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OPTIMIZATION TECHNIQUES FOR

URBAN HIGHWAY TRAFFIC SIGNALIZATION

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Sugeng Setyawan

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OPTIMIZATION TECHNIQUES
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BY

SUGENG SETYAWAN

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ABSTRACT

OPTIMIZATION TECHNIQUES
FOR
URBAN HIGHWAY TRAFFIC SIGNALIZATION

By

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Increasing construction costs which exceed revenues have forced traffic engineers to more closely fine tune the existing roadway facilities using various transportation system management strategies. Among these strategies, traffic signal coordination and optimization is recognized as one of the most cost effective and easiest to implement strategies.

Numerous computer packages are available to optimize and/or simulate existing or expected traffic flow conditions. However, few of these models have been introduced to the developing countries where the need for optimization is strong as financial constraints are one of their major problems.

Techniques for using two traffic signal models were introduced in this study and the consistency between the models tested. Furthermore, the impacts of signal timing optimization were evaluated. Delays, stops and fuel consumptions were estimated for before and after optimization of signal timing plans, and the results were converted into highway user costs, so that the benefit of optimization could be determined.

This study also identified the level of saturation in the traffic flow which limits the value to be gained from the use of optimization models on a network.

TO MY PARENTS

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Sugeng Setyawan

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CHAPTER ONE: INTRODUCTION

I.1. BACKGROUND

Currently, the emphasis in transportation planning has been shifted from long term, capital intensive - construction projects, to shorter term, relatively low cost projects, which are designed to optimize the use of existing facilities. Such a trend places heavy consideration on *transportation system management [tsm]* as a part of the planning process and as a prerequisite for improvements to increase the capacity and efficiency of transportation systems, in particular for urban traffic operations.

The provision of improved traffic signal systems for control at heavily trafficked intersections and corridors is by far the most common form of *tsm*. Inefficient use of the transportation system results when traffic signals are installed without sufficient study. While the U.S. Manual on Uniform Traffic Control Devices for Streets and Highways [25] discusses several warrants to justify traffic signal installations, the manual does not specify the operation of such signals.

The by-products of inefficient use of traffic signals include greater energy consumption, an increase in certain environmental impacts such as vehicle noise and emission levels, increased travel time and delay, higher accident rates, and less reliable service.

The Federal Highway Administration forecasted that energy consumption could be conserved by 100,000 barrels of crude oil per day by optimizing the timing of the 130,000 coordinated, signalized intersections that currently exist in the U.S. urban streets.[21][24] Thus, it is obvious that a signal optimization program could be one of the most cost effective strategies that can be implemented under *tsm*.

I.2. TRAFFIC SIGNAL TIMING OPTIMIZATION

In general, signalized intersections can be classified into two major systems : (a) ***isolated signals,*** and (b) ***coordinated signal systems*** which consist of two or more intersections and streets that link those inter sections. For the analysis of isolated signal timing, Webster's model represents one of the major advances in the development of optimizing signal timing. [6] [7] [8] Other analytical methods include the U.S. Highway Capacity Manual method [TRB Special-Report 209; ch.9], the Canadian Manual on Uniform Traffic Control Devices method, the Australian Road Capacity Guide method, the Average Loaded Phase Expanded [ALE] method, Bellis's method, Failure-rate method, and the use of certain British and Swedish models. For coordinated signals, various manual and computer aided progressive signal system designs have been used with reasonable success on single arterial streets. In the case of signal network design, simplification was traditionally made by providing preferential treatment to one or more major arterials within the network, and after assigning favorable splits and offsets to these arterials, the remaining signals were forced to conform with the various restraints imposed by those major arterials.

The manual solutions are subject to more human error, and are often cumbersome and time consuming. With the availability of the computer as a versatile analytical tool, complex algorithms for signal timing design were developed, which represent significant progress in the current *state of the art.*

I.3. MODELS AVAILABLE

A number of computer based optimization models have been demonstrated to be effective and reliable. Some of those are :

SOAP

SOAP stands for the *SIGNAL OPERATIONS and ANALYSIS PACKAGES*, developed by the University of Florida, for the Florida Department of Transportation, and the Federal Highway Administration. SOAP is a macroscopic analysis program, which provides a method of evaluating and developing a wide-range of signal design alternatives for isolated intersections. SOAP is an optimization model which determines the solution for optimal cycle lengths, splits, phasing patterns, and left turn configurations for three or four legged intersections. Inputs include traffic flow per-approach, truck and bus composition, left turn data, signal related data, saturation flow rates, and progression related data. Basic outputs include delays, percent stops, percent saturation, maximum queue, left turn conflicts, and excess fuel consumption. The program is well written and easy to use.

MAXBAND

The *MAXIMUM BANDWIDTH*, is a bandwidth optimization program which calculates signal settings on arterials and triangular networks. This program can handle as many as twelve signals efficiently. Inputs include the range of cycle lengths, the network geometry, traffic flows and their capacities, left turn patterns, queue clearence times, and the allowable range of speeds. The output include a data summary report and the solution report of cycle time and bandwidths, selected phase sequencing splits, the offsets, travel time and speed on links.

TEXAS

The *TRAFFIC EXPERIMENTAL and ANALYTICAL SIMULATION*, was developed by the University of Texas Austin Center for Highway Research, for the Texas Department of Highways and Public Transportation. This program has the ability to evaluate existing and proposed intersection designs for both geometric and traffic operations. TEXAS is a simulation model which provides quantifiable measures of changes in traffic operations from roadway geometry, driver and vehicle characteristics, intersection and lane control, flow conditions, and signal timing plans.

PASSER

PROGRESSION ANALYSIS and SIGNAL SYSTEM EVALUATION ROUTINE, was developed by the Texas A and M University's Texas Transportation Institute for the Texas Department of Highways and Public Transportation. PASSER provides a valuable tool for determining optimal splits, phases, and offsets, primarily for coordinating traffic signals along arterial highways. Basic inputs include the range of the cycle lengths, movement flows, saturation flows, left turn patterns, queue clearence times, the desired speeds, minimum green time, allocation of bandwidth by direction, cross street phase sequences, and link distances. Outputs include cycle length, bandwidths, band speeds, a time-space diagram, delay, probability of queue clearances, offsets, splits, phase sequences, and volume over capacity ratios.

SUB

SIMULATION OF URBAN BUSES, is a special purpose model which has been developed by the Federal Highway Administration for evaluating the benefits of alternative bus stop location [near side, farside or midblock], and physical characteristics such as protected or unprotected lanes. This model was developed to provide transit operators with a tool for evaluating bus operations along an arterial as well as the effect of various bus stop strategies on their performances.

TRANSYT

The *TRAFFIC NETWORK STUDY TOOL*. The original TRANSYT was developed by Mr. Dennis I. Robertson of the *Transport and Road Research Laboratory [TRRL]*, Crawthorne in the United Kingdom. TRANSYT is a major tool available to traffic engineers for analysis and evaluation of alternative traffic control strategies. It is primarily used for optimizing the signalization on arterial and grid networks. The model has a hill climb optimization algorithm that varies the offsets and phase-lengths at each signal to locate the particular set of signal timings that minimize a Performance Index, which is a weighted linear combination of stops and delays. Basic inputs include cycle lengths, phasing, performance index weights, lost time value, link lengths, either link travel times or speeds, link flows, turning movements and saturation flows. Basic link outputs include percent saturation, total travel, travel times, delays, rate of stops, maximum queue length, offsets and splits, plus the value of the performance index. Since the original model was introduced in 1968, numerous improvements have been made and a number of versions issued, some examples are :

- ***TRANSYT-6C***

  TRANSYT-6C includes fuel consumption, the estimation of emissions, demand response, a provision for priority links, and a more comprehensive measure of effectiveness. Users may determine the basis of optimization by weighting various variables.

- ***TRANSYT-7F***

  This is one of the recent versions available to day with the North American nomenclature on input and output. It also produces a time space diagram and the estimation of fuel consumption. A new revision will optimize the cycle length, and identify potential intersection blockages.

- ***TRANSYT-8***

TRANSYT-8, the newest version which includes gap acceptance functions for left turns and a cycle search routine. The British government charges a fee, limiting the use of the program.

SIGOP

SIGOP stands for the traffic *SIGNAL OPTIMIZATION*-model. It is a powerful analysis and design tool. Conditions, such as the existing conditions, might be analyzed in terms of a number of useful traffic engineering measures. The signal timing may be optimized for cycle length, splits and offsets to minimize the 'disutility' function. Comparison of the results of several alternatives enables the traffic engineer to evaluate the relative effectiveness of the designs. The current version of SIGOP was developed by KLD Assoc., Inc. for the Office of Research, Federal Highway Ad-

ministration. It can handle up to 150 intersections, multi-phase signals can be modeled as well.
Input includes arrival flows and saturation flows, the minimum green times, yellow times, special phase times, passenger car equivalent factors for trucks, buses, and turning vehicles, while the output include time-space diagrams along selected arterials and links.

NETSIM

NETSIM is an abbreviation of the name of a model for traffic *NETWORK SIMULATION*. It was developed by KLD and Associates for the Federal Highway Administration. NETSIM was designed primarily to provide a powerful analysis tool to test complex network problems. It is particularly useful for the analysis of dynamically controlled traffic signal systems with the highly variable nature of their operation. This simulation model can also evaluate several alternatives which are being considered and provides a basis for a comprehensive analysis and identification of potential problems which could occur that would not show up in other models. The inputs include : the network geometry, arrival flows, saturation flows, turning counts, traffic composition, and signal setting. Outputs include a variety of measures such as delay and stops, cycle failures for pretimed signals, fuel consumption and level of emissions. NETSIM simulates the performance of a network by using a microscopic, probabilistic model which incorporates car following, queue discharge, and lane switching algorithms. It has the capacity to handle 99 intersections, 160 links, and 1600 vehicles at a time.

