector data from each on-street master controller at pre-defined intervals. The operator schedules these uploads to occur throughout a given period on a specific day. The interval between uploads can be specified in increments of 1 minute. Up to 16 time periods can be scheduled in advance for each on-street master controller. Thus, if each time period is one day, 16 days of uploads can be scheduled for each arterial.

Once uploaded, the data are stored on the computer's hard drive under a unique file name for each arterial (e.g., field.xxx, where xxx designates the on-street master from which the data were received). This file is replaced each time a new set of data is uploaded from the respective on-street master. As a result, this file always contains only the data received by the most recent upload.

Communications - Arterial System/Integration Computer

Both on-street master controllers communicate directly to the arterial central computer at the TSMC via dedicated telephone circuits. Communications between the arterial central computer and the on-street master controllers include system status reports and accumulated traffic data reports from the on-street masters to the arterial central, and manual control commands from the arterial central to the on-street masters.

Communications between the integration computer and the arterial central computer are accomplished with an "off the shelf" PC networking program. Interaction between the integration computer and the arterial central computer consists of file writing and reading to and from the hard drive in the arterial central microcomputer. The arterial central program receives volume and occupancy data from each of its field masters and writes these data to separate files for each field master. The integration program reads and deletes these files and writes separate control files for each field master. The arterial central program reads these control files and implements the desired commands. These functions are repeated at operator assignable intervals.

INTEGRATION PROGRAM

This section describes the integration program developed specifically for this demonstration project.

Program Tasks

The integration program, written in the C programming language, has three basic tasks. These are as follows:

- receive and store detector data from each control system,
- perform algorithmic functions with these detector data to determine the need for control parameter modifications for any of the control systems, and
- transmit control parameter commands to respective control systems.

These three tasks, although performed sequentially and separately, are clearly interdependent. To provide the ability to perform these tasks, the research team had to define a required sequence of the events. The following section describes this sequence.

Sequence of Program Events

The program sequence of events takes the form a continuous cycle that is repeated at a consistent, predetermined interval. The duration of each cycle is determined by the desired length of the data collection time slices. For the purposes of this demonstration project, the selected time slice increment, and thus, the duration of the event cycle, was 5 minutes.

Data Interval Selection

The selection of 5-minute time slices was based on two factors. First, a short response time was necessary for determining the occurrence of severe congestion on any of the three facilities. Second, the data time slice interval had to be long enough to filter out short but intense fluctuations in traffic that might occur under normal conditions. For the freeway system, a relatively short interval (1 minute) might meet both of these criteria. However, for the two arterial systems, a longer interval would probably be required because platooning would cause fluctuations in arterial conditions.

Within each complete signal sequence, arterial conditions fluctuate considerably. A data interval obtained while the mainline was being served would likely differ considerably from an interval obtained while the side street was being served. Therefore, the minimum data time slice interval should be at least equal to the traffic signal cycle length, and ideally equal to a multiple of the signal cycle length. The signal cycle lengths vary widely throughout the day on the two arterial systems. The peak hour coordination plan cycle lengths are about 150 seconds. However, because these cycle lengths vary by time of day, a data time slice interval was selected that would last at least two complete signal cycles. The result was the 5-minute time slice interval.

Integration Program Event Sequence

The primary events that occur each integration program cycle (every 5 minutes) and the sequence of these events are described below.

1. Upload data. The traffic data accumulated during the current period are collected by the integration computer from each of the control systems. Three buffer locations, one for each control system, are maintained by the integration computer. The most recent set of data received from each

control system is placed in its respective buffer. This event comprises two communications functions.

A. Upload arterial data. This function checks for field master data files on the arterial computer's hard drive. If either of these files exist (there were two possible files in our demonstration project), they are copied into the integration computer's buffer. Transferred data files are then deleted from the arterial computer's hard drive.

B. Upload FLOW system data. The FLOW system's mainframe computer is queried for the most recent 5-minute data set. If ready, these data are transferred and loaded into their buffer location on the integration computer.

2. Scroll the data. The data from each control system are stored in one of three possible locations. Each of the locations contains one period of data. For this demonstration system, there were nine data storage locations, or three locations per control system. Because the data are collected in 5-minute time slices, 15 minutes of data are held for each system at any time. The purpose of the scroll function is to move the file pointer to the location that contains the oldest 5-minute period of data. These data are then replaced with the newest set of data (the data currently held in the buffer).

3. Process control plans. This function processes any control plans specified by the operator. A discussion of the functions involved in this event follows this section.

4. Transmit control modification request. Depending upon the outcome of Step 3, system control modification requests may or may not be set to freeway and/or arterial control systems. However, if a control modification is sent to any of the three systems, the request is repeated

every program cycle until the condition that required the request no longer exists.

As mentioned previously, each of these steps occurs each 5-minute integration system cycle. Following completion of the cycle, the process is repeated.

The integration program establishes its 5-minute cycle on the basis of time of day. Each cycle begins on an even 5-minute interval, as determined by the integration computer's internal clock. The integration program requests a clock update from the FLOW system computer each cycle and uses this time to update its own internal clock. This procedure ensures that the two computers' clocks are synchronized, and thus, that the database of the FLOW computer will be updated and ready to transmit when the integration computer sends its request for data.

The integration program is designed to run continuously. However, as discussed in the next section, all system control parameters can be implemented by time of day and by day of week. This feature allows the operation to be directed at peak hour traffic conditions, as well as at general, non-peak related operating conditions.

System Control Plans

The primary objective of traffic control system integration was not just to electronically communicate with and automatically extract traffic data from independent traffic control systems, but also to implement control strategy modifications to these systems on the basis of those data. Consequently, system control capabilities were developed and incorporated into the integration program to utilize these new communication and data collection capabilities.

In addition, the individual system operators needed the ability to control the plans that were implemented. Therefore, as described above, the integration computer only sends control codes that implement a control plan. Those codes do not specify the parameters within the plan. If the traffic control system operators want to change the timing plans associated with that control code sequence, they have that option.

In this manner, the integration system allows multiple control systems to work together, while the system operators still have "control" of the individual systems.

System Control Plans - Basic Parameters

The integration program allows the operator of a participating control system to define system control plans that can modify the operation of any of the three traffic control systems. The decision of whether to modify an operation is based on traffic conditions, as interpreted from the data received in Step 1 of the program sequence, described above. In the case of a multi-jurisdictional system, each agency must agree to the conditions that would necessitate implementation of alternative control plans. For the demonstration system, all control systems were operated by WSDOT District 1.

Each control plan contains information specific to the control system for which it is directed. This information includes the control system identification code and the control string to be sent. Additional information includes the starting and ending times that the plan should be active. The days of the week (Sunday through Saturday) for implementation are also selectable.

System Control Plans - Traffic Condition Parameters

Three traffic condition parameters, or comparisons, are available for determining whether to implement specific integration system control plans. Each of these comparisons utilizes data station volume and/or occupancy data, or in the case of the arterials, volume and occupancy data from signal system detectors. Thus six types of comparisons can be made--three using volume data and three using occupancy data.

These comparisons include volume or occupancy data compared with specific constant values, volume or occupancy data compared with similar data from another time period, and volume or occupancy data compared with data from other locations. These comparisons are explained in more detail below. The comparisons can also be made in combination (i.e., volume and occupancy values must be exceeded to indicate a specific condition). This flexibility was designed into the system to ensure that participating jurisdictions had sufficient control over the conditions that the integration system uses to determine "congestion." For the demonstration project, congestion occurred when volume and occupancy levels exceeded preset threshold values.

Once a condition has been detected that requires a response by the integration system, the integration program transmits a control string to the designated control system. The operator may also specify, as an additional prerequisite, a required number of consecutive periods that the plan conditions must be met before the control string is implemented. This gives the operator a greater level of confidence that the condition is really congestion, rather than just a temporary reduction in traffic performance.

The conditions or comparisons that may be defined for each plan are as follows.

A. Single Period Station Volume or Occupancy Comparison. For this parameter, an individual data station or arterial signal detector is identified, and a threshold value is assigned to it. When the threshold value has been exceeded, the condition is met.

B. Station Volume or Occupancy Change Over Time. For this parameter, a data station or arterial signal system detector is identified, and the data for the current period are compared with those of a past period (5 or 10 minutes previously). In setting up this condition, the operator identifies the station location, the differential threshold, and the previous period for comparison. If the difference between the two periods' data is greater than the threshold value, the condition is met.

C. Single Period Station to Station Volume or Occupancy Differential. For this parameter, two data station or arterial signal system detectors are identified, and the data from the two locations are compared. In setting up this condition the operator identifies the first and second station locations and the data differential threshold between the two stations.

In establishing a system control plan the operator may select and define one or more of these conditions, or multiple definitions of the same condition. When multiple conditions are defined for a single system control plan, all of the defined conditions must be met before the plan may be implemented. In addition, these conditions can apply to one or more traffic control systems. This allows conditions on one facility to affect one or more integrated systems without having the same impact on all of the connected systems.

System Control Plans - Implementation Parameters

The operator may define a minimum number of periods that the plan must remain effective, if the plan is implemented. This feature is included to address concerns regarding arterial operations. When the signal control system changes traffic signal coordination plans, it enters a "transition period." During this period (typically 1 to 3 coordination plan cycle lengths), each intersection controller makes timing adjustments necessary to accommodate the new cycle length and offset value, and traffic signal synchronization often deteriorates. By establishing a minimum number of periods that a system control plan must remain effective, this deterioration can be minimized.

Once implemented, the system control plan remains in effect until one or more of the following events occur:

- the time of day that the plan is available expires, or
- the traffic conditions defined by the plan are no longer met, and the minimum number of periods that the plan must remain effective have expired.

Control Plan Priority

Each system control plan is identified by plan number (1 through X). More than one system control plan can be defined for a particular facility. If conditions for more than one plan on a single facility are met, the plan whose conditions are met earliest takes priority over the other plans and remain in effect.

If the conditions for more than one plan on a single facility are met during the same period, the plan with the lowest plan identification number takes priority and is implemented (assuming no other plans for that facility are already in effect).

This prioritization scheme was adopted to allow different traffic flow conditions to produce changes on the parallel facilities, while local control can be maintained over the relative importance of those conditions. The research team adopted the operating philosophy that once a timing plan has been implemented, that plan should remain in effect until the conditions that warranted its selection have been alleviated. Because more than one plan might be applicable at any one time, the prioritization scheme was adopted to ensure an orderly selection between competing plans.

EXPANDING THE INTEGRATION SYSTEM

The demonstration system was designed to work with the specific WSDOT control systems described above. However, the system design also provides for expansion if other jurisdictions can add their traffic control systems to the integrated control structure. To expand the system to other traffic control systems requires the following:

- provision of communication capabilities to and from those systems,
- development of control codes to be sent by the integration system to the new control system, and
- revisions (if needed) to the central computer program of the new traffic control system to allow it to transmit traffic data to the integration system, recognize the control codes sent by the integration system, and automatically implement the plans identified by those codes.

To help other traffic control systems work in a more coordinated fashion, the project team developed a draft standard that would allow these functions to be built into the central programming portion of conventional "closed loop" traffic control devices. This draft document is included in the appendices of this report. Also included in the appendices is a draft document for cities purchasing new traffic control systems or system software so that they can include these functions in their new systems.

In addition to adding the above functionality, the operator of the new traffic control system must work with the operator of the integrated system (in this case, WSDOT) to define the conditions under which the integration system should send control codes to the new traffic control system. The operator must also determine the new traffic control plans under the identified conditions. WSDOT must determine whether conditions on the newly integrated facility warrant changed control plans on WSDOT facilities. If this is the case, WSDOT must also determine how to identify those conditions and the necessary changes in the existing control plans.

When the conditions for implementation are selected, the parameters that are available from the existing control systems must be considered. The integration system does not include traffic performance monitoring capabilities of its own. Instead, it relies on the data collection functions that exist within the individual control systems. Thus, the parameters used to identify "special" conditions must be currently available within the existing control systems.

For the demonstration system, the FLOW system already provided volume and occupancy data for use in detecting congestion. Most arterial systems do not have vehicle detectors to provide similar levels of data collection. Therefore, the integration system may have to rely on other types of data to detect the conditions when it should be implemented. For traffic signal systems, these data might include the continued presence of vehicles over a queue detector, or the inability of the existing signal timing plan to clear all vehicles attempting to make a movement during one or more signal cycles.

The selection of parameters for implementing an integrated control strategy often requires assumptions that are difficult to prove. For this project, the integration system utilized volume and occupancy thresholds as the congestion measures to drive the system.

Two assumptions provided the basis of this "threshold based" control strategy. These were

- a relationship between traffic conditions on the parallel facilities does exist during periods of extreme congestion; and
- extreme levels of congestion can be detected from volume and occupancy data collected by the existing control system's detection systems.

The validity of these assumptions should be confirmed. However, as will be discussed in the next section, problems associated with implementing the integration system undermined this project's confirmation effort.

The topic of multi-jurisdictional integration systems is further explored in the next chapter on implementation issues.

CHAPTER 5

IMPLEMENTATION

To implement the integration system described in the previous chapters, the research team first had to develop the timing plans for the integration system to implement and then calibrate the control parameters that would indicate when those plans should be implemented.

INTEGRATION SIMULATION AND CONTROL PLAN DEVELOPMENT

To help develop timing plans and calibrate control parameters, the integration program can store the data it receives from the arterial and freeway systems. Data for each day (midnight to midnight) are stored in separate files. Multiple days of data can be chained together with a simple DOS command and grouped, for example, into one week or one month increments. The integration program can then use these files to simulate actual conditions.

To use this system capability, the researchers connected the integration system to the arterial central computer and the FLOW system and placed it in the data collection mode. Arterial and freeway volume and occupancy data were then collected for several months (as the control algorithm portions of the integration program were written and tested) to provide a database for timing plan development and system calibration.

For the demonstration phase, the project team and WSDOT District 1 operations staff decided that the system would be designed to change "normal" control system operations only when "major" traffic problems occurred. With the idea that the integration control plans should respond to only extreme congestion, the objective in establishing control plan parameters was to define thresholds that would clearly indicate severe conditions.

Lane occupancy is the measure WSDOT uses to define traffic conditions on its FLOW system congestion map. This map identifies traffic conditions on freeway sections. Each section contains one data collection station. For this map display, an occupancy rate of greater than 30 percent for 5 minutes defines severe congestion. Other research has indicated that when occupancy is used to indicate traffic conditions, congestion is typically associated with rates of 30 percent to 40 percent. [14]

These parameter values were also tested as a measure of "extreme" congestion for the integrated system. To prevent congestion at a single point from indicating "extreme" congestion, the control algorithm also includes distance, or length of the congested section, in the control parameters by requiring that the congestion parameter threshold be surpassed simultaneously at two adjacent data stations. Thus each control plan involves two data stations. The stations of each plan overlap. For example, control plan 2 pertains to I-5 southbound stations at N. 145th St. and N. 155th St., and control plan 3 involves the same N. 155th St. station and also the N. 162nd St. station. In total, 18 stations are involved in 16 control plans.

Because of incomplete arterial data and the difficulty in interpreting lane occupancy data for arterials (vehicle platooning and queuing caused by signals make the lane occupancy values from arterials very different from those on freeways), only freeway conditions were examined for occupancy data. Data collected from September through November 1991 were compared with various occupancy threshold values, and the number of times a condition was met was recorded. The data were broken down into two peak periods, and only weekday data were included. The AM period contained data from 6:30 AM to 8:30 AM, while the PM period was defined as 4:00 PM to 6:00 PM.

When 30 percent occupancy was the threshold, the threshold condition for congestion was met on 10 days in the AM period and 10 days during the PM period. When this occupancy value was increased to 35 percent, the number of days that a condition was met decreased to four days in the AM period and six days in the PM period. Thus the 35 percent occupancy rate appeared to produce the number of responses consistent with only the severest congestion.

The average occupancy was calculated for each data station for which the 35 percent occupancy threshold was met. In the AM period, the southbound data station at N. 165th St. most often met the control plan conditions. At this station, the average occupancy for the defined time period was 16.7 percent, with a standard deviation of 6.9 and a sample size of 744 5-minute time slices. The 90th percentile occupancy for this station was 25.0 percent, while an occupancy of 35 percent represented the 99th percentile of the distribution. These figures seemed to support the use of a 30 to 40 percent occupancy rate as an indicator of severe congestion.

This same procedure was conducted for the PM condition. The data station near northbound I-5 and N. 175th St. was examined further. The average 5-minute occupancy during the PM period at this station was 26.4 percent, with a standard deviation of 11.3 and a sample of 744. The 90th percentile occupancy was 39.0 percent. This station, too, seemed to fit the 30 to 40 percent occupancy rate definition of congestion.

Examination of the relationship between average and 90th and 95th percentile occupancies of adjacent stations indicated that in some cases significant variation did occur. A more accurate way to determine the correct threshold for each station might be to select a percentile of the distribution, such as the 95th or 97th, and use the corresponding occupancy value of each station.

FREEWAY AND ARTERIAL INTERACTION

Previous work had briefly examined the relationship between conditions on the freeway and conditions on the arterials to determine any interaction. The results of this work, although not conclusive, indicated that interaction did occur between the freeway and SR 99, but only during extreme congestion on the freeway. On the other hand, the relationship did not extend to SR 522, nor was any interaction evident between SR 99 and SR 522.

To confirm these findings, data from arterial data stations were examined further to determine whether a pattern could be discerned. Data collected from the arterial stations at the SR 99 intersection of N. 200th St. and at the SR 522 intersection of N.E. 165th St. were examined for both the AM and PM periods. The average volumes, standard deviations, and 90th and 95th percentile volumes were calculated. The 90th and 95th percentile volumes were then compared to the volumes attained on days that the conditions of one or more congestion thresholds were met to determine the number of 5-minute volumes for that period that exceeded the respective percentiles. The results are summarized in Tables 1 and 2, below.