PRIFRE

PRIFRE is a reverse acronym for the *FREEWAY-PRIORITY LANE model.* This model was developed by the University of California Institute of Transportation Studies at Berkeley, to improve the efficiency of freeway systems. The physical system considered by PRIFRE is a directional freeway with a priority lane reserved for high occupancy vehicles [HOV's] and the on and off ramps to the freeway. PRIFRE can be used to evaluate various types of priority treatment of high occupancy vehicles, but its primary use is for the evaluation of freeway rather than signalized intersections.

FREQ3P

FREQ3P is an acronym for the *FREEWAY OPTIMIZATION with QUEUEING, version 3 control and PRIORITY treatment.* This model has been used frequently to evaluate alternative priority entry control strategies at any or all entrance ramps to optimize freeway operations. It can be used to maximize an objective function such as passenger input or miles of travel. The physical system considered by this model is a directional, urban freeway section and the associated ramps. The freeway section is described as a series of contiguous sections which are internally operationally homogenous. It was developed by the University of California Institute of Transportation Studies at Berkeley, and it is not proposed for signalized intersections.

OTHER MODELS

Recently, a number of advanced computer models for analyzing transportation corridors have been introduced. Models like ; ***FREQ6PL, FREQ6PE, FRESCOT, TRANSYT-6C,*** and ***SIMTOL*** provide the capability for investigating demand, supply and control interaction for transportation corridors. Such models are still in the process of development, testing and refinement, and won't be considered more in this study.

I.4. STUDY OBJECTIVES

These computer models have been developed and calibrated according to the conditions of the developed countries. Many of these factors are significantly different in developing countries. Thus, the models can not readily be used by practicing engineers for solving many of the transportation management problems in the developing countries. The lack of use in these countries is also caused by many other reasons, for example :

- lack of computer hardware to run the models,
- difficulties of obtaining the software program and model documentation,
- non-familiarity with the existing models and their uses,
- perception that use of models requires an expertise in traffic flow and higher mathematical theory,
- a belief that computer models will not give practical results,

Considering the beneficial use of such models in the U.S. and other developed countries, as well as remembering the 'optimization' policy introduced by the Indonesian Directorat General of Highway, in 1979, this study was performed to determine the feasibility of using such models in Indonesia. Hence, the purpose of this study is primarily to demonstrate optimization techniques and analyze the possible impacts of using signal optimization models in Indonesia.

I.5. OUTLINE OF THE STUDY

Two models were selected for more detailed study, TRANSYT-7F and SOAP84 versions, and their consistency was tested on an arterial street in the city of Lansing, Michigan. The performance measures of the models were compared statistically to examine the differences, if any. Furthermore, the effectiveness of TRANSYT-7F was tested in an Indonesian network. The existing network was loaded with volumes equal to $.10S$, $.20S$, $.30S$ and $.40S$, where S is the street saturation flow. Then the improvements of signal timing optimization were measured, so that the benefits of the optimization could be quantified.

CHAPTER TWO: THE STATE-OF-THE-ART IN TRAFFIC ENGINEERING

A brief insight of traffic engineering experiences in the developed countries and the developing countries are presented in this chapter. The greater population density that is commonly found in the developing countries, especially in urban areas, is associated with a lower level of traffic engineering service than in the developed countries. Many other factors also contribute to differences in traffic conditions, including nature, culture, government regulations, technology of public transportation systems, communication systems, alternate transportation facilities, pedestrian behaviors, etc. This chapter concludes briefly by examining what benefits are transferable, and what *'lessons'* could be learned from the success experiences of the developed countries.

II.1. TRANSPORTATION AND TRAFFIC ENGINEERING PRACTICES IN THE DEVELOPED COUNTRIES

"The inherent need of highly developed and industrialized nations is a sophisticated and widespread transportation system". [12]

This statement is certainly true for the developed countries, which is evidenced with their intricate urban, regional, and national transportation systems. The adequate mobility broadens the perspective of the individual as well as the nation. Mobility links the activities from different locations and facilitates the movement of ideas, people, and goods. A strong transportation system is the principal component of economic, social, cultural, and political structures of modern societies, which is an important factor in the national development. Nations that have strong and stable economics are generally those with more than adequate transportation systems.

Although Transportation Engineering has been practiced for many centuries, it was not until the last two decades that this study received recognition as a professional subdiscipline within civil engineering. For the developed countries, transportation today has benefited from centuries of experiences accumulated from across the globe, and has recently been crystalized as an interdiciplinary study involving :

- engineering;
- operation research; and
- the social sciences.

It can be defined as the science and art of planning, designing, implementing, operating, monitoring, and maintaining any medium for facilitating the movement of people and goods.

The planning stage involves a deliberate investigative study for identifying and evaluating needs and options. It is in this stage where the tools of system engineering and the social sciences receive great emphasis. The policy or a standard system of transportation planning for urban, state, regional or rural settings is always based on scientific, analytical design techniques such as *trip generation, trip distribution, modal split* and *traffic assignment.*

The designing of transportation facilities involves adherence to engineering science, design standards and an assortment of specifications. The science of engineering has a predominant role in facility design.

Implementation refers to construction and the final opening of transportation facilities to the public. The implementation process is one of the key successes of developed countries, especially for projects which are designed to encourage a particular human behavior. It is very uncommon to find the opening of modern facilities without parallel activities in the area of public education such that proper use is encouraged and negative impacts will be minimized.

Operation is usually the direct function of government, though the operation by quasi-governmental and private agencies is not uncommon. Good management is a key component of an effective operation.

Monitoring functions are keyed to the evaluation of the primary transportation objectives and the performance of the physical components. Monitoring is a data collection and analysis mechanism which generates an information base useful for future designs, service improvements, and detecting new needs. An example of monitoring activity is the maintenance of accident record systems, which is important for improvements to design or other policies on vehicle operation.

Maintenance is just emerging as an activity which must be deliberately planned. In the U.S., thousands of miles of interstate highway have been built since 1956. However, neglecting maintenance in the planning process caused the maintenance cost to be significantly higher than what was estimated.

II.1.1. U.S. SIGNAL TIMING OPTIMIZATION PROJECT

As stated before, one of the current *tsm* targets is to provide systematic control to the traffic operation over the existing highway network so as to achieve a comprehensive set of mobility, safety, energy, environmental and efficiency objectives.

The National Signal Timing Optimization Project was initiated by the Federal Highway Administration as a fuel conservation effort in response to the high cost of imported oil. About 35 percent of the U.S.' total daily oil consumption is consumed by vehicles traveling in urban areas throughout signalized intersections. [10] A significant portion of this is wasted due to poor traffic signal timing. In the networks with poorly timed traffic signals, the fuel consumed by vehicles stopping and idling at traffic signals accounts for approximately 40 percent of the network-wide vehicular fuel consumption. By improving traffic signal timing, the quality of traffic flow will be improved, and driving will be made faster and easier for all traffic using the street system.

There are an estimated 240,000 signalized intersections in the U.S.; of these, an estimated 130,000 are coordinated. [21][24] Just optimizing the signal timing at those intersections nationwide, it has been estimated, could conserve about two million gallons of gasoline per day. Therefore the FHWA's main target is the development of optimal signal timing plans for all of the coordinated signals and most of the non-coordinated signals within the U.S. As an initial part of the overall effort, the National Signal Timing Optimization Project was intended to satisfy the following objectives :

- establishing credible data on the effectiveness of signal timing optimization;
- making signal timing optimization projects easy to accomplish;
- defining cost, level of staff, computer, and other resources necessary to undertake a signal timing optimization project, so that such an optimization project can be effectively budgeted.

To accomplish these objectives, the TRANSYT-7F program was first developed, then applied to programs in 11 cities nationwide to evaluate the effectiveness of the model. The 11 cities participating in the project were : Charleston, SC ; Denver, CO ; Des Moines, IA ; Fort Wayne, IN ; Gainesville, FL ; Milwaukee, WI ; Nashville, TN ; Portland, OR ; Pawtucket, RI ; San-Francisco, CA ; and Syracuse, NY. By evaluating the results, it was concluded that a signal timing optimization program could significantly reduce vehicle delays, stops, and particularly fuel consumption which is a valid national objective that can be realized through the actions of state and local governments. TRANSYT-7F has proven to be a very valuable tool for signal timing optimization projects. Its success for design depends largely on the accuracy of the data used in the model.

II.2. TRAFFIC ENGINEERING IN THE DEVELOPING COUNTRIES

Most of the third world countries are experiencing rapid growth in motorization, as their urban centers are growing much faster than rural areas. However, such rapid developing motorized societies exist without adequately expanding the roadway infra-structure or transportation policies. As a result, urban centers are experiencing a major growth in the need for personal mobility, and consequently in increased traffic volumes and congestion. Traffic control practices are not keeping pace with this rapid growth. Economic resources for investment have become increasingly scarce, and this trend seems likely to continue. Traffic engineering problems are usually approached by managerial solutions rather than capital intensive ones to meet the rising mobility demands in urban centers. There are vast variations in traffic engineering characteristics, standards, and management techniques among the countries.

A study was performed by the *ITE Technical Council Committee 4A - 20*, in order to understand the specific types of traffic engineering practices in the developing countries. [20] The study included :

DATA COLLECTION AND INVENTORIES

The study was designed to assess in a comprehensive manner the collection techniques and their application in design, as well as to provide some insight into the *state of the art* in traffic engineering practices. The information gathered, can be summarized as follows :

- most of the countries have some method of traffic volume counting;
- accident reports are not regularly recorded;
- the study of pedestrian behavior, particularly at intersection locations, are not routinely conducted; and
- parking studies are not done regularly, especially with respect to duration and off-street parking facilities.

STANDARDS AND PRACTICES

Many countries have some form of highway capacity manual. Some of them use the U.S. Highway Capacity Manual [22] as well as their own manuals which were developed to take account of the different traffic behavior. Some specific differences in traffic behavior are a large percentage of heavy trucks, traffic with slow moving vehicles, mixed traffic problems, etc.

TRAFFIC CONTROL

Most of the countries use their own standards, which have been developed based on local conditions and represent modifications of U.S. or European manuals. Local languages are used for signs, and some warrants for the installation of traffic signals are modified. Certain countries, especially in Latin America, use the U.S. manual markings as well as their own markings. A lot of the countries do not incorporate the pedestrian phasing in traffic signal designs. With regard to having an inventory system for signs and markings, most countries maintain the drawings of the location record, and quite a few are using computerized maintenance systems.

TRAFFIC CONTROL PRACTICES ON SPECIAL EVENTS

Developing countries face serious traffic problems, particularly during special events due to the concentration of automobiles on the road networks within the urban centers. Few countries do trip-generation analysis, and parking demand studies. However, nearly all of the countries practice some form to control for the added traffic during special events. Those countries implement one way systems, detour by signs, and manned detours. In case of deficiency and or incidents on the roadway, usually no restrictions are provided, which could create a hazard to traffic.

TRAFFIC ENGINEERING PROBLEMS

In the surveys used to identify typical problems in the developing countries, most of those countries addressed nearly similar problems, which generally include the following :

- limited financial resources;
- poor geometric design of the roadway;
- deficiency of traffic control devices; especially signs and signals;
- insufficient roadway lighting;
- inability to manage parking;
- inadequate traffic law enforcement;
- difficulties in safely accomodating slow moving vehicles, and mixed traffic problems;
- inefficient traffic police forces; and
- the operation of unsafe vehicles.

Recognizing such problems, particularly the financial constraint, it would be reasonable if a signal timing optimization program which became the *state of the art* in transportation engineering in the developed countries, could be considered in setting policy in the developing countries. The benefits of such programs are obvious, and have been proven in the developed countries. However, care must be taken in implementing the models to include such specific behavior as previously mentioned. The differences cannot be neglected and good judgement is always necessary.

CHAPTER THREE: MODEL OVERVIEW

As previously described, the models selected in this study were TRANSYT-7F and SOAP84, for the reasons that they are easy to use and their use in the U.S. has demonstrated their reliability. Another consideration is that both models place the emphasis on various impact evaluations for their objective functions.

III.1. TRANSYT-7F

TRANSYT-7F stands for the *TRAffic Network StudY Tool*, version *7F*, where 'F' refers to the fact that this is the FHWA's version of TRANSYT-7, the TRRL's model. The newest version, TRANSYT-8, is now available under a licensing agreement.

III.1.1. MODEL DESCRIPTION

The TRANSYT model is a macroscopic, deterministic simulation and optimization program with independent time scan. The original program was written in machine language for use on the MARCONI MYRIAD Computer, and later rewritten in Fortran IV for more universal use. The model has been executed successfully on the IBM-360, 370, and 3033, AMDAHL-470, CDC-7700, digital VAX-11/780, BURROUGHS-7700, and HONEYWELL-6220. It requires 288k bytes of cpu addressable memory in unoverlayed format or 172k bytes if the program is overlayed. The physical characteristics of a system considered by TRANSYT-7F is coordinated signalization on arterials and networks of up to 50 intersections with about 250 links.

III.1.2. INPUT REQUIRED

The TRANSYT program requires as input, the description of : traffic volumes and flow patterns, signal timing parameters [cycle lengths, phasing, minimum pedestrian timing if any, and the offsets], network geometry [link sections and lengths, intersections, the saturation flows, and average free speeds], and control data which indicates what the user desires to take into account, e.g. ; simulate or optimize, read English or metric unit.

III.1.3. THE OPERATION

TRANSYT's optimization procedure uses a 'hillclimbing' process that begins with the calculation of the performance index [PI] of the network for an individual set of signal timings. The next stage is to alter the offset of one of the signals by the number of time units in the specified step size, and recalculate the network's PI. If the index is reduced, then the offset is altered successively in the same direction until a minimum value of the PI is obtained. If the first alteration increased the PI, the search is made in the opposite direction. Each signal is adjusted in a similar manner in a specified order until the minimum value of PI is reached. The process of optimizing the offset of each signal in turn is repeated to obtain the final signal settings. TRANSYT-7F also optimizes splits by altering the start of each phase and recalculating the PI as before. The current version has the capability to determine the optimal cycle length for a given range specified by the user. A number of executions will be done for every step size increment and the cycle with the lowest PI will then be selected. Therefore, optimization no longer requires multiple runs by varying input for cycle lengths as the earlier versions. Other features of the current version are the capability to provide a time-space diagram, the estimation of fuel consumption, and reduced control inputs by internally generating certain parameters.

III.1.4. COMPUTATIONAL ALGORITHMS

The major algorithms in TRANSYT-7F are the calculation of traffic characteristics and minimizing the objective function which is called the performance index [PI]. The index is a linear combination of delay and stops, and is expressed as :

$$PI = \sum_{i}^{n} [W(D)_i . d_i + k W(S)_i . s_i],$$

where :

W = the weighting factors for delay (D), and stops (S) respectively, for every link i,

d_i = delay on the i^{th} link of the network, in [veh-hr/hr],

s_i = average number of stops per-second on link i,

k = a user input coefficient to express the importance of stops relative to delay.

TRANSYT simulates traffic flow macroscopically, by considering vehicles as platoons rather than individually. There are three traffic flow patterns ; the 'IN', 'GO', and 'OUT' patterns considered.

The 'IN' pattern is the arrival pattern and is expressed mathematically as :

$$IN_{it} = \sum_{j}^{n} F_{ij} [P_{ij} * OUT_{jt}]$$

where :

IN_{it} = the 'IN' pattern on link i for step t [the cycle is divided into time increments called steps],

F_{ij} = a smoothing factor for flow from link j to link i,

P_{ij} = the proportion of OUT_{jt} that feeds link i,

OUT_{jt} = the out pattern of link j for step t, and

n = the number of links j that feed link i.

The smoothing function [F_{ij}] represents the dispersion of vehicles, which is expressed as :

$$F_{ij} = 1/[\ 1 + (\ s_p * c_e * t\ )]$$

where :

s_p = the smoothing parameter [usually assumed to be .35, but it might be varied],

c_e = a coefficient which 'shifts' the effective travel time [set to .8],

t = link travel time.

The 'GO' pattern is the flow rate at each step that would leave the stopline if there were enough traffic to saturate the green.

The 'OUT' pattern is the periodic traffic flow rate leaving a link, which would be equal to the 'GO' pattern as long as there is a queue, and after the queue dissipates, it would be equal to the 'IN' pattern for the duration of the effective green. To determine the 'OUT' pattern, the number of vehicles held at the stopline during time interval t, must first be determined by :

$$m_t = \max \{ [m_{t-1} + q_t - s_t]; 0 \}$$

where :

m_t = the number of vehicles in the queue in time interval t, on a given link [similarly for m_{t-1}],

q_t = number of vehicles arriving in interval t, given by 'IN' pattern,

s_t = number of vehicles allowed to leave in interval t, given by the 'OUT' pattern.

Thus, the 'OUT' pattern given for link i during time interval t is :

$$OUT_{it} = m_{i,t-1} + q_{it} - m_{it}$$

TRANSYT estimates a delay as composed of a uniform element, d_u; a random element, d_r, and the delay due to oversaturation, d_s. The uniform delay is determined by everaging the queue length over the cycle, or :

$$d_u = [C/(3600/N^2)] * \sum_{t}^{N} m_t$$

where :

d_u = uniform delay in [veh-hr/hr],

C = cycle length in seconds,

m_t = queue length during step t,

N = number of steps in the cycle.

TRANSYT computes the combined effect of random delay and saturation delay [d_{rs}] using an algorithm as follows :

$$d_{rs} = [(B_n/B_d)^2 + (x^2/B_d)]^{0.5} - [B_n/B_d]$$

where :

d_{rs} = random, and saturation delay,

B_n = $2 * [1-x] + [x * z]$,

B_d = $4 * z - z^2$,

z = $[2x/v] * [60/T]$,

x = the degree of saturation,

v = volume of the link,

T = simulation time, normally 60 minutes.

The total delay, then is computed as $D = [d_u + d_{rs}]$.

SECONDS OF DELAY :	1	2	3	4	5	6	7	8	9	10	>10
PERCENT OF STOPS :	20	50	65	76	83	88	93	95	97	99	100

Table III.1. Reduction of stops as a function of delay.