Table 1. Summary of Arterial Data

Time Period	Data Station	Ave. Vol. Veh/ 5 min	Std. Dev.	Percentiles	
				90th	95th
AM	SB SR 99 @ N. 200th St	93	17.0	106	115
PM	NB SR 99 @ N. 200th St.	196	31.1	227	235
AM	SB SR 522 @ NE 165th St.	213	47.0	247	253
PM	NB SR 522 @ NE 165th St	85	18.2	102	106

Table 2. Comparison of Arterial Data on Days Control Plan Conditions Are Met

Time Period	Data Station	Number of Intervals Exceeded Using 30% Occupancy Threshold / # of Potential Observations		Number of Intervals Exceeded Using 35% Occupancy Threshold / # of Potential Observations	
		Percentile		Percentile	
		90	95	90	95
AM	SB SR 99 @ N. 200th St.	30/71	4/36	13/71	2/36
PM	NB SR 99 @ N. 200th St.	22/90	11/45	15/90	9/45
AM	SB SR 522 @ NE 165th St.	19/74	10/37	2/74	1/37
PM	NB SR 522 @ NE 165th St.	28/78	18/39	13/78	8/39

As is shown in Table 2, on days when plan conditions on the freeway were met, neither arterial appeared to experience a significantly higher increase in demand. The results, while certainly not conclusive, do not support the existence of an interactive relationship between freeway conditions and the conditions on either arterial.

The calculation of timing plans for the alternative control plans (i.e., the plans for extreme congestion) was difficult. Because most movements in the study area were at or near saturation levels for much of the peak period, it was inappropriate to use existing traffic volume counts as a measure of this increased demand. This is because these volumes did not reflect increased demand on the facility when route shifting took place, since volumes could not grow beyond saturation levels. (Essentially, once the facility broke down, the volumes no longer reflected actual demand.)

To develop alternative timing plans, the existing design levels of traffic were expanded by various factors between 5 and 15 percent. The impacts of these volume increases on the optimal timing plans were then studied, and new plans (for the higher levels of volume) were created. These plans were then loaded into the local controllers under specific plan names so that they could be implemented as part of the integration system.

INTEGRATION SYSTEM IMPLEMENTATION LIMITATIONS

To implement the system, the project team worked with BiTrans Corporation (the firm that wrote the software that operates the two arterial networks) to define the communications protocols and techniques described earlier in this report. As part of this work, several alternative techniques were explored for connecting the integration computer to the arterial central computer.

Because the communications between these two components consist of writing to and reading from designated data files, the researchers thought that the capabilities of conventional, microcomputer based local area network (LAN) firmware would suffice. Two LAN technologies were selected, but both proved to be unreliable.

The initial solution was simple disk sharing software called Desklink. This software allows two computers, hooked together via RS-232 cabling, to share one hard disk. This very simple LAN alternative appeared to be exactly what was needed, given the selected method for transferring data and control commands between the integration and arterial central computers.

Unfortunately, the Desklink software was not designed to give two computers simultaneous access to one hard disk. More importantly, the Desklink software did not support automated file locking (in which the software program prevents one computer from accessing a file while another computer is using that file). As a result, difficulties arose when both the arterial central and integration computers simultaneously tried to access the same data file. When this occurred, an error message was sent to the second computer (whichever computer requested access to the file last). This message suspended the program running on that computer and required an operator response (a keystroke) to reactivate the program.

By itself, the error message did not cause either the arterial central or the integration computer software to "bomb." However, the functioning of both programs was interrupted until a key was pressed, and during that time, the integration system ceased functioning. Because the system was not monitored by a WSDOT staff person, this message could remain unobserved for several hours (and often several days.)

This situation was unacceptable. A variety of programming techniques were investigated to prevent the two computers from attempting to access the shared files simultaneously, including

- timing the two programs so that they requested information at specific but different times,
- creating a file copying scheme to reduce the time during which the two computers needed access to shared files,

- creating a file locking scheme that circumvented the limitations in the disk sharing software, and
- modifying the disk sharing software so that it sent a simple error message that could be handled by the software rather than requiring a physical keystroke.

Unfortunately, none of these solutions worked well enough to allow unstaffed operation.

The next solution was to employ a more complete LAN software system, rather than using the disk sharing software. BiTrans selected the LANTastic network software, and the project team tested it.

The problems that occurred were similar to the file sharing difficulties described above. The programming errors differed, but the end result was similar: an interruption in the integration system until an operator responded.

Program interruptions under the LANTastic system were less frequent than under the Desklink system, but the interruption still required operator input to resume system operations, and the system interruption suspended all integration system operations, including data collection and the implementation of control plan modifications.

When the integration system was not operating, the three control systems continued to operate in the mode under which they were last set, with unfortunate consequences for the arterial system. On the arterial system, if a "special" timing plan was implemented by the integration computer, that plan would operate until the integration computer commanded the system to resume normal operations. If the integration computer became inoperative while a special timing plan was effective, that plan would continue to operate indefinitely, even when it was totally inappropriate. (For example, an AM peak period timing plan might continue to operate in the PM peak, providing progression in the wrong direction.) This result was so undesirable that the system was never fully implemented.

Another consequence of system suspension was the inability to collect detector information from the arterial system. This problem significantly reduced the number of data available for analysis.

Despite the inability to fully implement the integration system, the basic integration system functions could be tested. This was done by telling the integration system to send all command instructions to a dummy 170 controller. With the controller, the researchers could determine whether the integration system was correctly monitoring the freeway and arterial systems and sending the appropriate commands. At the same time, if the integration system froze, no traffic control difficulties would arise in the field.

The biggest limitation to this test procedure was that the researchers could not measure the performance of the "special" timing plans selected by the integration system. As a consequence, the evaluation of the impacts of system integration relied on simulations of the arterials, as explained in the following chapter.

ISSUES FOR MULTI-JURISDICTIONAL IMPLEMENTATIONS

As with most undertakings of this nature, several issues had to be addressed during the development and implementation stages of this integration project. However, because all of the transportation facilities involved in this project were under the direction of one agency, WSDOT, many of the inter-jurisdictional issues that might have arisen had multiple agencies been involved did not have to be addressed. Most of the issues dealt with in this project related to implementation obstacles specific to the hardware and software.

The following issues had to be addressed before and during the implementation process. While the ability to reach consensus for many of these issues was enhanced because the project involved only one jurisdiction, they still represent important questions. These issues are also applicable to implementation of a similar system on a broader scope.

Level of Control Issues

Defining the level or type of control that the integration component would be allowed was an issue from the onset of the project. The determination to allow direct selection of traffic signal and ramp control plans was based on the following factors.

- The integration control algorithms would be defined to detect only extreme cases of traffic congestion. This would minimize the number of actual control plan changes that would take place, reducing the impacts to the control systems.
- This type of operation would simplify the required modifications to the two control system central computers.
- The WSDOT would retain the ability to define the actual control plans that would be implemented.

If this system had involved integrating the operations of additional control systems under the direction of other jurisdictions, the degree of control allowed the integration system would have depended on the desires of each agency. The result would have been an integration system designed to allow the operators of each control system to define

- the conditions that dictated when an action be implemented on their system, and
- the type of action.

This operator control could be accommodated by partitioning the control aspects of the integration system into individual control modules. Each agency could be given access to only its module. In this configuration, each agency would have direct access to and control in defining the algorithms that affect its system.

The integration actions would also have to definable. Instead of receiving a control plan implementation command from the integration computer, some agencies might be more interested in receiving such information as

- the volume from a detector location,
- the characteristics of a control plan in operation on a neighboring system, or
- notification of a condition or event implemented or detected by another of the on-line control systems.

Each agency would be able to define control algorithms on the basis of not only detector volume and occupancy, but also a multitude of other parameters or conditions.

<u>**Data Collection**</u>

If the control plan variables were expanded beyond volume and occupancy, this information would have to be available. It might or might not be, depending on the data collection capabilities of each control system (most of the signal systems reviewed had them). Related issues include the data that should be collected from each system, the data collection interval that should be used, and how these data should be stored.

Defining the appropriate data collection period was discussed in a previous chapter and so will not be mentioned here, except to say that as long as a minimum collection period was agreed upon, longer intervals could be developed by grouping multiple periods.

The data that should be collected would depend on the needs of all system operators and how they desired to define their integration control strategies. For this demonstration project, the researchers wanted to detect extreme congestion on the three facilities. As a result, they decided to collect only volume and occupancy data. In a broader scope, a data collection effort might have to be expanded to include items such as

- current control system status. This might involve cycle length, intersection offsets, or individual ramp metering rates;
- system pre-emptions. This could involve the type used for emergency vehicles, railroads, or priority bus treatments; and
- green time allocation data.

This type of data collection is available with many current signal systems. Regardless of the types of data that might be collected, the configuration of the integration system developed for this project would likely require modification to accommodate the needs of additional users or participants.

The data collection portion of the integration system would likely take the form of a network data library, which would allow each user access to the data collected from all on-line systems. Each agency would be able to select the types of information desired in defining its own control algorithms.

Integration System Hardware

The type of computer hardware that should be used would depend on the capabilities required of the integration system. Factors that would affect this determination include

- the number of users,
- the desired data collection interval,
- the number of data that would be collected and stored, and
- the number of control algorithms that might be effective at any one time.

As discussed earlier, a problem in implementing this project's integration system was the communications limitations of the hardware and software. In implementing a system of this nature on a broader scope, communications might very well determine the selection of computer hardware.

User Access

If this system had been developed to integrate the operation of traffic control systems under the direction of several agencies, user access to the system certainly would have been an issue.

Where the integration component should be located and how each user would gain access would be important questions. These concerns would probably be addressed by defining the system configuration to replicate that of a local area network.

The local area network, or LAN, system provides communications among multiple computers. In its typical configuration, a LAN system designates one or more computers as file servers and then allows other computers on the system to access these file servers. This allows file sharing, centralized data storage, and information exchange to occur among all users on the system.

In a multi-user integration system, the integration component would act as the central file server, collecting and storing all system data and containing all user control algorithms. The integration component would communicate directly with each of the control system's central computers via dedicated communications circuits, either agency owned or leased telephone lines. User access to the system would only be required when modifications to control algorithm parameters were necessary. Communications could be facilitated by adding communications ports to the integration computer for dial-up access. With the appropriate software, each user would have remote access to the integration computer through an additional computer, probably a typical desktop PC.

Additional Considerations

Additional factors that would play a role in defining the structure and operation of the integration system when multiple agencies were involved include the following:

- the designation of a lead agency for development of the system,
- an agency to take ultimate responsibility for the operation of the system,
- the capabilities of each agency's control system,
- the practicality of providing the necessary modifications to these systems,
- the availability of expertise required to define and develop the system, and
- the availability of funding alternatives.

These issues and others would all determine the shape of the final integration system.

DETERMINING THE NEED FOR INTEGRATION

Integrating the operation of independent traffic control systems can represent a major change in operating philosophy for many agencies. Fundamental questions that each agency should ask itself when considering the need for area-wide integration include whether a system of this nature is necessary and the benefits that can be derived from it. The answers to these questions can vary considerably, depending upon the needs of the area. Questions that agencies could ask themselves include the following.

- How do traffic conditions or events outside of my area of responsibility or control impact my control system(s)?
- Do I need traffic data from other systems to optimally operate my own system?
- Do current methods adequately meet my agency's need to exchange information with neighboring agencies?
- At what level am I able to operate my control systems now? Do I have the expertise available to utilize the features available in this type of system?

Questions and issues such as these have to be addressed at the very onset of developing a viable integration system. How they are addressed will be of great significance in determining the amount of support that a project of this nature will receive.

CHAPTER 6

SYSTEM EVALUATION

The research team evaluated the traffic impacts on the three facilities that integration of the three independent traffic control systems would produce. The evaluation involved determining the operational improvements on the arterials that would result from the integration. To do that, the arterials' performance under existing, or non-integrated, operations was compared with their performance under integrated control conditions.

The integration system was set up to respond only to freeway incidents that were significant enough to measurably affect the arterials. Therefore, there were three arterial conditions to study for each time period. These conditions were as follows:

- Condition 1 - No freeway incident (normal arterial conditions and control plans),
- Condition 2 - Freeway incident without arterial control parameter modifications (increased arterial demand and normal control plans), and
- Condition 3 - Freeway incident with arterial control parameter modifications (increased arterial demand and control plan modifications).

ALTERNATIVE METHODS OF EVALUATION

There are two methods for evaluating the impacts of changes in physical control systems. The preferred method is to measure physical changes in traffic performance that result from the changes in the traffic control system. The alternative is to use a computer model to simulate the roadway system under differing traffic control plans.

The advantage of directly measuring the impacts of the tested system is that errors are not introduced to the analysis as a result of limitations in the simulation model or through false assumptions inherent in developing or calibrating the model. The advantages of using simulation are that fewer data are needed for the simulation model, and many externalities can occur during field tests that mask the impact of the systems being tested. (For example, a volume increase on a road may be due to the opening of a new shopping center, rather than because the control system encouraged that volume growth.)

For this project, field data collection studies were initially planned; however, computer simulation was eventually selected because of difficulties encountered in implementing the integration system. These difficulties and the limitations they produced are explained below.

Because the intent of the integration project was to provide control system adjustments only in extreme conditions (one to two times a month on average), and because no advance warning of these conditions was possible, field data collection personnel would have been required to conduct field studies on an ongoing basis until enough "extreme condition" periods occurred to provide an accurate comparison. Many months of data collection would probably have been required.

This problem was exacerbated by the project team's reluctance to let the integration system directly control the arterial system (see Chapter 5, Implementation). To use the integration system to control the arterial systems, one to three WSDOT personnel (depending on the number of hours the system operated) would have been needed to operate the control system to keep it from freezing the arterial control systems inappropriately.

A final limitation was the significant change in traffic performance that resulted from the upgrade to the traffic signal system accomplished as part of this project. (New traffic signal plans and improved signal coordination were implemented at the beginning of this project.) It became difficult to separate the changes caused by the new timing plans from those caused by the integration system.

As a result, arterial simulation was selected as the best method for evaluating the impacts of the integration system.

TRANSYT 7F

The simulation program chosen for the evaluation was the Traffic Network Study Tool, more commonly known as TRANSYT. The version selected for this project was 7F - Release 6.0, Version 4.

The TRANSYT model is a macroscopic, deterministic, simulation model modified to provide system optimization capability. [15] It was originally developed by Robertson, of the Transport and Road Research Laboratory of Great Britain, in 1968. Adaptations to this model were made by the University of California, Berkeley, in 1977 and by the University of Florida in 1983. These adaptations made the model applicable to American cities, as well as easier to use.

The TRANSYT model is primarily used to optimize traffic signal operations along an arterial or within a grid system. However, it is suitable in simulating and evaluating existing coordinated signal system operations. Assuming accurate model calibration, TRANSYT provides measures of effectiveness (MOEs) such as vehicle delay, uniform stops, queue lengths, and fuel consumption.

MEASURES OF EFFECTIVENESS

The TRANSYT model has the capability to simulate traffic conditions on a signalized arterial and then calculate measures of effectiveness that describe that operation. This section discusses the MOEs that are estimated by the TRANSYT model and that were utilized to evaluate the effectiveness of the control system modifications selected by the integration system.

1. **Delay** - The amount of detainment or hesitation time lost to the motorist because of the operation of the traffic signal is referred to as delay. Two delay measures are commonly used to evaluate traffic signal performance. The first of these measures is referred to as stopped delay.

   Stopped delay is a measure of the amount of time vehicles stopped at the intersection spend waiting for right-of-way. It is commonly stated in the form of total stopped delay (veh-hr) or average stopped delay (sec/veh) and can be calculated for each movement or combined into a total intersection measure.

A second measure for delay is approach delay or uniform delay. Uniform delay combines stopped delay with the time vehicles spend coming to a stop, hesitating, or slowing because of queue discharge, and accelerating back to running speed. Thus, uniform delay is a measure of the total time vehicles spend not traveling at the prevailing running speed. It is based on the assumption that demand is uniformly distributed throughout the study period.

Uniform delay is one of the TRANSYT model's MOEs. Its estimation is based on the Webster method of delay calculation. This method is applicable for degrees of saturation less than 95 percent. Past research has demonstrated that when the degree of saturation exceeds 95 percent, additional delay estimations are required. [15] These additional estimations are referred to as random delay and saturation delay. The TRANSYT delay algorithm combines the effects of these two additional delay estimations into a single component, referred to as random delay.

The TRANSYT model also combines these two delay components, uniform and random delay, into single delay component, referred to as total delay, expressed in vehicle hours (veh.-hr.). The model also provides a second form of this delay estimation, average vehicle delay, which is expressed as average delay per vehicle (sec./veh.).

2. **Fuel Consumption** - The TRANSYT model calculates fuel consumption on the basis of the following MOEs:

- total travel (vehicle - miles),
- total delay (vehicle - miles / hour),

- total stops (vehicles / hour), and
- cruise speed (mph).

Note that various program assumptions (non-operator controlled variables) are part of this estimation. These assumptions include vehicle type and performance, roadway grades, and roadway surface quality. Therefore, this estimation is not intended to be used as an absolute value but as a comparison between operational plans.

3. **Total Operating Cost** - The TRANSYT model estimates total operating cost for the system. This MOE includes roadway user costs such as vehicle operation, fuel consumption, and passenger time. It does not include system operating cost (control equipment maintenance, operating personnel). As in the case of fuel consumption, this estimation contains assumptions that the operator cannot alter. Therefore, this estimation should not be treated as an absolute value but used as a method of comparing benefits between operational plans.