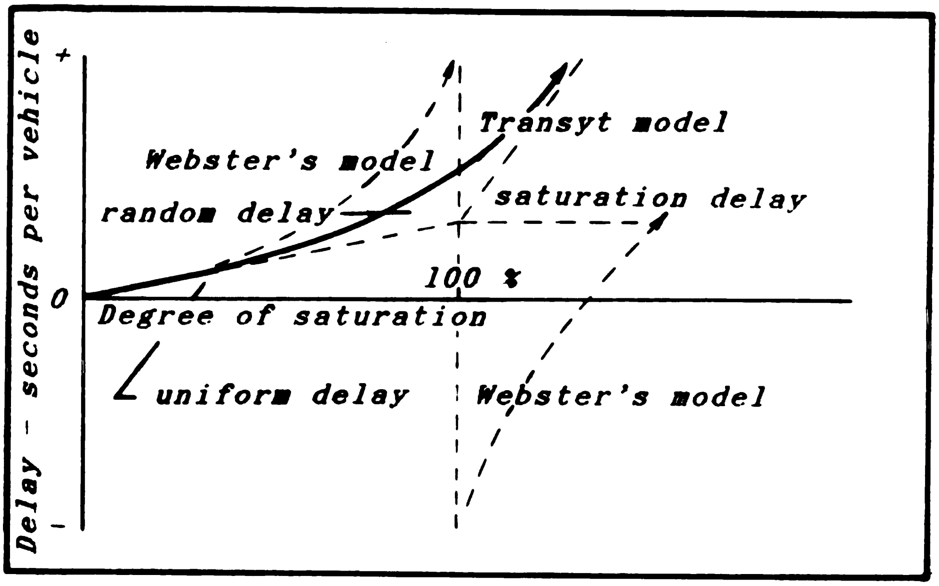


Figure III.1. TRANSYT-7F estimate of delay

The number of vehicles stopped is simply equal to the number of vehicles delayed. However, if the delay to such vehicles is small, only partial stops are counted.

The recommended adjustment of these stops, based on an empirical study suggested by TRRL are shown in Table III.1.

III.1.5. LIMITATIONS AND OTHER FEATURES

TRANSYT-7F is sufficiently realistic, and extremely useful in designing the optimal signalization of many network configurations. However, care should be taken in order to use this model. TRANSYT-7F assumes all major intersections in the network are signalized, even though mid-block bottlenecks or other sign controlled intersections can be modelled. TRANSYT does not adequately model unprotected left turnning movements. The fact that vehicles must wait for an acceptable gap in traffic in opposing link must be considered since this could reduce the rates of saturation flow, and cause increasing - delays and stops in the traffic streams. Tanner's curve and the approach introduced in the user's manual [29] do not adequately represent the real world. TRANSYT-7F calculates average speed in the network by excluding links having zero distance [e.g. external links] and links that have been assigned zero delay and stop - weights [e.g. non-vehicular links]. This could of course significantly influence the results of optimization, since average speed is an important factor in estimating total travel time which is an independent variable in the estimation of fuel consumption. The entering traffic for any network, the dispersion, volumes, and the proportion of turns are considered to be uniform and constant, which are not realistic over the entire period of analysis.

Despite those several limitations, TRANSYT-7F is an extremely powerful tool for the practicing traffic engineer. It can be used to design larger networks by subdividing those into sections handled by the present program. It also uses a fairly realistic flow model without requiring outrageous run times.

III.2. SOAP84

SOAP84, released by the Federal Highway Administration in June 1985, is one of several versions of the *Signal Operation Analysis Package.* It developes signal control plans for any three or four legged isolated intersection. This program can evaluate a wide range of control alternatives including pretimed or multiphase actual control. SOAP determines the optimal cycle length and phasing, and provides several measures of effectiveness including delay, stops, fuel consumption, and volume over capacity ratio. Left turn configurations might also be programmed with seperate capacity calculation made for protected phases, unprotected phases and the clearance intervals.

III.2.1. MODEL DESCRIPTION

The SOAP model, designed and written by the Univ. of Florida Transportation Research Center, is a deterministic, macroscopic, optimization program. It was written in Fortran IV on an IBM 370/165 computer system. The program requires 202 k bytes of computer memory. During its development phase, the program had been run using IBM Fortran G, H-extended and WATF IV computers. The current version is ready to run on most IBM systems with some changes required for other systems. A version is also available for the BORROUGH computer. For the microcomputer version, the computational methodology is similar, but not identical to the methodology used in the original IBM version. SOAP84 reconciles only one set of design volumes, saturation flows, phase sequences, etc. This version deals with a maximum of 48 contiguous time periods, each with its own characteristics. Phasing optimization is accomplished by a multiple run, trial and error procedure. The complete phase sequence must be specified for SOAP84.

III.2.2. INPUT REQUIRED

The input data required include the traffic volumes, which are adjusted to reflect trucks and buses if any, saturation flows per hour of green time given to each movement, the headway for each movement; the existing signal timing which includes minimum green time, cycle length, phasing, green time by movement, and all red time; the loss time due to starting and stopping of every movement; the growth factor to project future conditions at the intersection; left turns per cycle on clearance; peak-hour factor; speed; type of controller, pretimed or actuated control.

III.2.3. THE OPERATION

SOAP has the capability for design, analysis and evaluation. All of which can be accomplished by providing the input data previously described. To design signal timing, it is necessary to configure the intersection and input the appropriate data. SOAP then produces all legitimate phasing patterns. It internally analyzes each pattern and selects the one which can be executed using the minimum amount of green time. Cycle length is the most difficult design element to be determined, particularly when several control periods are being considered. However, SOAP determines this quickly based on the traffic volumes, capacity and other parameters. A trial and error optimization procedure is done to find the cycle length which produces the minimum total delay, subject to constraints which govern the tolerable length of the queue. To analyze the effects of various control strategies, a number of measures of effectiveness [MOE], are computed, including delay, stops, excess fuel consumption, degree of saturation, and left turn conflicts. Evaluation is done by comparing several alternative schemes. Comparisons can be produced automatically by SOAP or manually by the user.

III.2.4. COMPUTATIONAL ALGORITHMS

The algorithms used by SOAP for the calculation of the values of the MOE's identified above are :

DELAY

To estimate delay, SOAP utilizes Webster's delay model for unsaturated flow under fixed time operations. The Webster's model has three components, which are expressed as the delay due to uniform arrivals, D_1; random arrival, D_2; and an adjustment factor, D_3. The delay due to uniform vehicle arrivals, is :

$$D_1 = C[1 - L]^2/2/[1 - L * X]$$

where :

C = cycle length [sec.],

L = the proportion of green time given to the movement [effective green time/cycle length],

X = the degree of saturation of the movement or : approach flow [veh./sec.]/saturation-flow [veh./sec.]

The component due to random arrivals, is :

$$D_2 = [X^2]/[2*q]/[\ 1-X\ ]$$

where :

q = approach flow [veh./sec.], and the other notations are the same as previously described.

Then the adjustment factor is :

$$D_3 = [\ -\ .65][C/q^2]^{1/3} * X^{[2+5L]}$$

which was derived empirically to provide a better mathematical fit to the field data. Webster's delay increases infinitely as the degree of saturation X, approach 100 %, and reenters the finite realm from the negative side at values above 100 %. This is due to the [1-X] factor in the denominator of the second term. The upper limit on the useful range of X is generally in the neighborhood of 97.50 %. For the region where the saturation is between 97.50 % to 100 %, delay is assumed to be constant at the value for X = 97.50 % ; or 2.0 min./veh., whichever value is less.

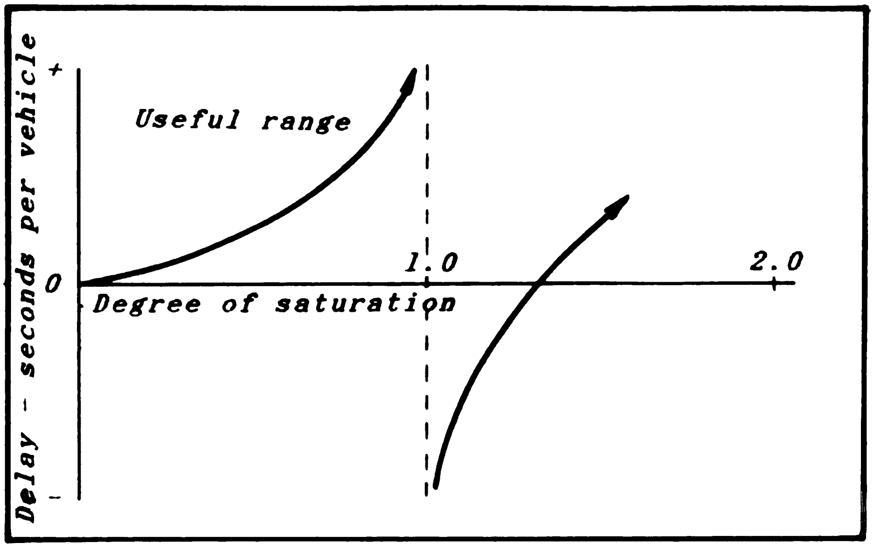


Figure III.2. Webster's model delay

Great care must be taken in applying Webster's equation under conditions of near or oversaturation. Webster's delay model is plotted in Figure III.2. For saturation in excess of capacity, the following formula is used :

$$Q_r = T[q - L * S]$$

where :

Q_r = the number of vehicles not accomodated during the green,

T = time period [sec.],

S = saturation flow [veh./sec.], while the queue length at the end of the phase, Q_e, is calculated as the sum of Q_b, the queue length at the beginning of the period, and Q_r.

Therefore with these values, the total delay is :

$$D = T/2/[Q_b + Q_r].$$

In the case of actuated control, the problem is quite complex, and no reliable delay model exists. The approximation used in SOAP simulates a 'well timed' actuated controller. The actuated control strategy is assumed to :

- distribute green time available in proportion to the demand on the critical approach;
- minimize 'wasted' time by terminating each green interval soon after the queue has been served.

THE CYCLE LENGTH

Cycle length is calculated by using Webster's -

method as well. For fixe timed operation, the optimal cycle length is :

$$C_o = [(1.5*l) + 5]/(1 - y)$$

where :

l = total lost time due to starting and stopping critical movements, and

y = the overall degree of saturation [i.e. the proportion of green time required for the traffic movement].

For actuated control, the cycle calculated is the average cycle length, which is determined as :

$$C_a = [1.1*l]/[1- y]$$

In the low to moderate demand range, this value will always be smaller than C_o. As the intersection approaches saturation, actuated control approaches fixed time control.

EXCESS FUEL CONSUMPTION

Fuel consumption is determined from the total of the percentages of stops and delay i.e :

$$E = E_s + E_d$$

The excess fuel consumption due to stops is calculated as :

$$E_s = f_s * q * P_s$$

where :

E_s = gallons of fuel consumed due to stops,

f_s = fuel consumption rate [gal/stop],

q = traffic volume [veh/hr],

P_s = percent of stops, which is equal to the number of vehicles joining the queue while it is still discharging, all divided by the number of arrivals per-cycle, or :

$$P_s = [r*S]/c/[S - v],$$

where :

r = red time [sec],

S = saturation flow during green [veh/sec],

Then, the excess fuel consumption associated with delay is :

$$E_d = f_i * q * d/3600$$

where :

f_i = fuel consumption rate per veh-hr of idling,

d = average vehicle delay [sec/veh].

LEFT TURN CONFLICTS

A conflict can occur when left turns are permissive, or not exclusively protected. The measure of effectiveness is described as the number of left turns which cannot be accomodated safely. The turning vehicles may cross traffic, if sufficient gaps in the oncoming traffic exist. Tanner's model is used to calculate the effective left turning saturation flow. This model relates the opposing flow to left turn traffic. Given the opposing flow, the left turn saturation flow is taken from a curve and compared to the left turn demand. Excess demand is the number of left turn conflicts.

III.2.5. LIMITATIONS AND OTHER FEATURES

As described before, SOAP has the capability of design and analysis for any traffic control strategy, either pretimed or actuated operations. However, several limitations warrant notice. The optimization and analysis are obviously based on mathematical models which often cannot take human behavior into consideration. The SOAP program does not exactly simulate the traffic in real world events. For instance, the combining of right turns with thru traffic presents a problem with the accurate estimation of the capacity. Some other problems include : the incapability of analyzing closed loops, lack of widespread testing, and lack of validation of the platoon dispersion algorithm.

CHAPTER FOUR: TRANSYT-7F & SOAP84 CONSISTENCY TEST OF THE MOE'S

TRANSYT-7F and SOAP84 are well accepted as producing realistic results with nearly similar computational bases. Both are deterministic, macroscopic, time scan, simulation and optimization models based on simple sets of equations. They offer practical methods of signal timing which are easy to use. TRANSYT-7F is generally used for the traffic signals along an arterial or network of up to 50 nodes with approximately 250 directional links, while SOAP84 provides a method of developing signal control plans at isolated intersections. This would of course raise an intriguing question: can TRANSYT-7F and SOAP84 produce consistent results under the same traffic condition?. A positive answer could reflect favorably on both models. Therefore, it is the objective of this study to reveal the answer to this question.

IV.1. DESCRIPTION OF THE STUDY SITE

In the downtown area of Lansing, the capitol of the state of MICHIGAN, a section of Michigan Avenue was selected as the case study. Michigan Avenue carries two way traffic, two lanes in each direction, 12 ft width each, with a left turning lane between directions.

Parking is permitted on both sides of the road.

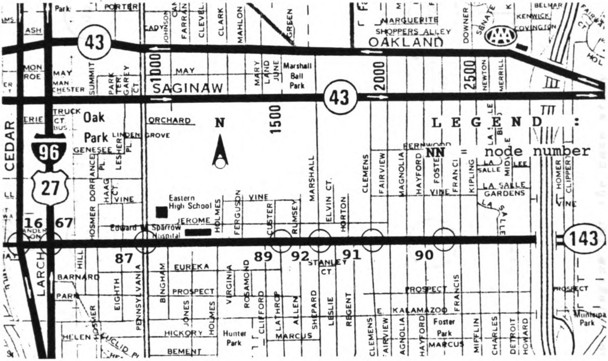


Figure IV.1. Section of arterial under study

The section under study consists of seven coordinated signalized intersections with 60 second cycle length, all are pretimed and operated in two phases.

IV.2. STUDY APPROACH

The TRANSYT-7F program was first run to determine the optimal cycle length, splits, and systemwide performance with optimal settings corresponding to the

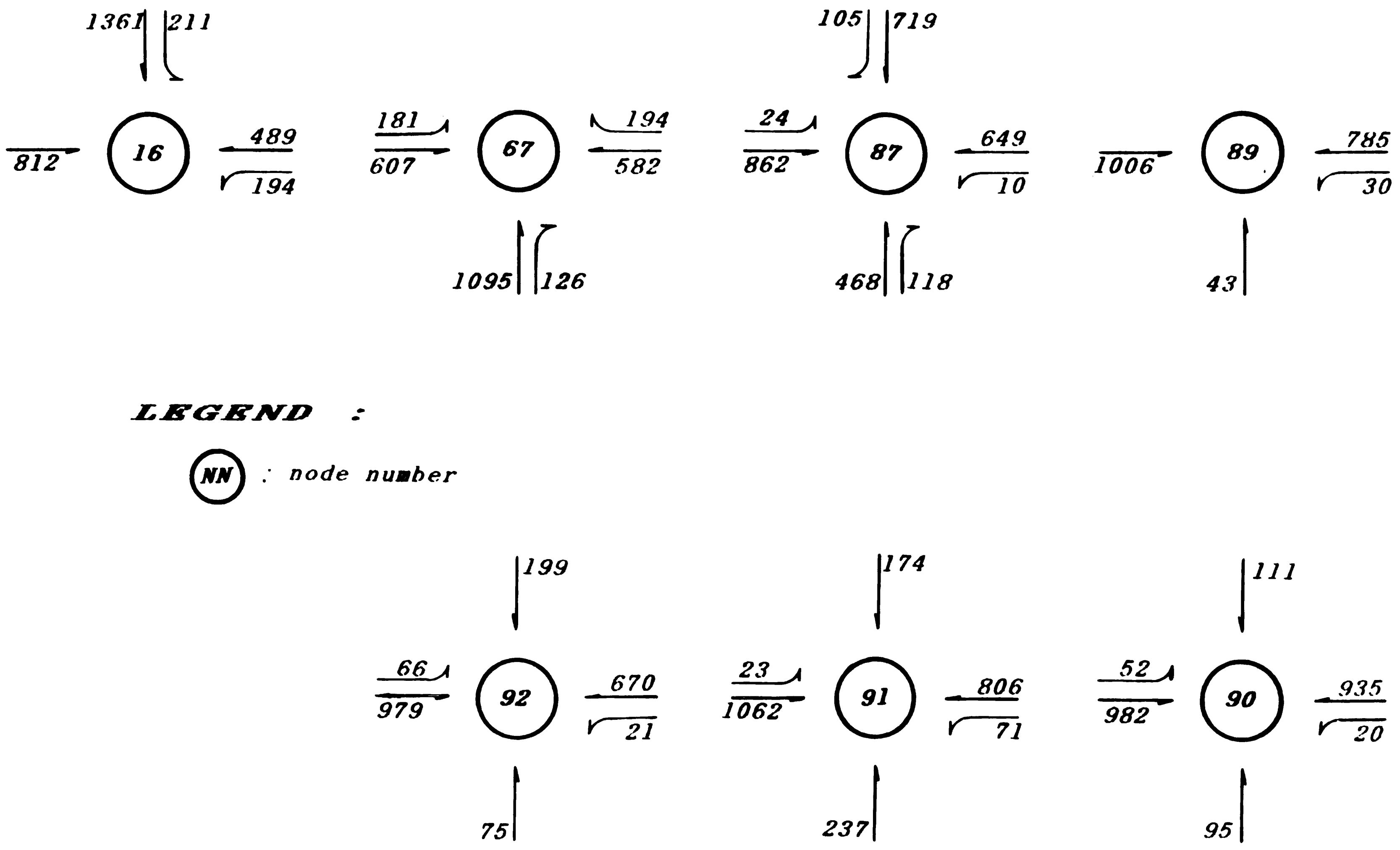


Figure IV.2. Traffic flow diagram for the case study traffic flows at the observation period of 16.00 - 17.00 hours. The optimal setting times resulting from the TRANSYT-7F run then were specified as inputs for the SOAP84 evaluation. The outputs generated by TRANSYT-7F and SOAP84 program are provided in the Appendix-1, and Appendix-2 respectively.

Total delays, stops and fuel consumptions predicted by both models were selected as performance measures for testing of their consistency. Scatter plots and linear regression equations were established to determine the relationship patterns of performance measures estimated by both models.

IV.3. RESULTS AND ANALYSIS OF PERFORMANCE MEASURES

Delay and stops are well recognized as very useful measures of effectiveness in a traffic control system.

DELAY

SOAP utilizes Webster's model to estimate the average delay per-vehicle. SOAP defines delay as the difference in average travel time through the intersection and the travel time for a vehicle which is not stopped or slowed down by a signal. Webster's delay model was modified by Mr. Robertson for use in the TRANSYT program to give more reasonable results, particularly for traffic volumes beyond the saturation point. TRANSYT and SOAP consider delay mostly as a waiting time in the queue caused by the red phase. Total delay is then defined by both models as the product of the average delays and the total intersection volumes.