MODEL CALIBRATION

The existing coordination plans for both arterials were developed and implemented by the WSDOT. SR 99 was selected for simulation primarily because of data availability. Because traffic conditions are similar on both arterials, the results attained through simulation were likely similar.

TRANSYT data decks were established for the AM and PM peak hour condition for SR 99. The result was two sets of data, each containing the respective signal timing plan. Traffic volume data were collected in two forms: AM and PM turning movement counts for each intersection provided by WSDOT, and arterial mainline volume data obtained by the integration program from each of the control systems.

Initial simulation runs were conducted with the model's default values for the various flow characteristic parameters, and MOEs for each of these runs were obtained. These MOEs were then compared to the conditions observed in the field.

The primary MOE used for the initial calibration of each set of data was the expected maximum queue length. Each of the initial simulation runs resulted in expected maximum queue lengths; in some locations these were significantly longer than those observed in the field. As a result, the following adjustments were made to the model,

1. Saturation flow rates were adjusted with the Highway Capacity Manual Software.
2. The network-wide, start-up lost time was decreased from 3.7 seconds to 3.0 seconds on the basis of the aggressive driving habits observed.
3. The network-wide extension of the effective green interval into the change interval was increased from 0 seconds to 2.0 seconds, again on the basis of field observations.
4. The number of allowed left turn sneakers (left turns permitted during the clearance) was increased from 0 to 1 vehicle per cycle. This change was also based upon observed driving habits.

A second set of simulation runs were then conducted with the above modifications. However, although the results of these runs were closer to actual observations, some inaccuracy remained in predicted side street queuing at certain locations.

The coordination plan timings and amount of time actually required for each movement were compared for the intersections in question. The traffic signal control software used on SR 99 includes a feature referred to as "fully actuated coordination." While the program does not actually operate in a fully actuated mode, it does allow the main line movements to "gap out" after a fixed amount of time and yield to non-main line movements before their maximum time has expired. This "gap out" condition occurs if mainline demand is less than the volume required to extend the movement to the maximum allowable green time. When this low volume occurs, the extra time is given to the next movements in the sequence. Again, if these movements require less than their allotted time, this extra time is transferred to the following movements. The effect of this feature is that some movements may receive more than their allotted amount of time. A check of the amount of time distributed to each movement indicated that this redistribution of cycle time was occurring. When queuing was greater than observed, these movements were actually receiving more time than the timing plan indicated.

The signal timing data for the intersections in question were modified, and new simulation runs were conducted. The results of these third runs compared satisfactorily with observed traffic conditions. The final simulation runs for both the AM and PM conditions are found in Appendix 2.

Volume Adjustments

The turning movement data utilized in initial simulations were collected manually in the field. These counts were then compared to the main line detector data retrieved from arterial data stations. The detector data accumulated during the associated manual count period were compared to daily averages for that time period to determine whether traffic conditions were normal, or volume adjustments were required. If adjustments were considered necessary, all respective movements were adjusted according the ratio of the average directional detector volume for that period to the actual directional detector volume for that same period. Side street through movements were adjusted by the average of the two directional adjustment factors.

This same method of volume adjustment was used to determine "incident condition" turning movement volumes with the following exception. Because an incident on the freeway would cause actual freeway volume, as well as potential freeway demand, to divert to the arterial, side street volumes on the arterial were only adjusted on the freeway side approaches. This resulted in side street adjustments in the westbound direction only at each of the SR 99 intersections.

Because a specific increase in arterial volumes during assumed incident conditions was not readily apparent, adjustment factors were assumed. The factors used in these adjustments were a 30 percent increase for the affected mainline movement, and a 10 percent increase for the affected side street movements.

SIMULATION RESULTS

The results of the simulation runs conducted for this evaluation are shown in Tables 3 and 4, below.

Table 3. SR 99 AM Peak Simulation Comparisons

Condition	Cycle Length (Sec)	Total Delay (V-Hr)	Ave. Delay (Sec/Veh)	Fuel Cons. (Gallons)	Total Cost ($$)
1. Normal Conditions	160	271	47.3	498	1731
2. Incident Cond. w/o Modification	160	911	135.0	1036	3082
3. Incident Cond. w/ Modification	180	810	120.4	933	2787

Table 4. SR 99 PM Peak Simulation Comparisons

Condition	Cycle Length (Sec)	Total Delay (V-Hr)	Ave. Delay (Sec/Veh)	Fuel Cons. (Gallons)	Total Cost ($$)
1. Normal Conditions	150	376	50.1	690	2408
2. Incident Cond. w/o Modification	150	1253	147.5	1399	4137
3. Incident Cond. w/ Modification	180	1060	125.0	1240	3742

Discussion

The results displayed in Tables 3 and 4 indicate that, under these assumed conditions, the ability to detect and respond to extreme or unusual traffic conditions could significantly increase system performance.

With this ability, average vehicle delay under incident conditions would be reduced by 10 to 15 percent, which would result in a fuel savings of approximately the same range. The end result would be a reduction in user operating costs of approximately 10 percent.

Assuming similar results could be attained on SR 522, with an estimated freeway incident rate of approximately two per month at a duration of 1 hour per incident, and an average fuel cost of $1.30 per gallon, the annual savings in fuel consumption for both arterials combined would be approximately $16,000 per year. The time savings that would result would be approximately 14,000 vehicle-hours per year, or, at an assumed vehicle occupancy rate of 1.2, nearly 18,000 person-hours per year.

Sensitivity of Results

Additional simulation runs were conducted to determine how changes in volume adjustment assumptions during incident conditions might affect these results. Affected movements were adjusted with a range of adjustment factors. The results of the simulations both with and without the integration timing modifications were then compared. The results of this analysis are displayed in Tables 5 and 6, below.

In conducting this analysis, the relationship between mainline volume adjustments and side street volume adjustments remained constant (a ratio of 3 to 1).

The results indicated that similar benefits would be attained under various degrees of demand adjustments. However, this analysis assumed that different signal control plans would be implemented for each separate condition. This would require that either

1. actual diversion could be accurately measured in the field, and control plans would be selected accordingly, or

2. a single incident control plan would be used but only implemented when a large enough incident took place to ensure that the anticipated diversion did occur.

This second condition provided the basis of the control plan modification for this project.

Table 5. Traffic Demand Sensitivity Summary - AM

Vol. Increase (Mainline / Side street)	Ave. Delay w / out Mod. (Sec./Veh.)	Ave. Delay with Mod. (Sec./Veh.)	Delay Reduction (%)
10% / 3%	62.3	55.0	12
20% / 6%	88.1	72.9	17
30% / 10%	135.0	120.4	11
40% / 13%	188.9	143.1	24
50% / 16%	249.1	196.6	21

Table 6. Traffic Demand Sensitivity Summary - PM

Vol. Increase (Mainline / Side street)	Ave. Delay w / out Mod. (Sec./Veh.)	Ave. Delay with Mod. (Sec./Veh.)	Delay Reduction (%)
10% / 3%	72.7	62.7	14
20% / 6%	106.0	82.4	22
30% / 10%	147.5	125.0	15
40% / 13%	191.0	163	15
50% / 16%	237.8	208.7	12

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

The integration method developed by this project was successful in meeting the majority of project objectives. However, problems arose in implementing the integration system. The links between the integration computer and the arterial central computer made communications unreliable between those two components. This problem could probably have been overcome with more highly sophisticated computer networking techniques.

The communications problem limited the implementation of the integration system to short duration functionality testing. Nevertheless, these tests proved to be successful. The integration computer was able to accurately receive data from the freeway control system, as well as from both arterial signal control systems. Success was also achieved when control parameter changes were sent from the integration computer to the respective control systems.

Computer simulation with the Transyt 7F model helped the researchers estimate the benefits of providing this type of control capability. They evaluated the benefits to the arterial system of integrating these control systems during freeway incidents. The evaluation demonstrated that measurable benefits in facility performance could be expected, given full implementation of this system. The degree of these benefits would be a function of the control parameters used (i.e., how often the system was set to override the normal operations of the existing systems) and the level of interaction between systems. However, because the demonstration system was programmed to respond only to extreme, non-recurrent congestion (with incident occurrence rates of approximately two per month), the estimated benefits for this project were limited.

RECOMMENDATIONS

The demonstration system developed for this project was limited, and the concept of control system integration has potential for application far beyond those implemented here. Such applications could be as simple as coordinated traffic signal control along arterials that cross control system or operating agency boundaries, or as broad as regional control and monitoring capabilities in a multi-user, multi-jurisdictional environment.

Broadening the application of traffic control system integration is, in itself, an area for which further study is justified. More information is needed for both the physical task of integrating independent traffic control systems and the challenge of addressing the jurisdictional issues associated with such an endeavor. Addressing these issues should provide significant benefits to the participating agencies.

Also needed is a standard method for supporting this capability in future traffic control systems. Appendix B of this report contains traffic control equipment specifications that are applicable to the method of integration developed and employed by this project. Further development of these specifications, with the goal of their acceptance by the traffic control equipment industry, would certainly be a significant step toward making traffic control system integration a viable component of traffic congestion management.

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APPENDIX A

TRANSYT 7F SIMULATION MODELS

SR 99 AM PEAK

EXISTING CONDITIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991

VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/23/92 START TIME OF RUN: 17: 0:44

I N P U T   D A T A   R E P O R T   F O R   S R 9 9   A M   P E A K

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	90	180	10	3	0	3	4	15	1	0	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	207	208	212	0	0
7	301	309	0	0	0	303	310	0	0	0	305	311	0	0	0
7	307	312	0	0	0	0	0	0	0	0	0	0	0	0	0
7	401	409	0	0	0	403	410	0	0	0	405	405	411	0	0
7	407	408	412	0	0	0	0	0	0	0	0	0	0	0	0
7	501	509	0	0	0	503	510	0	0	0	505	506	0	0	0
7	507	508	512	0	0	0	0	0	0	0	0	0	0	0	0
7	601	609	0	0	0	603	610	0	0	0	605	611	0	0	0
7	607	612	0	0	0	0	0	0	0	0	0	0	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155th St.

15	1	0	1	5	4	1	0	5	15	4	1	5	4	1	0
18	1	5	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	7	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	25	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	15	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	15	107	108	112	0	0	0	0	0	0
28	101	1000	3500	500	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	40	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	44	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	1495	115	203	1351	35	208	15	35	211	130	35	0
28	104	200	1600	70	0	203	63	35	211	10	35	0	0	0	0
28	105	500	0	84	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	177	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	25	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	229	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	162	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	153	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160th St.

14	2	0	1	5	4	1	0	5	10	4	1	7	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	8	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	20	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	15	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	527	115	101	319	35	106	164	35	112	97	35	0
28	202	200	3200	245	0	101	148	35	112	45	35	0	0	0	0
28	209	1347	0	10	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1826	115	303	1755	40	308	298	40	311	41	40	0
28	204	200	1600	13	0	303	13	40	0	0	0	0	0	0	0
28	210	200	1600	272	0	303	261	40	0	0	0	0	0	0	0
28	205	500	1600	33	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	103	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	175	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	57	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	20	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	16	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175th St.

15	3	0	1	5	4	1	0	4	1	10	4	1	5	4	0
18	3	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	11	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	11	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	11	307	308	312	0	0	0	0	0	0
28	301	4042	3400	405	115	201	330	40	206	103	40	212	16	40	0
28	302	200	1600	30	0	201	30	40	0	0	0	0	0	0	0
28	309	4042	0	14	0	201	14	40	0	0	0	0	0	0	0
28	303	2694	3400	1737	115	403	1525	35	408	124	35	411	86	35	0
28	304	300	3200	71	0	403	62	35	0	0	0	0	0	0	0
28	310	2694	0	23	0	403	20	35	0	0	0	0	0	0	0
28	305	500	3200	292	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	29	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	65	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	210	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	483	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	41	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	0	1	5	4	1	0	5	1	10	4	1	5	4	0
18	4	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	20	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	15	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	15	405	406	411	0	0	0	0	0	0
28	402	340	3279	46	0	301	39	35	0	0	0	0	0	0	0
28	401	2658	3564	380	116	301	324	35	312	39	35	306	28	35	0
28	409	2658	0	29	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	48	0	503	47	40	0	0	0	0	0	0	0
28	403	500	3503	1607	0	503	1580	40	508	16	40	511	11	40	0
28	410	500	0	38	0	503	37	35	0	0	0	0	0	0	0
28	406	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	249	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	92	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	131	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	112	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	35	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	0	1	10	4	1	5	4	0	0	0	0	0	0	1
21	5	1	1	2	3	20	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	441	115	401	351	40	406	60	40	112	34	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	14	0	401	14	40	0	0	0	0	0	0	0
28	503	2189	3400	1607	115	603	1551	40	608	30	40	611	30	40	0
28	504	200	0	39	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	79	0	603	76	40	0	0	0	0	0	0	0
28	505	500	1700	13	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	21	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	11	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	19	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	16	0	0	0	0	0	0	0	0	0	0	0
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	512	500	0	21	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	0	1	5	4	1	10	5	5	4	1	5	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	25	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	11	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	11	607	608	612	0	0	0	0	0	0
28	601	2189	3400	467	115	501	440	40	506	17	40	512	12	40	0
28	602	200	1600	10	0	501	10	40	0	0	0	0	0	0	0
28	609	2189	0	22	0	501	22	40	0	0	0	0	0	0	0
28	603	1347	3400	1782	115	703	1533	35	708	194	35	711	61	35	0
28	604	200	1600	29	0	703	25	35	0	0	0	0	0	0	0
28	610	1347	0	17	0	703	15	35	0	0	0	0	0	0	0
28	605	500	1600	43	0	0	0	0	0	0	0	0	0	0	0
28	606	500	1400	32	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	32	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	17	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	38	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	32	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	106	1	5	5	1	15	4	5	5	1	5	5	1	0
21	7	1	1	2	3	11	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	25	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	11	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	15	705	707	711	712	0	0	0	0	0
28	701	1347	3400	411	115	601	361	35	606	31	35	612	31	35	0
28	702	200	1600	16	0	601	14	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	88	0	601	77	35	0	0	0	0	0	0	0
28	703	500	3400	1585	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	34	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	155	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	326	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	162	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	249	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	196	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	34	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

PLOT AND OPTION CARDS

31	1	0	201	301	401	501	601	701	0	0	0	0	0	0	0
52	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CYCLE EVALUATION SUMMARY PERFORMANCE

CYCLE LENGTH (SEC)	STEP SIZE (STEPS)	AVERAGE DELAY (SEC/VEH)	PERCENT STOPS (%)	FUEL CONSUMPTION (GAL/HR)	PERFORMANCE INDEX	NUMBER SATURATED LINKS
90	30	134.44	52	857.8	828.9	12
100	34	85.94	61	670.3	3059.9	12
110	38	68.01	58	588.2	483.8	9
120	40	53.91	58	529.7	371.6	5
130	44	48.74	58	507.9	341.9	5
140	48	47.71	60	507.5	339.6	5
150	50	50.01	58	511.7	352.1	5
160	54	47.70	56	499.5	335.7	5
170	58	49.63	63	521.2	354.3	8
180	60	48.26	61	510.2	343.9	5

BEST CYCLE LENGTH = 160 SEC. CYCLE SENSITIVITY = 124.7 %

AURORA AVE AM PEAK NORMAL CONDITIONS
CYCLE: 160 SECONDS, 60 STEPS

<PERFORMANCE WITH OPTIMAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	: 25	94.76	5.13	2.41	17.3	238.(48)	11	80	7.15
102	: 27	1.52	.87	.83	74.3	38.(94)	2	16	1.00
103	: 71	366.99	15.86	5.50	13.2	587.(39)	31	108	22.45
104	: 47	2.65	1.56	1.48	76.2	57.(82)	3	8	1.72
105	S: 90	7.93	2.41	2.18	93.5	82.(97)	106	106S	2.51
106	P: 90	16.72	5.08	4.60	93.5	172.(97)	12	40	5.29
107	P: 82	21.63	5.26	4.64	72.9	215.(94)	17	40	5.82
108	S: 82	15.30	3.72	3.28	72.9	152.(94)	107	107S	4.12
109	: 5	4.16	.31	.19	15.2	19.(42)	1	20	.43
111	S: 90	2.36	.72	.65	93.5	24.(97)	106	106S	.84
112	: 45	14.45	2.76	2.35	55.3	129.(84)	6	20	3.23
NODE	1: 90	548.46	43.67	28.09	33.9	1712.(57)			54.55
201	P: 22	119.77	4.06	.68	4.6	126.(24)	7	108	6.00
202	: 64	9.29	5.30	5.04	74.0	206.(84)	9	16	5.63
203	: 83	1353.46	42.44	8.93	17.6	688.(38)	32	323	61.71
204	: 22	.49	.44	.43	118.9	13.(102)	1	8	.45
205	P: 80	3.12	.80	.71	77.4	31.(94)	9	20	.99
206	: 65	9.73	2.43	2.15	75.1	97.(94)	4	20	2.67
207	P: 38	5.38	1.14	.99	62.5	50.(87)	3	20	1.30
208	S: 21	1.89	.37	.32	57.3	17.(84)	207	207S	.50
209	S: 22	2.55	.09	.02	6.6	3.(29)	201	201S	.23
210	: 26	10.31	.43	.17	2.3	57.(21)	3	8	1.07
211	S: 80	16.53	4.24	3.76	77.4	164.(94)	205	205S	4.61
212	S: 38	1.51	.32	.28	62.5	14.(87)	207	207S	.42
NODE	2: 83	1534.03	62.06	23.47	25.6	1466.(44)			85.58
301	P: 28	265.64	9.55	2.97	26.4	217.(54)	10	323	13.83
302	: 43	1.14	.94	.91	109.0	30.(98)	1	8	.97
303	P:105*	856.53	89.44	65.26	135.3	1596.(92)	87	216	92.55
304	: 24	4.01	1.97	1.86	94.2	59.(84)	3	24	1.97
305	P:105*	27.58	16.91	16.11	198.7	278.(95)	31	40	14.92
306	: 17	2.74	.61	.53	65.6	26.(89)	1	20	.79
307	P: 30	19.83	3.34	2.77	47.5	162.(77)	9	40	4.00
308	:118*	45.62	49.57	48.26	359.7	410.(85)	35>	20C	40.14
309	S: 28	10.72	.39	.13	32.8	9.(66)	301	301S	.57
310	S:105*	11.73	1.18	.85	133.0	20.(88)	303	303S	1.22
311	S:105*	6.14	3.76	3.59	198.7	62.(95)	305	305S	3.32
312	S: 30	3.87	.65	.54	47.5	32.(77)	307	307S	.78
NODE	3:118*	1255.56	178.31	143.78	152.2	2901.(85)			175.05

AURORA AVE AM PEAK NORMAL CONDITIONS
CYCLE: 160 SECONDS, 60 STEPS

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
401	P: 19	162.07	6.31	1.74	16.5	175.(46)	8	213	8.76
402	: 14	2.97	1.21	1.13	88.4	46.(100)	2	27	1.40
403	P: 85	151.78	10.70	6.94	15.6	460.(29)	21	40	15.11
404	: 50	1.37	1.27	1.23	92.5	48.(99)	2	6	1.37
405	P: 83	23.52	5.84	5.16	74.6	234.(94)	17	40	6.42
406	S: 83	5.86	1.45	1.28	74.6	58.(94)	405	405S	1.60
407	P: 84	10.58	2.88	2.58	82.9	107.(96)	12	40	3.09
408	S: 84	12.37	3.37	3.02	82.9	125.(96)	407	407S	3.62
409	S: 19	14.60	.54	.12	14.8	13.(44)	401	401S	.74
410	S: 85	3.59	.27	.17	16.0	11.(29)	403	403S	.34
411	S: 83	8.69	2.16	1.91	74.6	86.(94)	405	405S	2.37
412	S: 84	3.31	.90	.81	82.9	33.(96)	407	407S	1.09
NODE	4: 85	400.69	36.91	26.09	33.2	1397.(49)			45.90
501	P: 16	122.09	3.11	.09	.7	43.(10)	2	135	4.85
502	: 8	.38	.03	.02	8.5	6.(62)	0	8	.09
503	P: 60	641.99	18.05	2.15	4.8	878.(55)	45	175	33.27
504	: 8	1.48	.04	.01	.5	2.(6)	0	8	.13
505	P: 27	1.23	.18	.14	40.1	11.(88)	0	20	.28
506	S: 17	1.98	.25	.20	33.6	18.(88)	505	505S	.43
507	P: 41	1.79	.26	.21	39.6	17.(88)	1	20	.41
508	S: 15	1.51	.19	.14	32.4	14.(85)	507	507S	.32
509	S: 16	4.46	.11	.00	.7	1.(10)	501	501S	.17
510	S: 60	32.74	.92	.11	5.0	45.(57)	503	503S	1.70
511	: 8	1.04	.13	.10	32.5	10.(88)	0	20	.22
512	S: 41	1.98	.29	.23	39.6	18.(88)	507	507S	.46
NODE	5: 60	812.68	23.57	3.41	5.4	1064.(46)			42.36
601	P: 20	169.51	5.01	.81	6.2	113.(24)	6	175	7.78
602	: 14	.38	.20	.19	68.2	9.(92)	0	8	.24
603	P: 75	440.28	14.07	1.64	3.3	159.(9)	10	108	19.11
604	: 41	1.10	.89	.86	107.2	25.(86)	1	8	.90
605	P: 54	4.06	1.02	.90	75.4	40.(92)	3	20	1.11
606	: 26	3.02	.70	.61	69.1	29.(91)	1	20	.90
607	P: 49	1.61	.42	.38	79.8	16.(94)	2	20	.52
608	: 38	3.59	.91	.80	76.1	36.(94)	2	20	.99

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
609	S: 20	9.12	.26	.04	6.0	5.(22)	601	601S	.40
610	S: 75	4.34	.13	.01	1.3	0.(2)	603	603S	.17
611	S: 54	3.02	.76	.67	75.4	30.(92)	605	605S	.94
612	S: 49	3.02	.80	.71	79.8	30.(94)	607	607S	.97
NODE	6: 75	643.05	25.17	7.62	10.9	492.(20)			34.03
701	: 22	90.15	4.35	1.80	15.8	196.(48)	9	108	6.24
702	: 12	.61	.35	.33	74.8	16.(99)	1	8	.41
703	: 86	149.70	19.02	14.72	33.4	1286.(81)	60>	40C	26.06
704	: 26	3.21	.75	.66	69.6	31.(91)	1	20	.95
705	P: 83	30.79	7.67	6.79	74.9	306.(94)	16	40	8.43
706	: 67	6.14	3.34	3.17	70.4	148.(91)	7	8	3.65
707	P: 61	23.52	5.28	4.60	66.6	226.(91)	12	40	5.95
708	: 82	7.43	4.57	4.36	80.1	184.(94)	8	8	4.84
709	: 8	4.98	.34	.20	8.3	21.(24)	1	12	.50
710	: 14	8.76	.55	.30	6.9	45.(29)	2	12	.89
711	S: 83	5.86	1.46	1.29	74.9	58.(94)	705	705S	1.60
712	S: 61	3.21	.72	.63	66.6	31.(91)	707	707S	.93
NODE	7: 86	334.35	48.41	38.85	42.2	2547.(77)			60.47

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFORMANCE INDEX
<TOTALS>	5529	418	271	47.3	11579(56)	498	13.2	1731	332.7

TERMINATION CARD

90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

--- PROGRAM NOTE --- END OF JOB!

SR 99 AM PEAK

INCIDENT CONDITIONS WITHOUT MODIFICATIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991 VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/24/92 START TIME OF RUN: 7:28:12

INPUT DATA REPORT FOR SR 99 AM PEAK W/O INTEGRATION

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	150	160	10	3	0	3	4	15	1	0	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	207	208	212	0	0
7	301	309	0	0	0	303	310	0	0	0	305	311	0	0	0
7	307	312	0	0	0	0	0	0	0	0	0	0	0	0	0
7	401	409	0	0	0	403	410	0	0	0	405	406	411	0	0
7	407	408	412	0	0	0	0	0	0	0	0	0	0	0	0
7	501	509	0	0	0	503	510	0	0	0	505	506	0	0	0
7	507	508	512	0	0	0	0	0	0	0	0	0	0	0	0
7	601	609	0	0	0	603	610	0	0	0	605	611	0	0	0
7	607	612	0	0	0	0	0	0	0	0	0	0	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155TH ST

15	1	0	1	6	4	1	3	5	90	4	1	14	4	1	0
18	1	22	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	8	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	95	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	19	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	27	107	108	112	0	0	0	0	0	0
28	101	1000	3500	500	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	40	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	44	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	1495	115	203	1351	35	208	15	35	211	130	35	0
28	104	200	1600	70	0	203	63	35	211	10	35	0	0	0	0
28	105	500	0	84	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	177	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	25	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	229	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	162	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	153	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160TH ST

14	2	130	1	5	4	1	8	5	102	4	1	25	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	13	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	107	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	30	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	527	115	101	319	35	106	164	35	112	97	35	0
28	202	200	3200	245	0	101	148	35	112	45	35	0	0	0	0
28	209	1347	0	10	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1826	115	303	1755	40	308	298	40	311	41	40	0
28	204	200	1600	13	0	303	13	40	0	0	0	0	0	0	0
28	210	200	1600	272	0	303	261	40	0	0	0	0	0	0	0
28	205	500	1600	33	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	103	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	175	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	57	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	20	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	16	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175TH ST

15	3	124	1	6	4	1	3	4	1	70	4	1	16	4	0
18	3	1	40	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	75	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	21	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	45	307	308	312	0	0	0	0	0	0
28	301	4042	3400	405	115	201	330	40	206	103	40	212	16	40	0
28	302	200	1600	30	0	201	30	40	0	0	0	0	0	0	0
28	309	4042	0	14	0	201	14	40	0	0	0	0	0	0	0
28	303	2694	3400	1737	115	403	1525	35	408	124	35	411	86	35	0
28	304	300	3200	71	0	403	62	35	0	0	0	0	0	0	0
28	310	2694	0	23	0	403	20	35	0	0	0	0	0	0	0
28	305	500	3200	292	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	29	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	65	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	210	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	483	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	41	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	100	1	8	4	1	3	4	1	87	4	1	15	4	0
18	4	1	22	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	92	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	20	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	27	405	406	411	0	0	0	0	0	0
28	402	340	3279	46	0	301	39	35	0	0	0	0	0	0	0
28	401	2658	3564	380	116	301	324	35	312	39	35	306	28	35	0
28	409	2658	0	29	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	48	0	503	47	40	0	0	0	0	0	0	0
28	403	500	3503	1607	0	503	1580	40	508	16	40	511	11	40	0
28	410	500	0	38	0	503	37	35	0	0	0	0	0	0	0
28	406	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	249	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	92	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	131	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	112	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	35	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	56	1	65	4	1	6	4	0	0	0	0	0	0	1
21	5	1	1	2	3	70	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	441	115	401	351	40	406	60	40	112	34	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	14	0	401	14	40	0	0	0	0	0	0	0
28	503	2189	3400	1607	115	603	1551	40	608	30	40	611	30	40	0
28	504	200	0	39	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	79	0	603	76	40	0	0	0	0	0	0	0
28	505	500	1700	13	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	21	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	11	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	19	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	16	0	0	0	0	0	0	0	0	0	0	0
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	512	500	0	21	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	73	1	6	4	1	112	5	13	4	1	9	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	117	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	18	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	14	607	608	612	0	0	0	0	0	0
28	601	2189	3400	467	115	501	440	40	506	17	40	512	12	40	0
28	602	200	1600	10	0	501	10	40	0	0	0	0	0	0	0
28	609	2189	0	22	0	501	22	40	0	0	0	0	0	0	0
28	603	1347	3400	1782	115	703	1533	35	708	194	35	711	61	35	0
28	604	200	1600	29	0	703	25	35	0	0	0	0	0	0	0
28	610	1347	0	17	0	703	15	35	0	0	0	0	0	0	0
28	605	500	1600	43	0	0	0	0	0	0	0	0	0	0	0
28	606	500	1400	32	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	32	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	17	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	38	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	32	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	50	1	9	4	1	86	4	24	4	1	22	4	1	0
21	7	1	1	2	3	14	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	90	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	29	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	27	705	707	711	712	0	0	0	0	0
28	701	1347	3400	411	115	601	361	35	606	31	35	612	31	35	0
28	702	200	1600	16	0	601	14	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	88	0	601	77	35	0	0	0	0	0	0	0
28	703	500	3400	1585	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	34	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	155	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	326	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	162	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	249	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	196	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	34	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

PLOT AND OPTION CARDS

31	1	0	201	301	401	501	601	701	0	0	0	0	0	0	0
36	130	0	103	203	303	403	503	603	703	0	0	0	0	0	0
36	110	0	108	208	308	408	508	608	708	0	0	0	0	0	0
51	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

<PERFORMANCE WITH INITIAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	: 25	94.76	5.04	2.32	16.7	236.(47)	11	80	7.07
102	: 27	1.52	.88	.84	75.7	38.(94)	2	16	1.01
103	: 92	477.06	21.73	8.26	15.3	699.(36)	38	108	29.52
104	: 47	2.65	1.33	1.25	64.5	46.(66)	2	8	1.47
105	S: 90	7.93	2.38	2.15	92.2	80.(96)	106	106S	2.48
106	P: 90	16.72	5.01	4.53	92.2	169.(96)	12	40	5.22
107	P: 86	21.63	5.51	4.89	76.9	218.(95)	17	40	6.03
108	S: 86	16.81	4.28	3.80	76.9	169.(95)	107	107S	4.69
109	: 5	4.16	.30	.18	14.5	18.(41)	1	20	.42
111	S: 90	2.36	.71	.64	92.2	24.(96)	106	106S	.83
112	: 45	14.45	2.81	2.40	56.4	129.(84)	6	20	3.26
NODE	1: 92	660.04	49.99	31.27	32.7	1826.(53)			61.99
201	P: 22	119.77	4.02	.64	4.4	126.(24)	7	108	5.98
202	: 64	9.29	5.31	5.05	74.2	203.(83)	9	16	5.62
203	:108*	1759.95	147.61	104.04	157.8	736.(31)	33	323	146.35
204	: 22	.49	.34	.32	89.9	10.(76)	0	8	.35
205	P: 80	3.12	.79	.70	76.1	31.(93)	9	20	.98
206	: 64	9.73	2.36	2.08	72.5	95.(93)	4	20	2.60
207	P: 39	5.38	1.13	.97	61.5	49.(86)	3	20	1.28
208	S: 22	2.08	.42	.36	58.5	18.(84)	207	207S	.56
209	S: 22	2.55	.09	.02	6.2	3.(28)	201	201S	.23
210	: 26	10.31	.38	.13	1.7	41.(15)	2	8	.87
211	S: 80	16.53	4.18	3.70	76.1	162.(93)	205	205S	4.55
212	S: 39	1.51	.32	.27	61.5	14.(86)	207	207S	.42
NODE	2:108*	1940.72	166.93	118.27	110.7	1488.(39)			169.77

CYCLE: 160 SECONDS, 60 STEPS

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
301	P: 28	265.64	9.41	2.84	25.2	210.(52)	10	323	13.66
302	: 43	1.14	.93	.90	108.5	30.(98)	1	8	.97
303	P:136*	1113.65	372.49	341.05	543.7	1661.(74)	150	216	304.78
304	: 24	4.01	1.75	1.64	83.1	54.(77)	2	24	1.77
305	P:105*	27.58	16.54	15.74	194.1	278.(95)	24	40	14.65
306	: 17	2.74	.60	.52	64.4	25.(87)	1	20	.78
307	P: 30	19.83	3.28	2.71	46.5	162.(77)	9	40	3.95
308	:130*	50.15	73.44	72.00	488.1	410.(77)	47>	20C	57.70
309	S: 28	10.72	.39	.12	31.3	9.(63)	301	301S	.56
310	S:136*	11.73	3.85	3.52	550.4	17.(76)	303	303S	3.15
311	S:105*	6.14	3.68	3.50	194.1	62.(95)	305	305S	3.26
312	S: 30	3.87	.64	.53	46.5	32.(77)	307	307S	.77
NODE	3:136*	1517.21	487.01	445.08	403.7	2950.(74)			406.01
401	P: 19	162.07	6.23	1.65	15.7	170.(45)	8	213	8.66
402	: 13	2.97	1.21	1.12	87.9	46.(100)	2	27	1.39
403	P:110*	197.30	117.12	112.24	193.4	1612.(77)	128>	40C	105.39
404	: 50	1.37	1.07	1.03	77.3	42.(88)	2	6	1.18
405	P: 83	23.52	5.75	5.07	73.3	234.(94)	17	40	6.35
406	S: 83	5.86	1.43	1.26	73.3	58.(94)	405	405S	1.58
407	P: 88	10.58	3.08	2.77	89.2	109.(97)	13	40	3.24
408	S: 88	13.60	3.96	3.57	89.2	140.(97)	407	407S	4.17
409	S: 19	14.60	.53	.11	14.1	12.(42)	401	401S	.73
410	S:110*	3.59	2.15	2.05	194.3	29.(76)	403	403S	1.86
411	S: 83	8.69	2.12	1.87	73.3	86.(94)	405	405S	2.35
412	S: 88	3.31	.96	.87	89.2	34.(97)	407	407S	1.14
NODE	4:110*	447.45	145.61	133.62	144.7	2573.(77)			138.05
501	P: 16	122.09	3.13	.11	.9	45.(10)	2	135	4.89
502	: 8	.38	.04	.03	12.1	6.(50)	0	8	.10
503	P: 77	834.71	25.09	4.42	7.6	1513.(72)	80	175	48.17
504	: 8	1.48	.04	.01	.7	3.(7)	0	8	.14
505	P: 27	1.23	.18	.15	40.7	12.(91)	0	20	.29
506	S: 18	1.98	.24	.19	32.2	18.(85)	505	505S	.42
507	P: 43	1.79	.27	.22	41.7	17.(91)	1	20	.43
508	S: 17	1.70	.21	.16	32.1	15.(85)	507	507S	.36
509	S: 16	4.46	.11	.00	.7	1.(10)	501	501S	.17
510	S: 77	32.74	.98	.17	7.9	59.(75)	503	503S	1.89
511	: 8	1.04	.13	.10	34.1	10.(88)	0	20	.23
512	S: 43	1.98	.30	.24	41.7	19.(91)	507	507S	.47
NODE	5: 77	1005.59	30.74	5.81	7.5	1719.(62)			57.55
601	P: 20	169.51	5.06	.87	6.7	114.(24)	6	175	7.83

AURORA AVE AM PEAK EXTREME CONDITIONS W/O INTEGRATION
CYCLE: 160 SECONDS, 60 STEPS

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
602	: 14	.38	.19	.18	66.1	9.(90)	0	8	.23
603	P: 97*	572.57	24.69	8.53	13.2	336.(14)	46	108	30.53
604	: 41	1.10	.80	.76	94.9	23.(80)	1	8	.82
605	P: 54	4.06	1.03	.91	76.5	40.(94)	3	20	1.13
606	: 26	3.02	.71	.62	70.1	29.(91)	1	20	.90
607	P: 49	1.61	.43	.38	80.9	16.(95)	2	20	.52
608	: 42	3.97	1.03	.92	78.7	39.(94)	2	20	1.12
609	S: 20	9.12	.27	.04	6.5	5.(22)	601	601S	.40
610	S: 97*	4.34	.17	.05	11.1	1.(9)	603	603S	.21
611	S: 54	3.02	.77	.68	76.5	30.(94)	605	605S	.95
612	S: 49	3.02	.81	.72	80.9	30.(95)	607	607S	.98
NODE	6: 97*	775.72	35.96	14.67	17.3	674.(22)			45.62
701	: 22	90.15	4.39	1.85	16.2	195.(47)	9	108	6.27
702	: 11	.61	.36	.34	76.6	16.(99)	1	8	.41
703	:111*	194.56	143.18	137.59	240.4	1849.(90)	183>	40C	121.95
704	: 24	3.21	.73	.64	67.9	31.(90)	1	20	.94
705	P: 79	30.79	7.36	6.48	71.5	306.(94)	16	40	8.19
706	: 65	6.14	3.24	3.06	68.1	147.(91)	7	8	3.57
707	P: 58	23.52	5.17	4.49	65.0	226.(91)	12	40	5.87
708	: 86	8.19	5.32	5.08	84.7	203.(94)	9>	8C	5.55
709	: 8	4.98	.32	.18	7.3	19.(22)	1	12	.47
710	: 13	8.76	.53	.28	6.5	42.(27)	2	12	.86
711	S: 79	5.86	1.40	1.23	71.5	58.(94)	705	705S	1.56
712	S: 58	3.21	.71	.61	65.0	31.(91)	707	707S	.92
NODE	7:111*	379.97	172.71	161.84	152.8	3122.(82)			156.56

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFORMANCE INDEX
<TOTALS>	6727	1089	911	135.3	14352(59)	1036	6.2	3082239528.6	

TERMINATION CARD
90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
--- PROGRAM NOTE --- END OF JOB!