STOPS

The proportion of vehicles stopped by the signal is also important. Stops are very significant factors in the estimation of both fuel consumption and potential accidents at a traffic signal. SOAP describes the proportion of vehicles stopped at a signal as equal to the number of vehicles in the queue at the beginning of the green time plus the number of vehicles which join the queue while the queue is still discharging, divided by the average number of arrivals per cycle. TRANSYT assumes that vehicles which are delayed are also stopped, though this is not always the case in the actual traffic flow. The problem of modelling this arises when vehicles do not actually stop. TRRL considers that the short periods of delay can be expressed as a fraction of stops for vehicles affected. [see table III.1.] The total delay, stops, and fuel consumption performances predicted by TRANSYT-7F and SOAP84

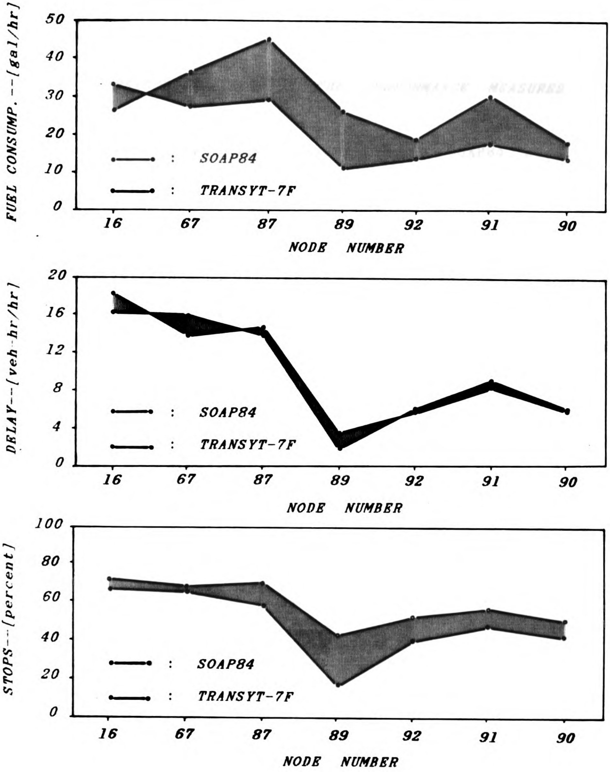


Figure IV.3. Comparison of performance measures programs are shown in Figure IV.3.

IV.4. CONSISTENCY TEST OF THE PERFORMANCE MEASURES

As stated earlier, TRANSYT-7F and SOAP84 were developed for different purposes. TRANSYT-7F is primarily used for analyzing traffic signals along an arterial or a network, while SOAP84 is a model for analyzing isolated intersections. Therefore, it would be reasonable if in some cases their estimation of the performance measures would be different. However, their reliability will be enhanced if they generate consistent results under similar traffic conditions.

In this case, the regression equations were first established to determine the relationship patterns for the performance measures generated by both models under similar traffic conditions. The linear regression equations presented in Table IV.1. indicate that the results for total delay and stops generated by both models were strongly correlated.

Within the conditions investigated in this study, TRANSYT-7F and SOAP84 produced compatible results in terms of the estimation of delay and stops. However, if we consider the fuel consumption performances predicted in this study, they seem significantly different. The bases of computing fuel consumption are obviously different between these models.

M.O.E. :	*REGRESSION EQUATION*	*CORREL. COEF., [R].*	*S.S.E.*
Tot. del.	*STDEL = .69640 + .95 TTDEL*	*.97*	*1.52*
Stops	*SSTOP = 30.66364 + .59 TSTOP*	*.96*	*3.64*
Fuel cons.	*SFCON = 3.69637 + .60 TFCON*	*.62*	*7.70*

Table IV.1. Relationship between TRANSYT-7F and SOAP84 results

NOTE :

STDEL = SOAP84 total delay.

TTDEL = TRANSYT-7F total delay.

SSTOP = SOAP84 total uniform stops.

TSTOP = TRANSYT-7F total uniform stops.

SFCON = SOAP84 total fuel consumption.

TFCON = TRANSYT-7F total fuel consumption.

TRANSYT-7F generates the total gallons of fuel consumed by all vehicles based on exprimental studies. A stepwise multiple regression analysis was used which resulted in the following equation : [4][29]

$$F = k1 * TT + k2 * TD + k3 * TS$$

where ;

F = gallons of fuel consumption per-hour.

TT = total travel per-hour.

TD = total delay.

TS = total stops.

k1, k2, k3, are coefficients of regression.

SOAP84 on the other hand, estimates only the total fuel consumption due to idling delays and accelerations from stopped positions. Therefore, it would be reasonable if the estimation from SOAP84 is lower than that estimated by TRANSYT-7F. However, this will not always be the case. At node # 16 for example, [see Figure IV.3.], because of a high level of saturation, SOAP84 produces a high value of the estimation of fuel consumption. TRANSYT-7F also poses a problem in the estimation of fuel consumption. The calculation of the average speed which excludes the contribution of external links will give different results for the determination of total travel for intersections with various ratios of external to internal link volumes but the same total volume. The effect of the ratio of external to internal link volumes on fuel consumption estimation are shown in Table IV.2.

	LINK VOLUME			***FUEL CONS. [GAL/HR]***		
NN	***EXTERNAL***	***INTERNAL***	***RATIO***	***TRANSYT-7F***	***SOAP84***	***RATIO***
89	*43*	*1,821*	*.02*	*26.71*	*10.16*	*.38*
90	*206*	*1,989*	*.10*	*19.10*	*14.57*	*.76*
92	*274*	*1,736*	*.16*	*19.64*	*14.11*	*.72*
91	*411*	*1,962*	*.21*	*30.12*	*18.45*	*.61*
67	*1,221*	*1,564*	*.78*	*36.42*	*27.50*	*.76*
87	*1,410*	*1,545*	*.91*	*45.06*	*29.66*	*.66*
16	*2,384*	*683*	*3.49*	*26.45*	*33.23*	*1.26*

Table IV.2. The effect of the ratio of external to internal link volumes.

CHAPTER FIVE : EXAMINING THE IMPACTS OF SIGNAL OPTIMIZATION

The optimization of traffic signal settings for a particular network are determined by a given set of roadway geometrics [supply variables], and the traffic patterns [demand conditions]. If either the supply or demand changes significantly, the existing signal timings may not be optimal, and retiming signals might be desired. The most important issues addressed in the maintenance of signal timing are :

- level of congestion under existing traffic conditions; and
- the magnitude of traffic growth in the future.

In a heavily trafficked network, small increases in traffic volume might offset the benefits of signal optimization. On the other hand, a network consisting of light traffic might be able to accomodate the increasing traffic volume without significant effect. This chapter addresses the magnitude of the traffic impacts likely to be caused by the increasing traffic, and to evaluate alternative policies for managing it whenever needed.

V.1. DESCRIPTION OF THE STUDY SITE

A network in a suburban area of the city of Cirebon, Indonesia, was selected as the case study for the following reasons :

- the availability of traffic signal timing data;
- the possibility of facing serious traffic signal problems caused by the increasing traffic volume in the future under the existing signal timings; and
- learning the beneficial impacts of signal timing optimization, by applying TRANSYT-7F directly to an Indonesian Network.

This network is located near Cirebon harbor which gives a specific meaning to its traffic. The study area includes four signalized intersections, all of which are pretimed and operated in two phases. The street system operates two way traffic, which consists of one or two 10 ft width lanes in each direction. No parking is permitted on the street. The business activities in the downtown area, and the potential of new developments in the city is expected to increase the traffic volumes, which will affect the traffic pattern throughout the network, and could create a serious level of congestion.

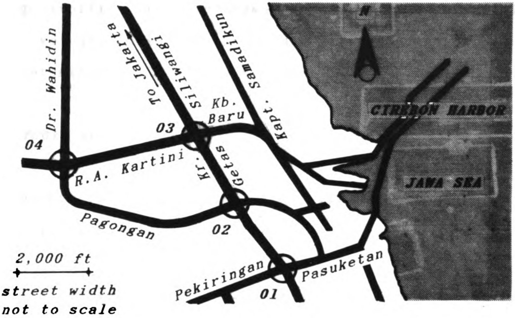


Figure V.1. Network system of the case study

For this particular network, two issues will be addressed :

- how sensitive is the existing signal timing to the increasing traffic volumes throughout the network; and
- what is the maximum level of traffic that can be accepted with signal timing optimization, before major design changes, and

other TSM measures would be considered.

A simple way to examine the network sensitivity to increasing traffic is to assume incremental networkwide traffic volume, then measure the performances before and after optimization, by using the TRANSYT model.

V.2. STUDY APPROACH

TRANSYT-7F runs in this study were performed for two kinds of submodels :

- a submodel that simulates, at macro level the performance with existing signal - timings; and
- an optimization submodel that seeks the - 'best' signal settings.

The *'best'* signal setting, as previously described, was chosen based on a performance index - a weighted sum of stops and delays. TRANSYT input data characterize network geometry [road sections, intersections, and the saturation flows], signal timing parameters [cycle lengths, phasings, and minimum pedestrian timings if any], and the traffic volumes.

For the purpose of this study, traffic volumes were varied sequentialy as a proportion of the saturation flow, *S*, to the values of : .10*S*, .20*S*, .30*S*, and .40*S*, for both simulation and optimization runs. The turning traffic was assumed to be 20 percent of the total volumes, for either left or right turn flows. The direct outputs of TRANSYT include delay and stops along with the optimized signal settings. The values of the saturation flows were determined by considering the street geometries, percentage of trucks and the turning volumes. [22] To measure the impacts of these changes, TRANSYT system performance was converted into highway user costs and direct energy consumption. While the assumption that volumes increase uniformly throughout the network might not be realistic for design purposes, it nevertherless provides the first cut estimation of the impacts at a sketch planning level. An alternative way to determine the frequency of retiming could be by monitoring traffic growth through systematic traffic counts, observe the operation of the intersections, identify the problems, and then apply the TRANSYT model to evaluate the need for installation of new timings.

V.3. RESULTS AND ANALYSIS

To code the data for TRANSYT-7F runs, an illustration of the link-node diagram is presented in Fig. V.2. TRANSYT-7F simulation runs were first performed for the existing signal timings. Traffic flows were varied in the order of : .10S, .20S, .30S, and .40S

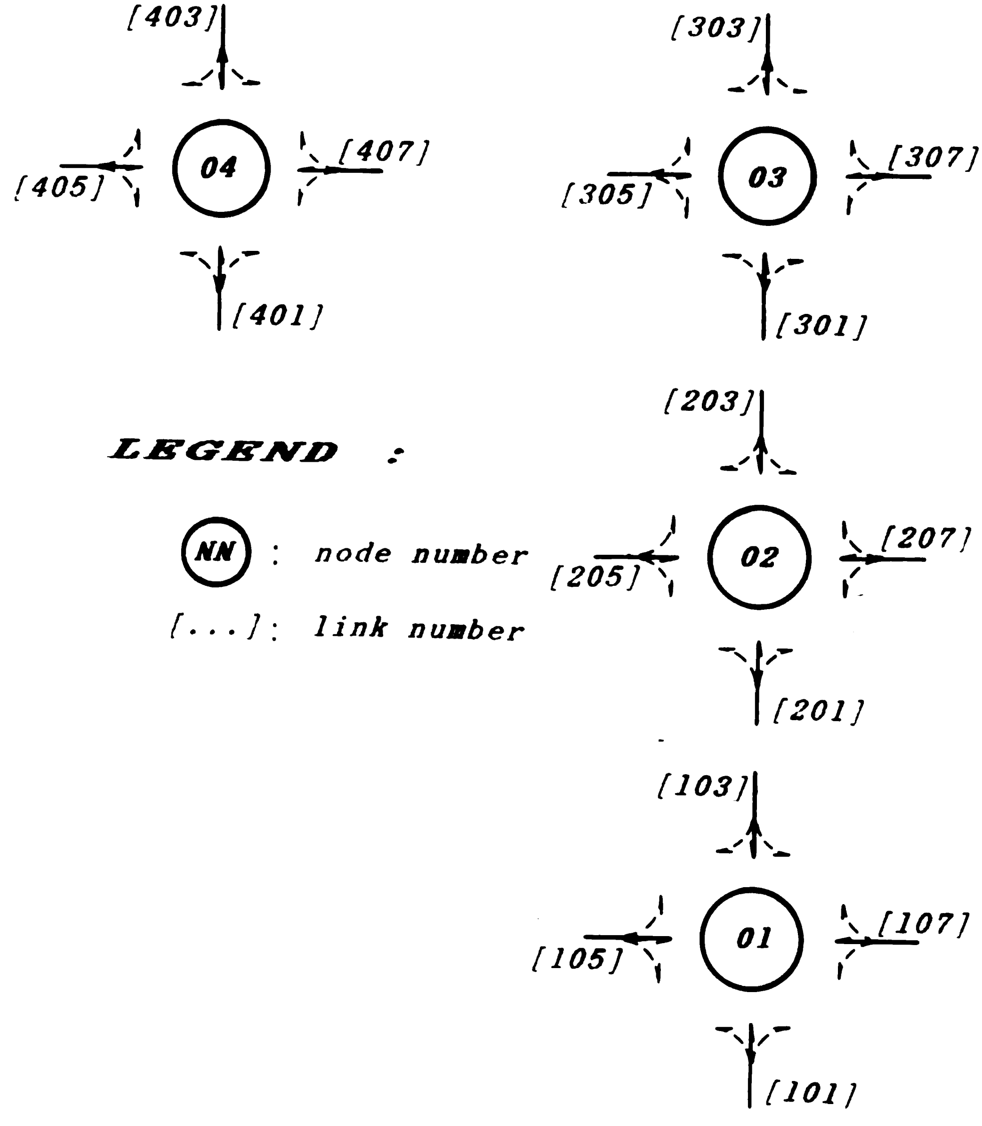
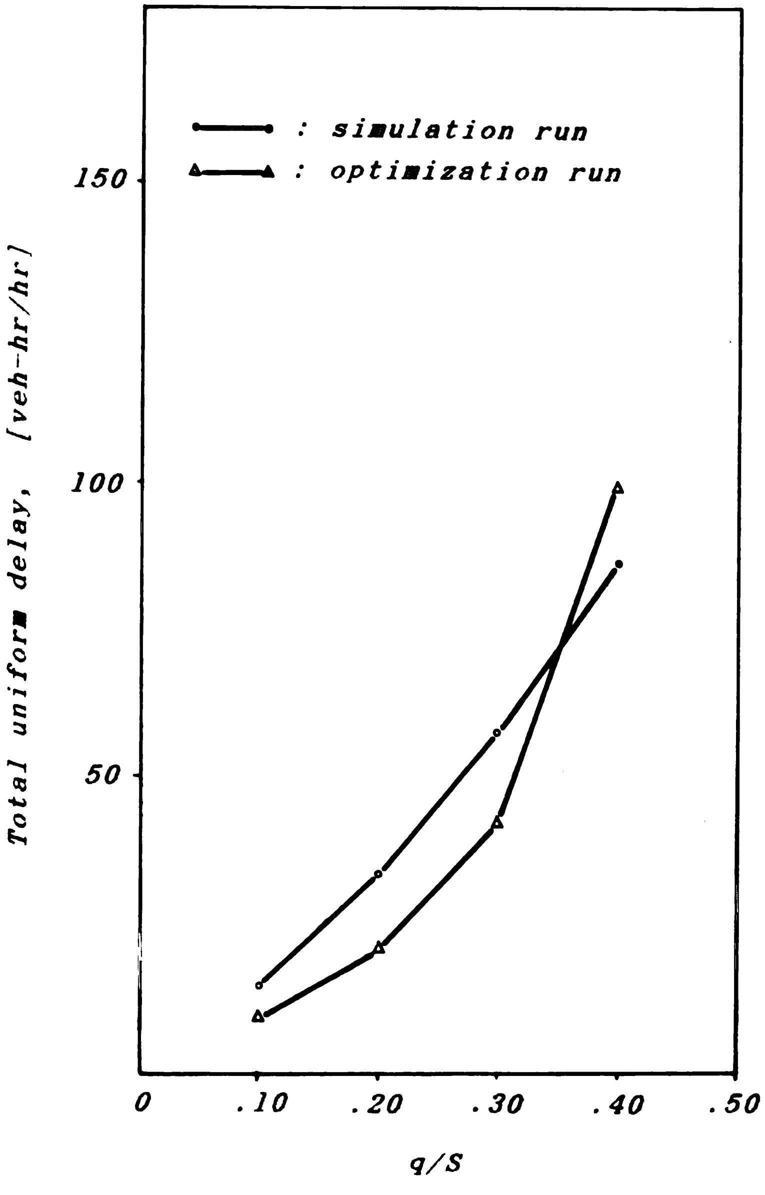
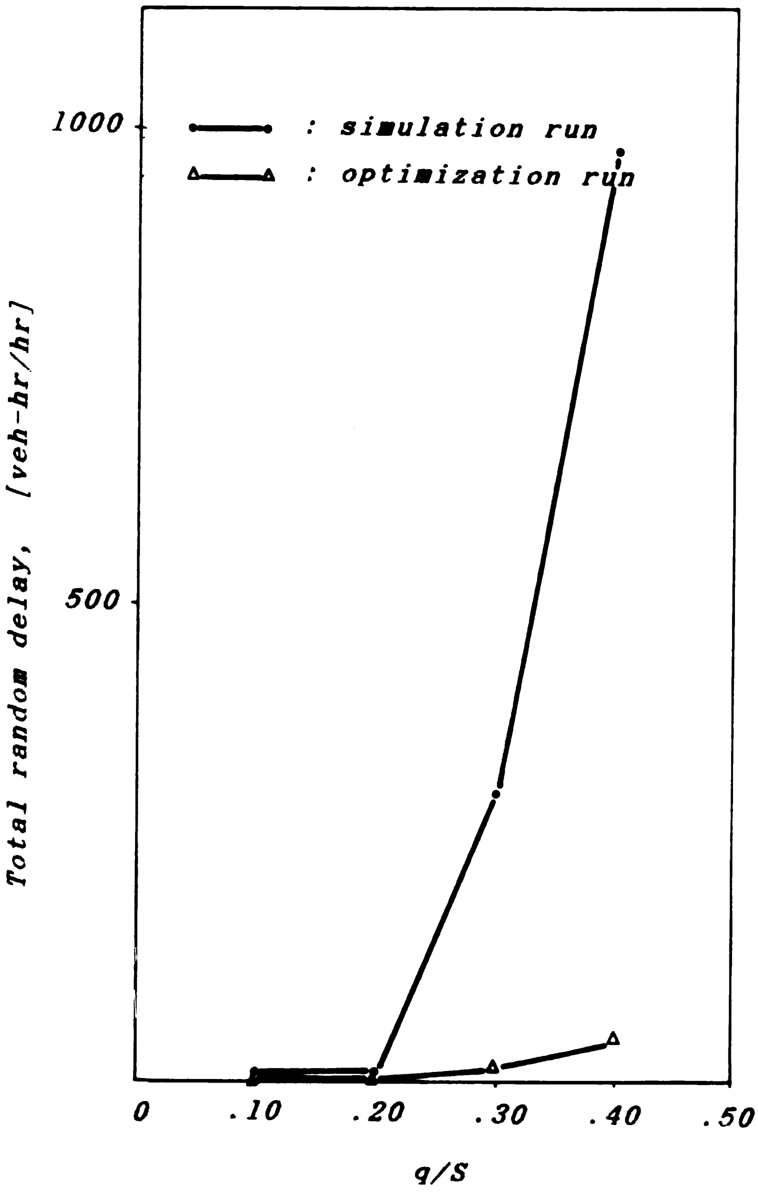