SR 99 AM PEAK

INCIDENT CONDITIONS WITH MODIFICATIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991

VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/23/92 START TIME OF RUN: 19: 5:57

I N P U T   D A T A   R E P O R T   F O R   SR 99 AM PEAK W/ INTEGRATION

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	90	180	10	3	0	3	4	15	1	0	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	207	208	212	0	0
7	301	309	0	0	0	303	310	0	0	0	305	311	0	0	0
7	307	312	0	0	0	0	0	0	0	0	0	0	0	0	0
7	401	409	0	0	0	403	410	0	0	0	405	406	411	0	0
7	407	408	412	0	0	0	0	0	0	0	0	0	0	0	0
7	501	509	0	0	0	503	510	0	0	0	505	506	0	0	0
7	507	508	512	0	0	0	0	0	0	0	0	0	0	0	0
7	601	609	0	0	0	603	610	0	0	0	605	611	0	0	0
7	607	612	0	0	0	0	0	0	0	0	0	0	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155TH ST

15	1	0	1	5	4	1	0	5	15	4	1	5	4	1	0
18	1	5	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	7	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	25	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	15	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	15	107	108	112	0	0	0	0	0	0
28	101	1000	3500	500	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	40	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	44	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	1495	115	203	1351	35	208	15	35	211	130	35	0
28	104	200	1600	70	0	203	63	35	211	10	35	0	0	0	0
28	105	500	0	84	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	177	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	25	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	229	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	162	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	153	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160TH ST

14	2	0	1	5	4	1	0	5	10	4	1	7	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	8	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	20	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	15	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	527	115	101	319	35	106	164	35	112	97	35	0
28	202	200	3200	245	0	101	148	35	112	45	35	0	0	0	0
28	209	1347	0	10	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1826	115	303	1755	40	308	298	40	311	41	40	0
28	204	200	1600	13	0	303	13	40	0	0	0	0	0	0	0
28	210	200	1600	272	0	303	261	40	0	0	0	0	0	0	0
28	205	500	1600	33	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	103	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	175	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	57	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	20	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	16	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175TH ST

15	3	0	1	5	4	1	0	4	1	10	4	1	5	4	0
18	3	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	11	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	11	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	11	307	308	312	0	0	0	0	0	0
28	301	4042	3400	405	115	201	330	40	206	103	40	212	16	40	0
28	302	200	1600	30	0	201	30	40	0	0	0	0	0	0	0
28	309	4042	0	14	0	201	14	40	0	0	0	0	0	0	0
28	303	2694	3400	1737	115	403	1525	35	408	124	35	411	86	35	0
28	304	300	3200	71	0	403	62	35	0	0	0	0	0	0	0
28	310	2694	0	23	0	403	20	35	0	0	0	0	0	0	0
28	305	500	3200	292	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	29	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	65	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	210	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	483	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	41	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	0	1	5	4	1	0	5	1	10	4	1	5	4	0
18	4	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	20	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	15	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	15	405	406	411	0	0	0	0	0	0
28	402	340	3279	46	0	301	39	35	0	0	0	0	0	0	0
28	401	2558	3564	380	116	301	324	35	312	39	35	306	28	35	0
28	409	2658	0	29	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	48	0	503	47	40	0	0	0	0	0	0	0
28	403	500	3503	1607	0	503	1580	40	508	16	40	511	11	40	0
28	410	500	0	38	0	503	37	35	0	0	0	0	0	0	0
28	406	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	249	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	92	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	131	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	112	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	35	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	0	1	10	4	1	5	4	0	0	0	0	0	0	1
21	5	1	1	2	3	20	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	441	115	401	351	40	406	60	40	112	34	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	14	0	401	14	40	0	0	0	0	0	0	0
28	503	2189	3400	1607	115	603	1551	40	608	30	40	611	30	40	0
28	504	200	0	39	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	79	0	603	76	40	0	0	0	0	0	0	0
28	505	500	1700	13	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	21	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	11	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	19	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	16	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0
28	512	500	0	21	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	0	1	5	4	1	10	5	5	4	1	5	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	25	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	11	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	11	607	608	612	0	0	0	0	0	0
28	601	2189	3400	467	115	501	440	40	506	17	40	512	12	40	0
28	602	200	1600	10	0	501	10	40	0	0	0	0	0	0	0
28	609	2189	0	22	0	501	22	40	0	0	0	0	0	0	0
28	603	1347	3400	1782	115	703	1533	35	708	194	35	711	61	35	0
28	604	200	1600	29	0	703	25	35	0	0	0	0	0	0	0
28	610	1347	0	17	0	703	15	35	0	0	0	0	0	0	0
28	605	500	1600	43	0	0	0	0	0	0	0	0	0	0	0
25	606	500	1400	32	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	32	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	17	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	38	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	32	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	106	1	5	5	1	15	4	5	5	1	5	5	1	0
21	7	1	1	2	3	11	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	25	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	11	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	15	705	707	711	712	0	0	0	0	0
28	701	1347	3400	411	115	601	361	35	606	31	35	612	31	35	0
28	702	200	1600	16	0	601	14	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	88	0	601	77	35	0	0	0	0	0	0	0
28	703	500	3400	1585	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	34	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	155	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	326	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	162	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	62	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	249	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	196	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	34	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLOT AND OPTION CARDS															
31	1	0	201	301	401	501	601	701	0	0	0	0	0	0	0
36	130	0	103	203	303	403	503	603	703	0	0	0	0	0	0
36	110	0	108	208	308	408	508	608	708	0	0	0	0	0	0
52	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CYCLE EVALUATION SUMMARY PERFORMANCE

CYCLE LENGTH (SEC)	STEP SIZE (STEPS)	AVERAGE DELAY (SEC/VEH)	PERCENT STOPS (%)	FUEL CONSUMPTION (GAL/HR)	PERFORMANCE INDEX	NUMBER SATURATED LINKS
90	30	338.72	52	2021.1	2352.6	19
100	34	275.19	41	1688.1	1905.0	19
110	38	251.66	39	1567.0	1743.9	19
120	40	236.42	42	1498.4	1646.4	22
130	44	182.08	42	1228.6	1279.2	20
140	48	183.89	41	1236.9	1291.5	19
150	50	217.90	36	1392.9	1515.3	19
160	54	214.29	33	1369.6	1486.0	17
170	58	147.92	45	1065.5	1052.8	16
180	60	134.00	47	1001.8	963.6	16

BEST CYCLE LENGTH = 180 SEC. CYCLE SENSITIVITY = 27.2 %

<PERFORMANCE WITH OPTIMAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	: 24	94.76	5.21	2.48	17.9	229.(46)	12	80	7.14
102	: 30	1.52	1.01	.97	87.1	38.(96)	2	16	1.11
103	: 89	477.06	22.66	9.19	17.0	929.(48)	48	108	31.97
104	: 46	2.65	1.49	1.41	72.6	51.(72)	3	8	1.61
105	S: 89	7.93	2.56	2.33	100.0	81.(96)	106	106S	2.61
106	P: 89	16.72	5.40	4.92	100.0	170.(96)	14	40	5.50
107	P: 89	21.63	6.26	5.64	88.6	218.(95)	20	40	6.58
108	S: 89	16.81	4.86	4.38	88.6	170.(95)	107	107S	5.11
109	: 5	4.16	.31	.19	15.7	18.(41)	1	20	.43
111	S: 89	2.36	.76	.69	100.0	24.(96)	106	106S	.87
112	: 48	14.45	3.23	2.82	66.3	133.(87)	7	20	3.60
NODE 1	: 89	660.04	53.75	35.03	36.6	2060.(60)			66.54
201	P: 21	119.77	4.15	.76	5.2	165.(31)	9	108	6.37
202	: 92	9.29	8.08	7.82	114.9	223.(91)	12	16	7.80
203	: 97*	1759.95	59.14	15.56	23.6	763.(32)	38	323	81.83
204	: 21	.49	.39	.38	105.8	12.(89)	1	8	.40
205	P: 98*	3.12	1.37	1.28	139.8	32.(96)	10	20	1.41
206	: 82	9.73	3.32	3.04	106.4	99.(96)	5	20	3.33
207	P: 48	5.38	1.35	1.20	75.7	51.(89)	3	20	1.46
208	S: 26	2.08	.49	.44	71.2	19.(87)	207	207S	.62
209	S: 21	2.55	.09	.02	6.0	3.(27)	201	201S	.23
210	: 24	10.31	.30	.04	.6	13.(5)	1	8	.53
211	S: 98*	16.53	7.27	6.79	139.8	168.(96)	205	205S	6.85
212	S: 48	1.51	.38	.34	75.7	14.(89)	207	207S	.47
NODE 2	: 98*	1940.72	86.34	37.68	35.3	1562.(41)			111.31
301	P: 22	265.64	8.33	1.76	15.6	148.(37)	8	323	12.24
302	: 48	1.14	1.10	1.08	129.1	30.(98)	1	8	1.10
303	P:108*	1113.65	123.75	92.31	147.2	788.(35)	47	216	115.88
304	: 25	4.01	1.67	1.55	78.8	51.(72)	3	24	1.68
305	P:201*	27.58	86.62	85.83	1058.2	145.(50)	31	40	65.00
306	: 33	2.74	.76	.68	84.8	27.(94)	1	20	.91
307	P: 39	19.83	4.21	3.64	62.4	177.(84)	11	40	4.74
308	:171*	50.15	128.92	127.47	864.2	311.(59)	40>	20C	97.59
309	S: 22	10.72	.34	.08	19.4	6.(44)	301	301S	.50
310	S:108*	11.73	1.25	.91	143.0	6.(28)	303	303S	1.16
311	S:201*	6.14	19.28	19.11	1058.2	32.(50)	305	305S	14.47
312	S: 39	3.87	.82	.71	62.4	35.(84)	307	307S	.92
NODE 3	:201*	1517.21	377.06	335.13	304.0	1757.(44)			316.20
401	P: 18	162.07	6.11	1.54	14.6	167.(44)	9	213	8.55
402	: 13	2.97	1.01	.93	72.8	46.(100)	2	27	1.25
403	P:103*	197.30	49.21	44.32	76.4	454.(22)	23	40	44.05

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
404	: 57	1.37	1.09	1.06	79.4	37.(77)	2	6	1.16
405	P: 98*	23.52	9.10	8.43	121.8	240.(96)	20	40	8.86
406	S: 98*	5.86	2.27	2.10	121.8	60.(96)	405	405S	2.20
407	P: 99*	10.58	4.76	4.46	143.3	109.(97)	14	40	4.48
408	S: 99*	13.60	6.12	5.73	143.3	140.(97)	407	407S	5.76
409	S: 18	14.60	.52	.10	12.8	11.(38)	401	401S	.72
410	S:103*	3.59	.91	.81	76.9	9.(23)	403	403S	.80
411	S: 98*	8.69	3.36	3.11	121.8	89.(96)	405	405S	3.27
412	S: 99*	3.31	1.49	1.39	143.3	34.(97)	407	407S	1.53
NODE	4:103*	447.45	85.97	73.98	80.1	1396.(42)			82.62
501	P: 16	122.09	3.33	.31	2.5	128.(29)	6	135	5.87
502	: 8	.38	.05	.04	13.1	4.(38)	0	8	.08
503	P: 76	834.71	22.78	2.11	3.6	757.(36)	45	175	38.91
504	: 8	1.48	.04	.01	.7	3.(7)	0	8	.14
505	P: 31	1.23	.20	.17	47.0	11.(88)	0	20	.30
506	S: 20	1.98	.29	.23	39.2	19.(88)	505	505S	.46
507	P: 48	1.79	.30	.25	47.7	17.(91)	1	20	.45
508	S: 20	1.70	.24	.19	38.8	16.(88)	507	507S	.39
509	S: 16	4.46	.12	.01	3.6	6.(42)	501	501S	.23
510	S: 76	32.74	.89	.08	3.7	29.(37)	503	503S	1.52
511	: 9	1.04	.15	.12	38.5	10.(88)	0	20	.24
512	S: 48	1.98	.34	.28	47.7	19.(91)	507	507S	.50
NODE	5: 76	1005.59	28.74	3.80	4.9	1019.(37)			49.08
601	P: 19	169.51	4.79	.59	4.6	107.(23)	6	175	7.55
602	: 16	.38	.26	.25	90.5	10.(96)	0	8	.28
603	P: 90	572.57	18.74	2.57	4.0	128.(6)	16	108	24.57
604	: 47	1.10	.83	.80	99.5	20.(69)	1	8	.82
605	P: 65	4.06	1.24	1.13	94.2	41.(95)	4	20	1.28
606	: 32	3.02	.82	.73	82.4	30.(93)	1	20	.99
607	P: 79	1.61	.66	.62	130.4	16.(96)	2	20	.69
608	: 67	3.97	1.42	1.30	111.8	40.(96)	2	20	1.41
609	S: 19	9.12	.25	.02	3.8	4.(20)	601	601S	.39
610	S: 90	4.34	.14	.02	3.3	1.(3)	603	603S	.18
611	S: 65	3.02	.92	.84	94.2	30.(95)	605	605S	1.07
612	S: 79	3.02	1.25	1.16	130.4	31.(96)	607	607S	1.31
NODE	6: 90	775.72	31.32	10.03	11.8	458.(15)			40.54

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
701	: 26	90.15	5.68	3.13	27.4	233.(57)	12	108	7.51
702	: 14	.61	.38	.36	81.4	16.(99)	1	8	.43
703	:131*	194.56	295.46	289.87	506.6	1568.(76)	144>	40C	231.39
704	: 29	3.21	.85	.76	80.7	31.(93)	2	20	1.04
705	P: 53	30.79	6.49	5.61	61.9	279.(86)	17	40	7.36
706	: 59	6.14	3.43	3.25	72.3	144.(89)	7	8	3.69
707	P: 38	23.52	4.78	4.10	59.3	205.(82)	12	40	5.43
708	: 78	8.19	5.14	4.90	81.7	200.(93)	10>	8C	5.39
709	: 8	4.98	.46	.32	13.2	27.(31)	1	12	.64
710	: 15	8.76	.77	.51	11.9	56.(36)	3	12	1.12
711	S: 53	5.86	1.23	1.07	61.9	53.(86)	705	705S	1.40
712	S: 38	3.21	.65	.56	59.3	28.(82)	707	707S	.86
NODE	7:131*	379.97	325.33	314.46	296.9	2842.(75)			266.27

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFOR-MANCE INDEX
<TOTALS>	6727	989	810	120.4	11093(46)	933	6.8	2787	884.8

TERMINATION CARD

90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

--- PROGRAM NOTE --- END OF JOB!

SR 99 PM PEAK

EXISTING CONDITIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991

VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/23/92 START TIME OF RUN: 21: 9:31

I N P U T   D A T A   R E P O R T   F O R   R U N   SR 99 PM PEAK

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	90	180	10	3	0	3	4	15	1	0	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	0	0	0	0	0
7	301	309	0	0	0	303	310	0	0	0	207	208	212	0	0
7	307	312	0	0	0	0	0	0	0	0	305	311	0	0	0
7	401	409	0	0	0	403	410	0	0	0	0	0	0	0	0
7	407	408	412	0	0	0	0	0	0	0	405	406	411	0	0
7	501	509	0	0	0	503	510	0	0	0	0	0	0	0	0
7	507	508	512	0	0	0	0	0	0	0	505	506	0	0	0
7	601	609	0	0	0	603	610	0	0	0	0	0	0	0	0
7	607	612	0	0	0	0	0	0	0	0	605	611	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155TH ST

15	1	0	1	5	4	1	0	5	15	4	1	5	4	1	0
18	1	5	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	7	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	25	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	15	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	15	107	108	112	0	0	0	0	0	0
28	101	1000	3500	1651	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	129	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	249	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	803	115	203	681	35	208	12	35	211	112	35	0
28	104	200	1600	144	0	203	122	35	211	20	35	0	0	0	0
28	105	500	0	312	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	438	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	114	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	195	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	124	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	231	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160TH ST

14	2	0	1	5	4	1	0	5	10	4	1	7	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	8	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	20	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	15	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	1712	115	101	1436	35	106	397	35	112	201	35	0
28	202	200	3200	238	0	101	166	35	112	23	35	0	0	0	0
28	209	1347	0	18	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1053	115	303	683	40	308	258	40	311	51	40	0
28	204	200	1600	22	0	303	14	40	0	0	0	0	0	0	0
28	210	200	1600	204	0	303	132	40	308	50	40	0	0	0	0
28	205	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	293	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	172	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	68	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	16	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	22	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175TH ST

15	3	0	1	5	4	1	0	4	1	10	4	1	5	4	0
18	3	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	11	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	11	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	11	307	308	312	0	0	0	0	0	0
28	301	4042	3400	1561	115	201	1326	40	206	240	40	212	22	40	0
28	302	200	1600	63	0	201	54	40	0	0	0	0	0	0	0
28	309	4042	0	32	0	201	27	40	0	0	0	0	0	0	0
28	303	2694	3400	829	115	403	645	35	408	137	35	411	77	35	0
28	304	300	3200	186	0	403	145	35	411	17	35	0	0	0	0
28	310	2694	0	24	0	403	19	35	0	0	0	0	0	0	0
28	305	500	3200	223	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	53	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	52	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	424	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	308	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	152	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	0	1	5	4	1	0	5	1	10	4	1	5	4	0
18	4	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	20	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	15	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	15	405	406	411	0	0	0	0	0	0
28	402	340	3279	147	0	301	132	35	312	12	35	0	0	0	0
28	401	2658	3564	1510	116	301	1354	35	312	121	35	306	44	35	0
28	409	2658	0	60	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	64	0	503	56	40	0	0	0	0	0	0	0
28	403	500	3503	886	0	503	771	40	508	13	40	511	12	40	0
28	410	500	0	98	0	503	85	35	0	0	0	0	0	0	0
28	406	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	310	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	103	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	242	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	87	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	0	1	10	4	1	5	4	0	0	0	0	0	0	1
21	5	1	1	2	3	20	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	1632	115	401	1411	40	406	144	40	112	83	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	31	0	401	27	40	0	0	0	0	0	0	0
28	503	2189	3400	912	115	603	900	40	608	79	40	611	21	40	0
28	504	200	0	38	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	10	0	603	10	40	0	0	0	0	0	0	0
28	505	500	1700	41	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	106	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	12	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	24	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	13	0	0	0	0	0	0	0	0	0	0	0
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	512	500	0	38	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	0	1	5	4	1	10	5	5	4	1	5	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	25	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	11	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	11	607	608	612	0	0	0	0	0	0
28	601	2189	3400	1894	115	501	1632	40	506	106	40	512	38	40	0
28	602	200	1600	40	0	501	34	40	0	0	0	0	0	0	0
28	609	2189	0	68	0	501	56	40	0	0	0	0	0	0	0
28	603	1347	3400	988	115	703	694	35	708	214	35	711	60	35	0
28	604	200	1600	81	0	703	81	35	711	10	35	0	0	0	0
28	610	1347	0	81	0	703	57	35	708	18	35	0	0	0	0
28	605	500	1600	65	0	0	0	0	0	0	0	0	0	0	0
28	606	500	1400	109	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	22	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	77	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	91	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	106	1	5	5	1	15	4	5	5	1	5	5	1	0
21	7	1	1	2	3	11	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	25	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	11	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	15	705	707	711	712	0	0	0	0	0
28	701	1347	3400	1615	115	601	1461	35	606	88	35	612	86	35	0
28	702	200	1600	91	0	601	82	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	280	0	601	253	35	606	15	35	0	0	0	0
28	703	500	3400	808	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	101	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	192	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	308	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	271	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	70	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	330	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	232	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	211	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLOT AND OPTION CARDS															
52	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CYCLE EVALUATION SUMMARY PERFORMANCE

CYCLE LENGTH (SEC)	STEP SIZE (STEPS)	AVERAGE DELAY (SEC/VEH)	PERCENT STOPS (%)	FUEL CONSUMPTION (GAL/HR)	PERFORMANCE INDEX	NUMBER SATURATED LINKS
90	30	118.90	64	1060.9	963.2	30
100	34	88.89	66	900.4	740.7	30
110	38	70.91	71	811.0	610.7	26
120	40	59.66	70	746.5	525.4	21
130	44	53.62	71	716.7	482.0	14
140	48	51.19	73	707.3	465.6	14
150	50	49.95	74	703.8	457.8	14
160	54	52.22	66	696.9	466.3	9
170	58	52.51	66	697.8	468.4	10
180	60	54.11	62	698.5	475.8	13

BEST CYCLE LENGTH = 150 SEC. CYCLE SENSITIVITY = 29.4 %

<PERFORMANCE WITH OPTIMAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	:103*	312.89	55.69	46.70	101.8	1589.(96)	89>	80C	57.98
102	: 81	4.89	3.46	3.32	92.6	125.(97)	5	16	3.54
103	: 47	190.26	10.87	5.50	24.7	429.(53)	18	108	14.54
104	: 96*	5.46	6.13	5.98	149.5	144.(100)	6	8	5.70
105	S:103*	29.47	12.40	11.55	133.3	301.(97)	106	106S	11.83
106	P:103*	41.37	17.40	16.22	133.3	423.(97)	37	40	16.60
107	P:104*	18.42	10.12	9.59	177.0	187.(96)	25	40	9.12
108	S:104*	11.71	6.43	6.10	177.0	119.(96)	107	107S	5.80
109	: 34	23.52	2.47	1.79	25.9	151.(61)	6	20	3.33
111	S:103*	10.77	4.53	4.22	133.3	110.(97)	106	106S	4.32
112	: 87	21.82	5.75	5.12	79.8	217.(94)	9	20	6.20
NODE	1:104*	670.57	135.25	116.08	95.2	3795.(86)			138.96
201	P: 81	422.40	18.11	6.18	13.0	715.(42)	36	108	26.05
202	: 74	9.02	5.97	5.72	86.5	205.(86)	9	16	6.11
203	: 55	761.70	26.45	7.59	26.0	776.(74)	33	323	40.51
204	: 34	.83	.36	.34	55.5	21.(95)	1	8	.47
205	P: 63	7.84	1.45	1.22	53.0	71.(86)	9	20	1.72
206	:127*	27.67	39.38	38.59	474.1	231.(79)	21>	20C	31.04
207	P: 28	6.42	1.04	.86	45.5	53.(77)	3	20	1.27
208	S: 17	1.51	.24	.19	43.7	12.(77)	207	207S	.35
209	S: 81	4.60	.22	.09	18.0	10.(57)	201	201S	.32
210	: 23	7.73	.92	.73	12.9	59.(29)	2	8	1.40
211	S: 63	16.25	3.00	2.53	53.0	148.(86)	205	205S	3.57
212	S: 28	2.08	.34	.28	45.5	17.(77)	207	207S	.49
NODE	2:127*	1268.06	97.48	64.33	59.4	2318.(59)			113.28
301	P: 95*	1150.59	41.07	12.59	29.0	1214.(78)	56	323	62.42
302	: 84	2.39	1.95	1.89	108.1	58.(92)	2	8	2.00
303	P: 46	393.32	13.66	2.55	11.1	392.(47)	18	216	19.79
304	: 58	10.52	2.11	1.81	35.0	162.(87)	7	24	2.97
305	P: 92	21.06	6.50	5.89	95.1	215.(96)	11	40	6.72
306	: 35	5.01	1.12	.97	66.2	48.(91)	2	20	1.26
307	P: 84	40.05	8.59	7.44	63.2	395.(93)	23	40	9.92
308	: 93	29.09	8.26	7.43	86.8	293.(95)	12	20	8.73
309	S: 95*	24.50	.83	.22	25.2	24.(74)	301	301S	1.27
310	S: 46	12.24	.39	.04	6.5	12.(50)	303	303S	.59
311	S: 92	4.91	1.51	1.37	95.1	50.(96)	305	305S	1.57
312	S: 84	14.36	3.08	2.67	63.2	141.(93)	307	307S	3.55
NODE	3: 95*	1708.03	89.07	44.88	41.4	3003.(77)			120.79
401	P: 91	730.81	32.44	11.80	28.1	1388.(92)	61	213	47.03
402	: 35	9.50	1.50	1.24	30.3	116.(79)	5	27	2.16
403	P: 68	83.68	8.83	6.76	27.5	427.(48)	20	40	12.21

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
404	: 63	1.83	1.57	1.52	85.6	62.(96)	3	6	1.72
405	P: 90	29.28	6.96	6.12	71.1	296.(95)	23	40	7.80
406	S: 90	14.17	3.37	2.96	71.1	143.(95)	405	405S	3.78
407	P: 90	22.86	5.67	5.01	74.6	227.(94)	19	40	6.24
408	S: 90	14.17	3.51	3.11	74.6	141.(94)	407	407S	3.86
409	S: 91	30.20	1.45	.58	35.0	54.(90)	401	401S	1.98
410	S: 68	9.26	1.01	.75	27.4	46.(47)	403	403S	1.25
411	S: 90	9.73	2.31	2.03	71.1	98.(95)	405	405S	2.59
412	S: 90	8.22	2.04	1.80	74.6	82.(94)	407	407S	2.24
NODE	4: 91	963.69	70.67	43.69	41.3	3080.(81)			92.87
501	P: 67	501.73	14.03	1.60	3.5	317.(19)	10	135	22.24
502	: 5	.38	.05	.04	15.9	7.(72)	0	8	.11
503	P: 37	353.94	9.18	.41	1.6	121.(13)	5	175	14.14
504	: 32	1.44	.35	.32	29.9	29.(75)	1	8	.55
505	P: 61	3.87	.67	.56	48.8	36.(88)	1	20	.82
506	S: 51	10.01	1.19	.90	30.6	90.(84)	505	505S	1.71
507	P: 27	2.27	.25	.19	28.2	20.(82)	1	20	.46
508	S: 11	1.23	.12	.09	23.5	10.(74)	507	507S	.23
509	S: 67	9.88	.27	.03	3.5	6.(19)	501	501S	.43
510	S: 37	4.14	.11	.00	1.4	1.(12)	503	503S	.16
511	: 4	1.13	.12	.08	25.1	9.(78)	0	20	.22
512	S: 27	3.59	.40	.30	28.2	31.(82)	507	507S	.59
NODE	5: 67	893.62	26.73	4.52	5.7	675.(24)			41.66
601	P: 91	760.94	35.53	16.69	31.7	1229.(65)	54	175	51.68
602	: 42	1.52	.86	.82	73.7	37.(93)	2	8	.99
603	P: 50	237.51	9.57	2.86	10.4	262.(26)	14	108	13.11
604	: 84	3.07	3.06	2.97	132.2	70.(86)	3	8	2.94
605	P: 63	6.14	1.55	1.38	76.3	61.(94)	3	20	1.70
606	: 90	10.29	3.84	3.55	117.1	106.(97)	4	20	3.78
607	P: 93	7.27	2.54	2.33	109.1	74.(96)	7	20	2.53
608	: 46	7.84	1.71	1.49	64.5	75.(91)	3	20	1.95
609	S: 91	28.18	1.31	.61	32.4	44.(65)	601	601S	1.90
610	S: 50	20.69	.78	.20	8.9	16.(20)	603	603S	1.05
611	S: 63	2.08	.53	.47	76.3	21.(94)	605	605S	.65
612	S: 93	8.59	3.00	2.76	109.1	87.(96)	607	607S	2.99
NODE	6: 93	1094.12	64.29	36.13	36.1	2081.(58)			85.27

MOVEMENT/ NODE NOS.		V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
701	:	96*	397.63	32.81	21.59	48.1	1186.(73)	56	108	40.01
702	:	85	3.45	3.16	3.06	121.0	89.(97)	4	8	3.17
703	:	48	76.31	7.75	5.56	24.8	505.(62)	22	40	10.74
704	:	95*	9.54	4.37	4.10	146.0	98.(97)	4	20	4.09
705	P:	67	29.09	6.00	5.16	60.4	279.(91)	14	40	6.97
706	:	94	10.27	7.48	7.19	95.5	258.(95)	11>	8C	7.58
707	P:	95*	31.17	8.74	7.85	85.6	315.(96)	22	40	9.28
708	:	81	8.79	4.76	4.51	69.9	214.(92)	9>	8C	5.23
709	:	25	15.83	.88	.43	5.6	41.(15)	2	12	1.23
710	:	17	10.86	.72	.41	7.7	61.(32)	3	12	1.17
711	S:	67	6.61	1.36	1.17	60.4	63.(91)	705	705S	1.58
712	S:	95*	19.93	5.59	5.02	85.6	202.(96)	707	707S	5.94
NODE	7:	96*	619.49	83.63	66.03	52.7	3311.(73)			96.99

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFOR-MANCE INDEX
<TOTALS>	7218	567	376	50.1	18263(68)	690	12.7	2408	451.8

TERMINATION CARD

90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

--- PROGRAM NOTE --- END OF JOB!

SR 99 PM PEAK

INCIDENT CONDITIONS WITHOUT MODIFICATIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991

VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/27/92 START TIME OF RUN: 11:31:17

I N P U T D A T A R E P O R T F O R R U N 1

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	150	150	10	3	0	3	4	15	1	1	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	207	208	212	0	0
7	301	309	0	0	0	303	310	0	0	0	305	311	0	0	0
7	307	312	0	0	0	0	0	0	0	0	0	0	0	0	0
7	401	409	0	0	0	403	410	0	0	0	405	406	411	0	0
7	407	408	412	0	0	0	0	0	0	0	0	0	0	0	0
7	501	509	0	0	0	503	510	0	0	0	505	506	0	0	0
7	507	508	512	0	0	0	0	0	0	0	0	0	0	0	0
7	601	609	0	0	0	603	610	0	0	0	605	611	0	0	0
7	607	612	0	0	0	0	0	0	0	0	0	0	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155TH ST

15	1	0	1	6	4	1	2	5	68	4	1	36	4	1	0
18	1	13	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	7	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	25	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	15	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	15	107	108	112	0	0	0	0	0	0
28	101	1000	3500	1651	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	129	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	249	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	803	115	203	681	35	208	12	35	211	112	35	0
28	104	200	1600	144	0	203	122	35	211	20	35	0	0	0	0
28	105	500	0	312	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	438	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	114	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	195	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	124	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	231	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160TH ST

14	2	19	1	5	4	1	4	5	84	4	1	37	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	8	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	20	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	15	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	1712	115	101	1436	35	106	397	35	112	201	35	0
28	202	200	3200	238	0	101	166	35	112	23	35	0	0	0	0
28	209	1347	0	18	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1053	115	303	683	40	308	258	40	311	51	40	0
28	204	200	1600	22	0	303	14	40	0	0	0	0	0	0	0
28	210	200	1600	204	0	303	132	40	308	50	40	0	0	0	0
28	205	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	293	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	172	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	68	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	16	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	22	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175TH ST

15	3	81	1	6	4	1	3	4	1	73	4	1	13	4	0
19	3	1	30	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	11	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	11	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	11	307	308	312	0	0	0	0	0	0
28	301	4042	3400	1561	115	201	1326	40	206	240	40	212	22	40	0
28	302	200	1600	63	0	201	54	40	0	0	0	0	0	0	0
28	309	4042	0	32	0	201	27	40	0	0	0	0	0	0	0
28	303	2594	3400	829	115	403	645	35	408	137	35	411	77	35	0
28	304	300	3200	186	0	403	145	35	411	17	35	0	0	0	0
28	310	2594	0	24	0	403	19	35	0	0	0	0	0	0	0
28	305	500	3200	223	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	53	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	52	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	424	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	308	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	152	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	7	1	8	4	1	6	4	1	61	4	1	23	4	0
18	4	1	27	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	20	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	15	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	15	405	406	411	0	0	0	0	0	0
28	402	340	3279	147	0	301	132	35	312	12	35	0	0	0	0
28	401	2658	3564	1510	116	301	1354	35	312	121	35	306	44	35	0
28	409	2658	0	60	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	64	0	503	56	40	0	0	0	0	0	0	0
28	403	500	3503	886	0	503	771	40	508	13	40	511	12	40	0
28	410	500	0	98	0	503	85	35	0	0	0	0	0	0	0
28	406	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	310	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	103	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	242	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	87	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	46	1	54	4	1	12	4	0	0	0	0	0	0	1
21	5	1	1	2	3	20	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	1632	115	401	1411	40	406	144	40	112	83	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	31	0	401	27	40	0	0	0	0	0	0	0
28	503	2189	3400	912	115	603	900	40	608	79	40	611	21	40	0
28	504	200	0	38	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	10	0	603	10	40	0	0	0	0	0	0	0
28	505	500	1700	41	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	106	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	12	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	24	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	13	0	0	0	0	0	0	0	0	0	0	0
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	512	500	0	38	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	0	1	8	4	1	94	5	12	4	1	16	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	25	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	11	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	11	607	608	612	0	0	0	0	0	0
28	601	2189	3400	1894	115	501	1632	40	506	106	40	512	38	40	0
28	602	200	1600	40	0	501	34	40	0	0	0	0	0	0	0
28	609	2189	0	68	0	501	56	40	0	0	0	0	0	0	0
28	603	1347	3400	988	115	703	694	35	708	214	35	711	60	35	0
28	604	200	1600	81	0	703	81	35	711	10	35	0	0	0	0
28	610	1347	0	81	0	703	57	35	708	18	35	0	0	0	0
28	605	500	1600	65	0	0	0	0	0	0	0	0	0	0	0
28	606	500	1400	109	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	22	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	77	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	91	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	93	1	6	4	1	72	5	27	4	1	25	4	1	0
21	7	1	1	2	3	11	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	25	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	11	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	15	705	707	711	712	0	0	0	0	0
28	701	1347	3400	1615	115	601	1461	35	606	88	35	612	86	35	0
28	702	200	1600	91	0	601	82	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	280	0	601	253	35	606	15	35	0	0	0	0
28	703	500	3400	808	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	101	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	192	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	308	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	271	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	70	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	330	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	232	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	211	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

PLOT AND OPTION CARDS

35	130	101	201	301	401	501	601	701	0	0	0	0	0	0	0
36	110	112	212	312	412	512	612	712	0	0	0	0	0	0	0
51	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CYCLE: 150 SECONDS, 60 STEPS

<PERFORMANCE WITH INITIAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	:121*	406.71	229.99	218.30	366.2	1773.(83)	118>	80C	188.61
102	: 81	4.89	3.50	3.36	93.7	125.(97)	5	16	3.58
103	: 43	190.26	9.90	4.53	20.3	391.(49)	16	108	13.54
104	: 96*	5.46	6.25	6.10	152.5	141.(98)	6	8	5.76
105	S:119*	29.47	32.91	32.06	370.0	262.(84)	106	106S	26.56
106	P:119*	41.37	46.20	45.01	370.0	368.(84)	72>	40C	37.28
107	P:121*	18.42	23.15	22.62	417.6	161.(83)	26	40	18.47
108	S:121*	11.71	14.72	14.38	417.6	103.(83)	107	107S	11.74
109	: 31	23.52	2.18	1.51	21.8	138.(56)	6	20	3.03
111	S:119*	10.77	12.02	11.72	370.0	96.(84)	106	106S	9.70
112	:104*	23.99	13.48	12.80	181.4	244.(96)	20	20	12.11
NODE	1:121*	766.55	394.31	372.38	273.1	3803.(77)			330.39
201	P: 93	549.33	22.57	7.06	11.4	558.(25)	24	108	30.29
202	: 51	9.02	5.02	4.77	72.1	194.(81)	8	16	5.32
203	: 52	761.70	22.53	3.67	12.6	432.(41)	19	323	34.19
204	: 34	.83	.67	.55	106.1	21.(97)	1	8	.70
205	P: 92	7.84	2.30	2.08	90.1	79.(95)	10	20	2.41
206	:179*	27.67	76.14	75.35	925.8	164.(56)	23>	20C	57.46
207	P: 41	6.42	1.26	1.08	57.0	58.(86)	3	20	1.47
208	S: 21	1.51	.28	.24	54.2	14.(85)	207	207S	.39
209	S: 93	4.60	.21	.08	15.5	8.(44)	201	201S	.29
210	: 21	7.73	1.02	.83	14.7	127.(52)	5	8	2.16
211	S: 92	16.25	4.77	4.30	90.1	164.(95)	205	205S	4.99
212	S: 41	2.27	.45	.38	57.0	21.(86)	207	207S	.60
NODE	2:179*	1395.17	137.24	100.49	81.9	1841.(42)			140.29

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
301	P:112*	1495.84	166.50	129.46	229.7	1411.(70)	63	323	162.31
302	: 84	2.39	2.28	2.22	126.7	53.(84)	2	8	2.20
303	P: 42	393.32	15.26	4.15	18.0	436.(53)	19	216	21.31
304	: 58	10.52	5.01	4.71	91.2	185.(99)	8	24	5.27
305	P:107*	21.06	14.73	14.13	228.1	208.(93)	13	40	12.70
306	: 41	5.01	1.17	1.03	69.7	49.(92)	2	20	1.31
307	P:103*	40.05	19.22	18.07	153.4	409.(96)	48>	40C	17.80
308	:111*	29.09	24.70	23.87	279.0	277.(90)	25>	20C	20.65
309	S:112*	24.50	2.66	2.06	231.4	22.(69)	301	301S	2.60
310	S: 42	12.24	.49	.14	21.1	12.(51)	303	303S	.66
311	S:107*	4.91	3.44	3.29	228.1	48.(93)	305	305S	2.96
312	S:103*	15.77	7.57	7.12	153.4	161.(96)	307	307S	7.01
NODE	3:112*	2054.70	263.02	210.24	172.4	3270.(74)			256.78
401	P:106*	949.75	109.01	82.19	150.7	1239.(63)	56	213	105.73
402	: 40	9.50	3.22	2.95	72.3	124.(85)	5	27	3.48
403	P: 59	83.68	8.63	6.55	26.6	462.(52)	23	40	12.41
404	: 63	1.83	1.52	1.47	82.9	61.(96)	3	6	1.68
405	P:105*	29.28	15.68	14.84	172.3	296.(95)	46>	40C	14.19
406	S:105*	14.17	7.59	7.18	172.3	143.(95)	405	405S	6.87
407	P:105*	22.86	12.87	12.22	181.7	230.(95)	23	40	11.53
408	S:105*	14.17	7.98	7.57	181.7	142.(95)	407	407S	7.15
409	S:106*	30.20	3.39	2.53	151.6	48.(81)	401	401S	3.36
410	S: 59	9.26	1.01	.75	27.5	52.(53)	403	403S	1.30
411	S:105*	9.73	5.21	4.93	172.3	98.(95)	405	405S	4.71
412	S:105*	9.07	5.11	4.85	181.7	91.(95)	407	407S	4.57
NODE	4:106*	1183.48	181.22	148.03	124.8	2987.(70)			176.98
501	P: 78	652.51	20.48	4.33	7.3	1133.(53)	49	135	37.79
502	: 4	.38	.02	.01	2.8	3.(33)	0	8	.06
503	P: 33	353.94	9.27	.51	2.0	214.(23)	10	175	15.14
504	: 34	1.44	.29	.25	24.0	25.(65)	1	8	.48
505	P:113*	3.87	4.26	4.15	364.5	36.(88)	3	20	3.46
506	S: 87	10.01	2.46	2.17	73.7	100.(94)	505	505S	2.72
507	P: 52	2.27	.33	.26	39.2	22.(91)	1	20	.53
508	S: 13	1.23	.15	.11	30.6	11.(87)	507	507S	.26
509	S: 78	9.88	.32	.07	8.3	19.(61)	501	501S	.59
510	S: 33	4.14	.11	.01	2.2	3.(26)	503	503S	.18
511	: 8	1.13	.13	.10	29.8	10.(85)	0	20	.23
512	S: 52	3.97	.57	.46	39.2	38.(91)	507	507S	.77
NODE	5:113*	1044.78	38.38	12.42	13.3	1614.(48)			62.21
601	P:111*	989.30	164.03	139.53	204.0	2012.(82)	89	175	157.64
602	: 54	1.52	.82	.78	70.5	33.(82)	1	8	.93
603	P: 47	237.51	9.67	2.97	10.8	323.(33)	14	108	13.66
604	:108*	3.07	7.55	7.46	331.7	75.(92)	7	8	6.26

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
605	P: 74	6.14	1.78	1.60	88.9	62.(96)	4	20	1.87
606	:106*	10.29	7.80	7.50	247.7	103.(94)	5	20	6.65
607	P:111*	7.27	6.45	6.24	291.8	70.(90)	15	20	5.37
608	: 52	7.84	1.82	1.59	69.1	77.(92)	3	20	2.04
609	S:111*	28.18	4.56	3.86	204.4	55.(82)	601	601S	4.39
610	S: 47	20.69	.82	.23	10.4	23.(28)	603	603S	1.13
611	S: 74	2.08	.60	.54	88.9	21.(96)	605	605S	.71
612	S:111*	9.44	8.38	8.10	291.8	90.(90)	607	607S	6.97
NODE	6:111*	1323.33	214.27	180.43	155.5	2943.(70)			207.62
701	:113*	516.90	154.13	139.53	239.3	1755.(84)	110>	108C	135.30
702	: 78	3.45	2.69	2.59	102.4	79.(87)	3	8	2.75
703	: 43	76.31	6.61	4.42	19.7	448.(55)	19	40	9.49
704	: 86	9.54	3.29	3.02	107.6	97.(96)	4	20	3.29
705	P: 76	29.09	6.49	5.65	66.0	287.(93)	15	40	7.39
706	:110*	10.27	20.01	19.71	261.9	245.(91)	13>	8C	16.65
707	P:113*	31.17	27.98	27.08	295.4	293.(89)	46>	40C	23.20
708	: 95*	8.79	6.95	6.70	103.9	221.(95)	9>	8C	6.89
709	: 24	15.83	.57	.12	1.5	11.(4)	0	12	.77
710	: 17	10.86	.63	.31	5.9	52.(27)	2	12	1.03
711	S: 76	6.61	1.47	1.28	66.0	65.(93)	705	705S	1.68
712	S:113*	21.91	19.67	19.04	295.4	206.(89)	707	707S	16.31
NODE	7:113*	740.74	250.48	229.46	164.8	3760.(75)			224.76

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFORMANCE INDEX
<TOTALS>	8509	1479	1253	147.8	20217(66)	1399	5.8	4137	1349.6

TERMINATION CARD

90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

--- PROGRAM NOTE --- END OF JOB!

SR 99 PM PEAK

INCIDENT CONDITIONS WITH MODIFICATIONS

TRANSYT-7F -- TRAFFIC SIGNAL SYSTEM OPTIMIZATION PROGRAM

RELEASE 6 MARCH 1991 VERSION 4.0

SPONSORED BY:
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC OPERATIONS

DEVELOPED BY:
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UNIVERSITY OF FLORIDA

DATE OF RUN: 8/24/92 START TIME OF RUN: 8:27:41

I N P U T D A T A R E P O R T F O R SR 99 PM PEAK

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	4	7	8	0	56	0	0	0	0	0	0	0
1	140	180	10	3	0	3	4	15	1	1	60	0	0	0	0
2	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0
7	106	105	111	0	0	107	108	0	0	0	0	0	0	0	0
7	201	209	0	0	0	205	211	0	0	0	207	208	212	0	0
7	301	309	0	0	0	303	310	0	0	0	305	311	0	0	0
7	307	312	0	0	0	0	0	0	0	0	0	0	0	0	0
7	401	409	0	0	0	403	410	0	0	0	405	406	411	0	0
7	407	408	412	0	0	0	0	0	0	0	0	0	0	0	0
7	501	509	0	0	0	503	510	0	0	0	505	506	0	0	0
7	507	508	512	0	0	0	0	0	0	0	0	0	0	0	0
7	601	609	0	0	0	603	610	0	0	0	605	611	0	0	0
7	607	612	0	0	0	0	0	0	0	0	0	0	0	0	0
7	705	711	0	0	0	707	712	0	0	0	0	0	0	0	0
10	1	4	0	1700	35	25	100	25	0	95	45	40	100	140	120

INTERSECTION 1 - N. 155TH ST

15	1	0	1	5	4	1	0	5	15	4	1	5	4	1	0
18	1	5	4	1	0	0	0	0	0	0	0	0	0	0	0
21	1	1	1	2	3	11	102	104	112	0	0	0	0	0	0
22	1	4	4	5	0	7	103	104	0	0	0	0	0	0	0
23	1	6	6	7	8	25	101	109	103	0	0	0	0	0	0
24	1	9	9	10	11	15	105	106	111	0	0	0	0	0	0
25	1	12	12	13	14	15	107	108	112	0	0	0	0	0	0
28	101	1000	3500	1651	0	0	0	0	0	0	0	0	0	0	0
28	102	200	3400	129	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	109	500	1600	249	0	0	0	0	0	0	0	0	0	0	0
28	103	1347	3400	803	115	203	681	35	208	12	35	211	112	35	0
28	104	200	1600	144	0	203	122	35	211	20	35	0	0	0	0
28	105	500	0	312	0	0	0	0	0	0	0	0	0	0	0
28	106	500	3400	438	0	0	0	0	0	0	0	0	0	0	0
28	111	500	0	114	0	0	0	0	0	0	0	0	0	0	0
28	107	500	3300	195	0	0	0	0	0	0	0	0	0	0	0
28	108	500	0	124	0	0	0	0	0	0	0	0	0	0	0
28	112	500	1600	231	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 2 - N. 160TH ST

14	2	0	1	5	4	1	0	5	10	4	1	7	4	1	0
21	2	1	1	2	3	10	202	204	0	0	0	0	0	0	0
22	2	4	4	5	0	8	201	202	209	0	0	0	0	0	0
23	2	6	6	7	8	20	201	203	209	210	0	0	0	0	0
24	2	9	9	10	11	15	205	-206	211	207	-208	212	0	0	0
28	201	1347	3400	1712	115	101	1436	35	106	397	35	112	201	35	0
28	202	200	3200	238	0	101	166	35	112	23	35	0	0	0	0
28	209	1347	0	18	0	0	0	0	0	0	0	0	0	0	0
28	203	4042	3400	1053	115	303	683	40	308	258	40	311	51	40	0
28	204	200	1600	22	0	303	14	40	0	0	0	0	0	0	0
28	210	200	1600	204	0	303	132	40	308	50	40	0	0	0	0
28	205	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	206	500	1600	293	0	0	0	0	0	0	0	0	0	0	0
29	206	0	4	0	2	0	0	0	207	100	0	0	0	0	0
28	211	500	0	172	0	0	0	0	0	0	0	0	0	0	0
28	207	500	1600	68	0	0	0	0	0	0	0	0	0	0	0
28	208	500	0	16	0	0	0	0	0	0	0	0	0	0	0
29	208	0	4	0	2	0	0	0	205	100	0	0	0	0	0
28	212	500	0	22	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 3 - N. 175TH ST

15	3	0	1	5	4	1	0	4	1	10	4	1	5	4	0
18	3	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	3	1	1	2	3	11	302	304	0	0	0	0	0	0	0
22	3	4	4	5	6	8	303	304	310	0	0	0	0	0	0
23	3	7	7	8	9	11	301	303	309	310	0	0	0	0	0
24	3	10	10	11	12	11	306	305	311	0	0	0	0	0	0
25	3	13	13	14	15	11	307	308	312	0	0	0	0	0	0
28	301	4042	3400	1561	115	201	1326	40	206	240	40	212	22	40	0
28	302	200	1600	63	0	201	54	40	0	0	0	0	0	0	0
28	309	4042	0	32	0	201	27	40	0	0	0	0	0	0	0
28	303	2694	3400	829	115	403	645	35	408	137	35	411	77	35	0
28	304	300	3200	186	0	403	145	35	411	17	35	0	0	0	0
28	310	2694	0	24	0	403	19	35	0	0	0	0	0	0	0
28	305	500	3200	223	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	306	500	1600	53	0	0	0	0	0	0	0	0	0	0	0
28	311	500	0	52	0	0	0	0	0	0	0	0	0	0	0
28	307	500	3300	424	0	0	0	0	0	0	0	0	0	0	0
28	308	500	1600	308	0	0	0	0	0	0	0	0	0	0	0
28	312	500	0	152	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 4 - N. 185TH ST

15	4	0	1	5	4	1	0	5	1	10	4	1	5	4	0
18	4	1	5	4	1	0	0	0	0	0	0	0	0	0	0
21	4	1	1	2	3	13	402	404	0	0	0	0	0	0	0
22	4	4	4	5	6	8	401	402	409	0	0	0	0	0	0
23	4	7	7	8	9	20	401	403	409	410	0	0	0	0	0
24	4	10	10	11	12	15	407	408	412	0	0	0	0	0	0
25	4	13	13	14	15	15	405	406	411	0	0	0	0	0	0
28	402	340	3279	147	0	301	132	35	312	12	35	0	0	0	0
28	401	2658	3564	1510	116	301	1354	35	312	121	35	306	44	35	0
28	409	2658	0	60	0	0	0	0	0	0	0	0	0	0	0
28	404	150	1693	64	0	503	56	40	0	0	0	0	0	0	0
28	403	500	3503	886	0	503	771	40	508	13	40	511	12	40	0
28	410	500	0	98	0	503	85	35	0	0	0	0	0	0	0
28	406	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	405	500	3367	310	0	0	0	0	0	0	0	0	0	0	0
28	411	500	0	103	0	0	0	0	0	0	0	0	0	0	0
28	408	500	0	150	0	0	0	0	0	0	0	0	0	0	0
28	407	500	3310	242	0	0	0	0	0	0	0	0	0	0	0
28	412	500	0	87	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 5 - N. 192ND ST

12	5	0	1	10	4	1	5	4	0	0	0	0	0	0	1
21	5	1	1	2	3	20	501	-502	503	-504	509	510	0	0	0
22	5	4	4	5	0	10	505	-506	511	507	-508	512	0	0	0
28	501	1684	3400	1632	115	401	1411	40	406	144	40	112	83	40	0
28	502	200	0	10	0	401	10	40	0	0	0	0	0	0	0
29	502	0	4	0	15	0	0	0	503	100	0	0	0	0	0
28	509	1684	0	31	0	401	27	40	0	0	0	0	0	0	0
28	503	2189	3400	912	115	603	900	40	608	79	40	611	21	40	0
28	504	200	0	38	0	601	38	40	0	0	0	0	0	0	0
29	504	0	4	0	15	0	0	0	501	100	0	0	0	0	0
28	510	2189	0	10	0	603	10	40	0	0	0	0	0	0	0
28	505	500	1700	41	0	0	0	0	0	0	0	0	0	0	0
28	506	500	0	106	0	0	0	0	0	0	0	0	0	0	0
29	506	0	0	0	15	0	0	0	507	100	0	0	0	0	0
28	511	500	1600	12	0	0	0	0	0	0	0	0	0	0	0
28	507	500	1700	24	0	0	0	0	0	0	0	0	0	0	0
28	508	500	0	13	0	0	0	0	0	0	0	0	0	0	0
29	508	0	0	0	15	0	0	0	505	100	511	50	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
28	512	500	0	38	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 6 - N. 200TH ST

14	6	0	1	5	4	1	10	5	5	4	1	5	4	1	0
21	6	1	1	2	3	11	602	604	0	0	0	0	0	0	0
22	6	4	4	5	0	25	601	603	609	610	0	0	0	0	0
23	6	6	6	7	8	11	605	606	611	0	0	0	0	0	0
24	6	9	9	10	11	11	607	608	612	0	0	0	0	0	0
28	601	2189	3400	1894	115	501	1632	40	506	106	40	512	38	40	0
28	602	200	1600	40	0	501	34	40	0	0	0	0	0	0	0
28	609	2189	0	68	0	501	56	40	0	0	0	0	0	0	0
28	603	1347	3400	988	115	703	694	35	708	214	35	711	60	35	0
28	604	200	1600	81	0	703	81	35	711	10	35	0	0	0	0
28	610	1347	0	81	0	703	57	35	708	18	35	0	0	0	0
28	605	500	1600	65	0	0	0	0	0	0	0	0	0	0	0
28	606	500	1400	109	0	0	0	0	0	0	0	0	0	0	0
28	611	500	0	22	0	0	0	0	0	0	0	0	0	0	0
28	607	500	1600	77	0	0	0	0	0	0	0	0	0	0	0
28	608	500	1600	83	0	0	0	0	0	0	0	0	0	0	0
28	612	500	0	91	0	0	0	0	0	0	0	0	0	0	0

INTERSECTION 7 - N. 205TH ST

14	7	106	1	5	5	1	15	4	5	5	1	5	5	1	0
21	7	1	1	2	3	11	702	704	0	0	0	0	0	0	0
22	7	4	4	5	0	25	701	703	709	710	0	0	0	0	0
23	7	6	6	7	8	11	706	708	709	710	0	0	0	0	0
24	7	9	9	10	11	15	705	707	711	712	0	0	0	0	0
28	701	1347	3400	1615	115	601	1461	35	606	88	35	612	86	35	0
28	702	200	1600	91	0	601	82	35	0	0	0	0	0	0	0
29	702	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	709	300	1600	280	0	601	253	35	606	15	35	0	0	0	0
28	703	500	3400	808	0	0	0	0	0	0	0	0	0	0	0
28	704	500	1600	101	0	0	0	0	0	0	0	0	0	0	0
29	704	0	4	0	0	0	0	0	0	0	0	0	0	0	0
28	710	300	1600	192	0	0	0	0	0	0	0	0	0	0	0
28	705	500	3400	308	0	0	0	0	0	0	0	0	0	0	0
28	706	200	1600	271	0	0	0	0	0	0	0	0	0	0	0
28	711	500	0	70	0	0	0	0	0	0	0	0	0	0	0
28	707	500	3400	330	0	0	0	0	0	0	0	0	0	0	0
28	708	200	1600	232	0	0	0	0	0	0	0	0	0	0	0
28	712	500	0	211	0	0	0	0	0	0	0	0	0	0	0

FIELDS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

PLOT AND OPTION CARDS

31	1	201	301	401	501	601	701	0	0	0	0	0	0	0	0
36	130	101	201	301	401	501	601	701	0	0	0	0	0	0	0
36	110	112	212	312	412	512	612	712	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CYCLE EVALUATION SUMMARY PERFORMANCE

CYCLE LENGTH (SEC)	STEP SIZE (STEPS)	AVERAGE DELAY (SEC/VEH)	PERCENT STOPS (%)	FUEL CONSUMPTION (GAL/HR)	PERFORMANCE INDEX	NUMBER SATURATED LINKS
140	48	152.87	62	1419.7	1730.5	36
150	50	142.06	58	1341.3	1565.9	40
160	54	135.92	61	1309.2	1507.4	40
170	58	129.36	62	1271.6	1416.2	38
180	60	125.32	62	1245.4	1371.5	41

BEST CYCLE LENGTH = 180 SEC.   CYCLE SENSITIVITY = 9.3 %

<PERFORMANCE WITH OPTIMAL SETTINGS>

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
101	:100*	406.71	50.30	38.61	64.8	2046.(95)	111>	80C	59.04
102	: 98*	4.89	6.29	6.15	171.6	126.(98)	6	16	5.63
103	: 36	190.26	7.79	2.42	10.8	273.(34)	14	108	11.08
104	:116*	5.46	15.05	14.89	372.3	124.(86)	12>	8C	12.07
105	S:208*	29.47	96.46	95.61	1103.2	150.(48)	106	106S	72.27
106	P:208*	41.37	135.41	134.22	1103.2	211.(48)	81>	40C	101.45
107	P: 97*	18.42	7.18	6.65	122.7	188.(96)	16	40	6.97
108	S: 97*	11.71	4.56	4.23	122.7	119.(96)	107	107S	4.43
109	: 25	23.52	1.75	1.07	15.5	106.(42)	5	20	2.47

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. BACK OF QUEUE NO.	MAX. BACK OF QUEUE CAP.	FUEL CONS. (GA)
111	S:208*	10.77	35.24	34.94	1103.2	55.(48)	106	106S	26.41
112	: 99*	23.99	10.53	9.84	139.5	248.(97)	12	20	9.97
NODE	1:208*	766.55	370.56	348.63	255.7	3645.(74)			311.78
201	P: 96*	549.33	25.68	10.17	16.4	889.(40)	55	108	35.11
202	: 64	9.02	6.49	6.23	94.3	213.(89)	11	16	6.55
203	: 51	761.70	27.13	8.27	28.3	592.(56)	30	323	39.16
204	: 41	.83	.56	.54	88.5	20.(91)	1	8	.61
205	P: 75	7.84	1.90	1.68	72.8	75.(91)	12	20	2.09
206	:166*	27.67	69.65	68.86	846.0	176.(60)	23>	20C	52.80
207	P: 34	6.42	1.32	1.14	60.3	56.(82)	4	20	1.50
208	S: 20	1.51	.31	.27	60.7	13.(83)	207	207S	.41
209	S: 96*	4.60	.24	.11	21.9	10.(55)	201	201S	.33
210	: 21	7.73	.56	.36	6.4	39.(19)	2	8	.94
211	S: 75	16.25	3.94	3.48	72.8	156.(91)	205	205S	4.33
212	S: 34	2.27	.47	.40	60.3	20.(82)	207	207S	.61
NODE	2:166*	1395.17	138.26	101.51	82.7	2259.(51)			144.43
301	P:102*	1495.84	74.87	37.83	67.1	1457.(72)	77	323	95.67
302	:101*	2.39	4.10	4.04	231.1	55.(88)	3	8	3.56
303	P: 39	393.32	15.79	4.68	20.3	450.(54)	24	216	21.80
304	: 70	10.52	4.70	4.40	85.2	180.(97)	9	24	5.01
305	P:172*	21.06	55.14	54.53	880.4	130.(58)	20	40	41.71
306	: 66	5.01	1.69	1.55	105.1	51.(96)	3	20	1.70
307	P: 98*	40.05	13.50	12.35	104.9	406.(96)	29	40	13.60
308	:105*	29.09	17.85	17.01	198.8	293.(95)	19	20	15.75
309	S:102*	24.50	1.18	.57	64.3	23.(70)	301	301S	1.52
310	S: 39	12.24	.54	.19	28.5	18.(75)	303	303S	.74
311	S:172*	4.91	12.86	12.72	880.4	30.(58)	305	305S	9.73
312	S: 98*	15.77	5.32	4.87	104.9	160.(96)	307	307S	5.36
NODE	3:172*	2054.70	207.53	154.75	126.9	3253.(74)			215.13
401	P: 97*	949.75	40.24	13.43	24.6	843.(43)	54	213	52.32
402	: 50	9.50	3.62	3.35	82.1	116.(79)	6	27	3.71
403	P: 52	83.68	7.01	4.94	20.1	331.(37)	18	40	9.92
404	: 76	1.83	2.04	2.00	112.4	61.(95)	3	6	2.06
405	P:111*	29.28	26.06	25.22	292.9	278.(90)	56>	40C	21.66
406	S:111*	14.17	12.61	12.20	292.9	135.(90)	405	405S	10.48
407	P:115*	22.86	23.23	22.58	335.8	210.(87)	29	40	18.97
408	S:115*	14.17	14.40	13.99	335.8	130.(87)	407	407S	11.76
409	S: 97*	30.20	1.45	.59	35.1	39.(65)	401	401S	1.87
410	S: 52	9.26	.79	.53	19.6	36.(37)	403	403S	1.02
411	S:111*	9.73	8.66	8.38	292.9	92.(90)	405	405S	7.20
412	S:115*	9.07	9.22	8.96	335.8	83.(87)	407	407S	7.52
NODE	4:115*	1183.48	149.35	116.17	98.0	2354.(55)			148.49

MOVEMENT/ NODE NOS.	V/C (%)	TOTAL TRAVEL (V-MI)	TOTAL TIME (V-HR)	TOTAL DELAY (V-HR)	AVG. DELAY (SEC/V)	UNIFORM STOPS NO. (%)	MAX. OF NO.	BACK QUEUE CAP.	FUEL CONS. (GA)
501	P: 81	652.51	19.83	3.67	6.2	828.(39)	75	135	34.26
502	: 5	.38	.02	.01	3.5	4.(38)	0	8	.06
503	P: 35	353.94	9.39	.63	2.5	170.(19)	6	175	14.79
504	: 39	1.44	.48	.44	41.6	34.(89)	1	8	.68
505	P: 73	3.87	.96	.85	74.5	36.(88)	1	20	1.04
506	S: 67	10.01	1.67	1.39	47.1	97.(92)	505	505S	2.12
507	P: 34	2.27	.30	.24	35.4	20.(85)	1	20	.50
508	S: 13	1.23	.15	.12	32.0	11.(82)	507	507S	.26
509	S: 81	9.88	.30	.06	6.6	13.(42)	501	501S	.52
510	S: 35	4.14	.11	.00	1.7	1.(13)	503	503S	.16
511	: 5	1.13	.14	.11	32.7	10.(82)	0	20	.24
512	S: 34	3.97	.53	.41	35.4	36.(85)	507	507S	.72
NODE	5: 81	1044.78	33.88	7.92	8.5	1260.(37)			55.36
601	P:104*	989.30	85.14	60.65	88.7	1196.(49)	51	175	91.69
602	: 50	1.52	1.01	.97	87.3	34.(85)	2	8	1.08
603	P: 44	237.51	9.47	2.77	10.1	284.(29)	15	108	13.22
604	:101*	3.07	6.00	5.92	263.0	80.(99)	8	8	5.17
605	P: 98*	6.14	3.66	3.48	192.7	63.(97)	4	20	3.25
606	:140*	10.29	20.27	19.97	659.7	78.(71)	11	20	15.60
607	P:124*	7.27	10.69	10.48	490.0	62.(80)	18	20	8.41
608	: 58	7.84	2.20	1.97	85.6	77.(93)	4	20	2.32
609	S:104*	28.18	2.36	1.66	87.9	31.(46)	601	601S	2.54
610	S: 44	20.69	.80	.22	9.6	19.(24)	603	603S	1.09
611	S: 98*	2.08	1.24	1.18	192.7	21.(97)	605	605S	1.18
612	S:124*	9.44	13.88	13.61	490.0	80.(80)	607	607S	10.93
NODE	6:140*	1323.33	156.72	122.87	105.9	2026.(49)			156.47
701	:105*	516.90	84.53	69.94	120.0	1605.(76)	86	108	83.18
702	: 93	3.45	4.41	4.31	170.7	82.(90)	4	8	4.04
703	: 40	76.31	6.51	4.31	19.2	408.(50)	21	40	9.11
704	:103*	9.54	6.98	6.71	239.1	97.(97)	10	20	6.00
705	P: 74	29.09	7.36	6.52	76.2	285.(92)	18	40	8.01
706	:139*	10.27	47.11	46.81	621.9	196.(72)	27>	8C	36.13
707	P:110*	31.17	25.92	25.02	272.9	299.(91)	55>	40C	21.74
708	:119*	8.79	25.22	24.97	387.4	196.(84)	23>	8C	20.08
709	: 24	15.83	.59	.14	1.8	11.(4)	1	12	.78
710	: 16	10.86	.71	.40	7.5	55.(29)	3	12	1.12
711	S: 74	6.61	1.67	1.48	76.2	65.(93)	705	705S	1.82
712	S:110*	21.91	18.22	17.59	272.9	211.(91)	707	707S	15.29
NODE	7:139*	740.74	229.22	208.20	149.5	3509.(70)			207.28

CYCLE: 180 SECONDS, 60 STEPS

<SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

PERFORMANCE MEASURES	TOTAL TRAVEL V-MI	TOTAL TIME V-HR	TOTAL DELAY V-HR	AVG. DELAY SEC/V	UNIFORM STOPS NO. (%)	FUEL CONS. GA	SYSTEM SPEED MI/H	TOTAL COST	PERFOR-MANCE INDEX
<TOTALS>	8509	1286	1060	125.0	18306(60)	1240	6.6	3742	1330.9

TERMINATION CARD

90 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

--- PROGRAM NOTE --- END OF JOB!

APPENDIX B

INTEGRATED CONTROL SYSTEM SPECIFICATIONS

INTEGRATED CONTROL SYSTEM SPECIFICATIONS

This appendix describes the interaction between the integration computer and the individual control system components as developed for this project's demonstration system. Specifications regarding individual control system modifications, necessary to allow control system interaction in an integrated environment, are included.

The integration program is designed to operate on a microcomputer (IBM compatible). Using dedicated serial communication ports, the integration microcomputer communicates through an "off the shelf" local area networking program to the arterial central microcomputer, and via an RS-232 connection to the freeway control system mainframe computer. The arterial central microcomputer provides access to two separate signal control systems, thus linking three independent signal systems to the integration computer.

Interaction between the integration microcomputer and the arterial central microcomputer consists of file writing and reading to and from the hard drive in the arterial central microcomputer. The arterial central program receives volume and occupancy data from each of its field masters and writes these data to separate files for each field master. The integration program reads and deletes these files and writes separate control files for each field master. The arterial central program reads these control files and implements the desired commands. These functions are repeated at operator assignable intervals.

Interaction between the integration microcomputer and the freeway control system mainframe is conducted in a similar manner, except via RS-232 serial ports. The integration microcomputer receives a "request to send" message from the freeway mainframe computer, receives the data into its buffer, and reads the data from the buffer into its control algorithm. It then transmits a control message to the freeway mainframe buffer at each time interval. This message consists of a specific control command or a command for no action.

Control commands to the arterial central direct the arterial central to command a field master to implement a specific, pre-programmed coordination plan; to revert back to its normal pre-assigned operation; or to maintain current status. However, the actual character strings transferred between the integration computer and a specific arterial central is entirely dependent upon the desires of the arterial central system operators and the capabilities of their control systems. Depending upon the desires of the system operators, the data transmitted could consist of a specific control string, the status of another system, or specific detector data received from another system.

CENTRAL CONTROL SOFTWARE SPECIFICATIONS

The following are proposed design specifications that could be incorporated into an agency's set of specifications for purchasing traffic signal control equipment. These specifications require that the purchased equipment be able to transmit and receive information conveyed via electronic media from an external source.

Writing Files

The introduction of PC-based central control programs has given operators direct access to the traffic data accumulation capabilities of the on-street signal control systems. The majority of these programs allow the operator to schedule periodic up-loads of traffic data from on-street masters to the central PC. These data are then typically stored on a disk drive housed in the PC and later reformatted for use in a traffic data record or report.

Traffic control system integration requires an extension of this procedure which allows these data to be shared with processors other than the central PC. The following are recommended specifications that would facilitate this process.

- The central program shall have the ability to schedule a sequence of multiple up-loads from the field masters. This ability shall include the time of day to begin and end the sequence for each on-line field master, and the period between up-loads (5 minutes minimum).
- The central program shall have the ability to write this file to an alternative computer via a local area network or an RS-232 connection through the use of a protocol defined and published by the manufacturer (RS-232 communications are preferred).
- Data transmitted by the central system shall contain one record for each individual detector. Each record shall include data that identify the detector (i.e., intersection and detector identification number), a time stamp, and the transmitted data (volume and/or occupancy). The format of this raw data file shall be published in the system's user's guide.

The data collection would not have to be limited to detector data. Other information such as current status of a field master (coordinated or free, coordination plan number, cycle length, offset, sync point, etc.) could also be transmitted. These additions, if requested, should be fully documented by the manufacturer.

Reading Files

The central control program allows the operator to communicate directly with the field masters. Common capabilities of these central programs include modification of local intersection controller timing parameters, modification of traffic responsive control parameters, and manual implementation of specific control plans. All of these capabilities are accessed through the keyboard of the central control computer through software supplied by the manufacturer. The individual agency should specify which of these features should be accessible by an external computer. A sample specification that includes the recommended capabilities follows.

- The central control program shall provide the operator with the ability to implement specific coordination plans stored in the local controllers. The central program shall be able to perform these functions automatically on the basis of input received from an external computer.
- The central control program shall have a specified input procedure. This procedure shall allow the central PC to read the input according to the manufacturer's specifications and implement the control strong containing commands the manufacturer or operator has enabled. The program will facilitate this function by reading the contents of a serial port buffer (for RS-232 communications), or by examining the contents of a specific file (for LAN configuration).
- In establishing this capability the central control program shall contain the following operator assignable parameters:
    1. the time of day and days of the week in which this operation will be enabled for the central program, or specific field masters, and
    2. the commands and/or controls that will be allowed for each field master. (The manufacturers must define how to specify each available command function.)

Additional parameters may be necessary, depending on the type of communication media specified.

Specifying these capabilities in the central control program will give operators the ability to interact with the operators of neighboring systems while they maintain their ability to choose their desired supplier of control equipment.

The decision of who develops and operates the linking system will have to be made by the relative jurisdictions. However, the ability to control which data are sent to the linking system, and what action is performed upon receiving data from the linking system, will still reside with each system operator.