Figure V.2. Link-node diagram for the case study

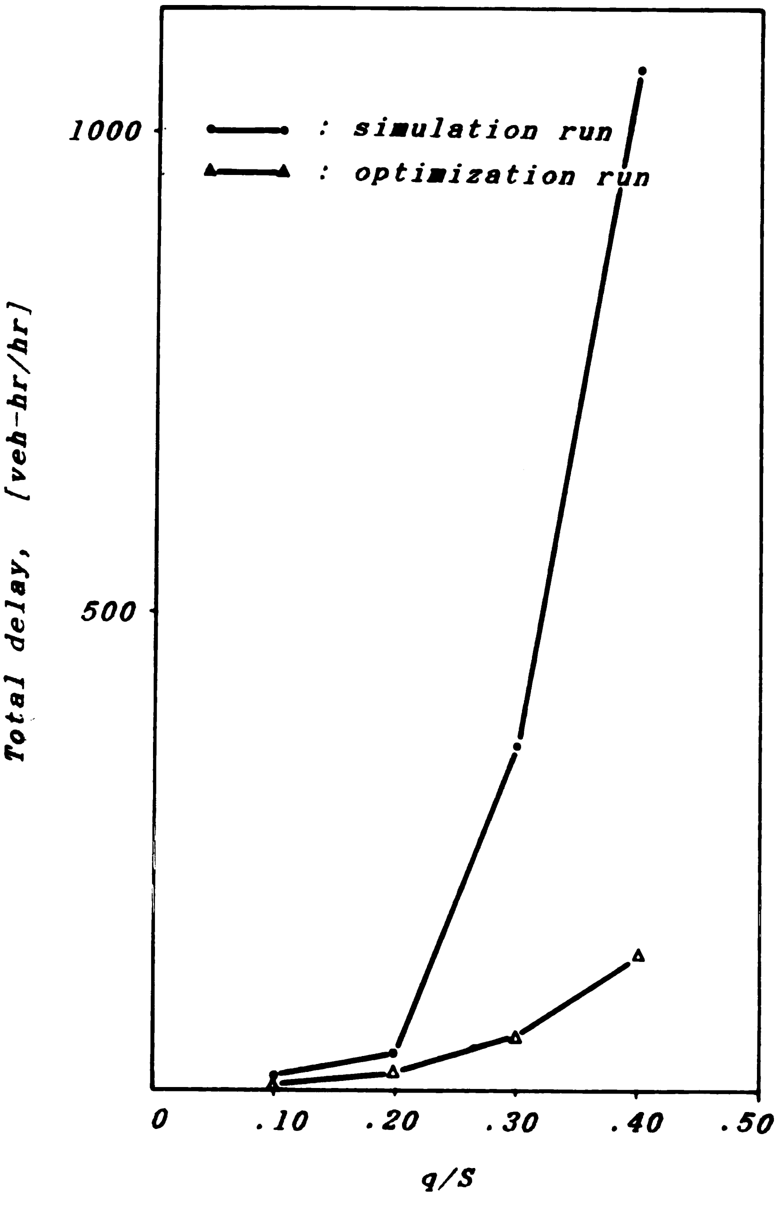
Figure V.3. Network-wide traffic performance



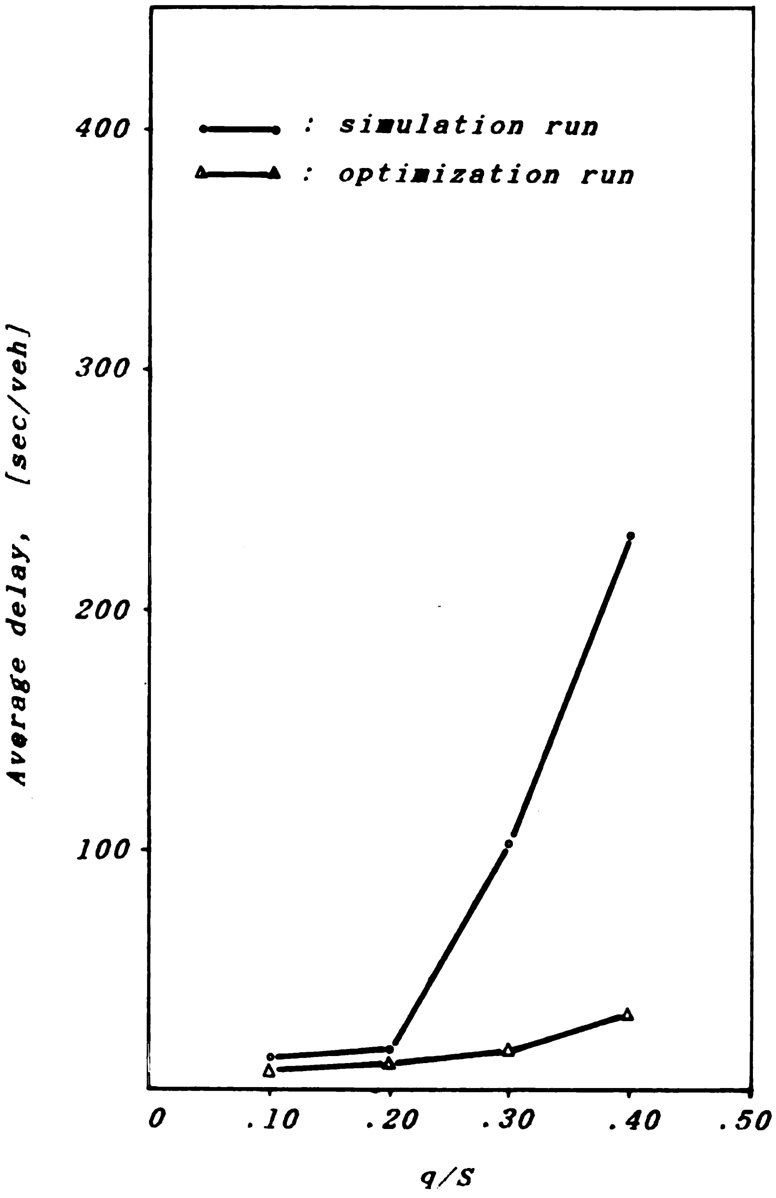
[a] total uniform delay vs q/S



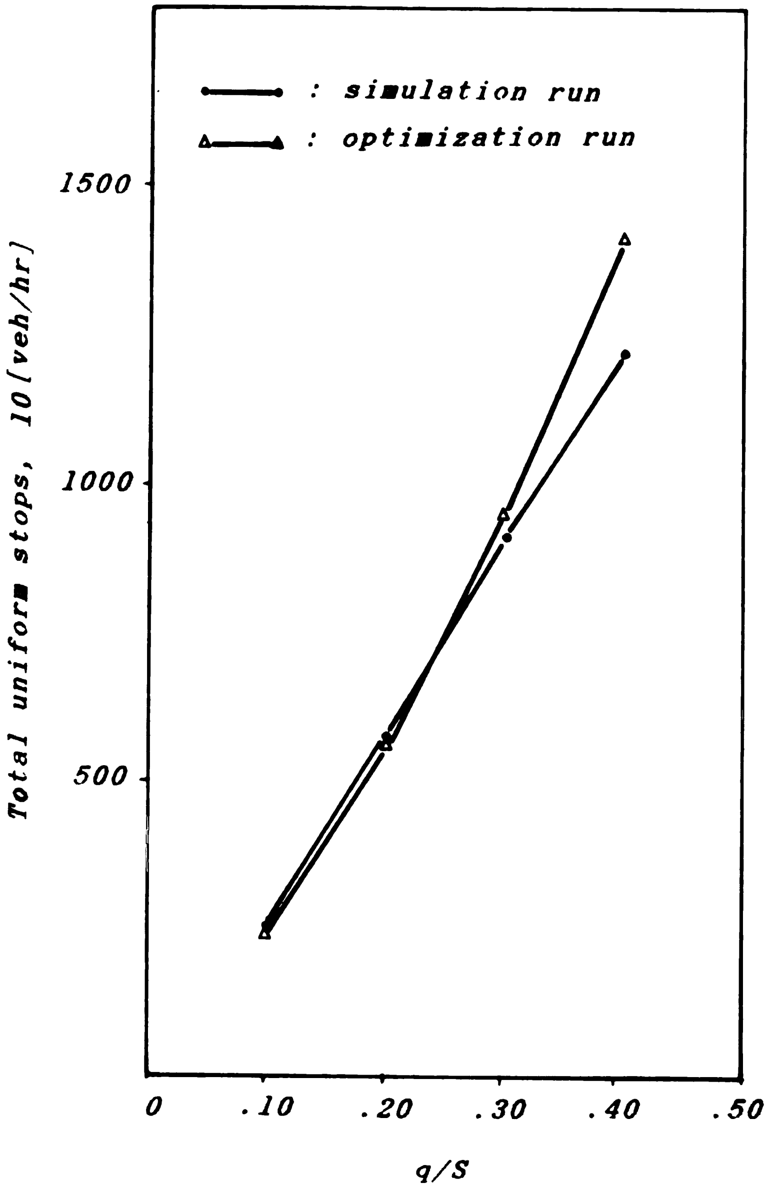
[b] Total random delay vs q/S



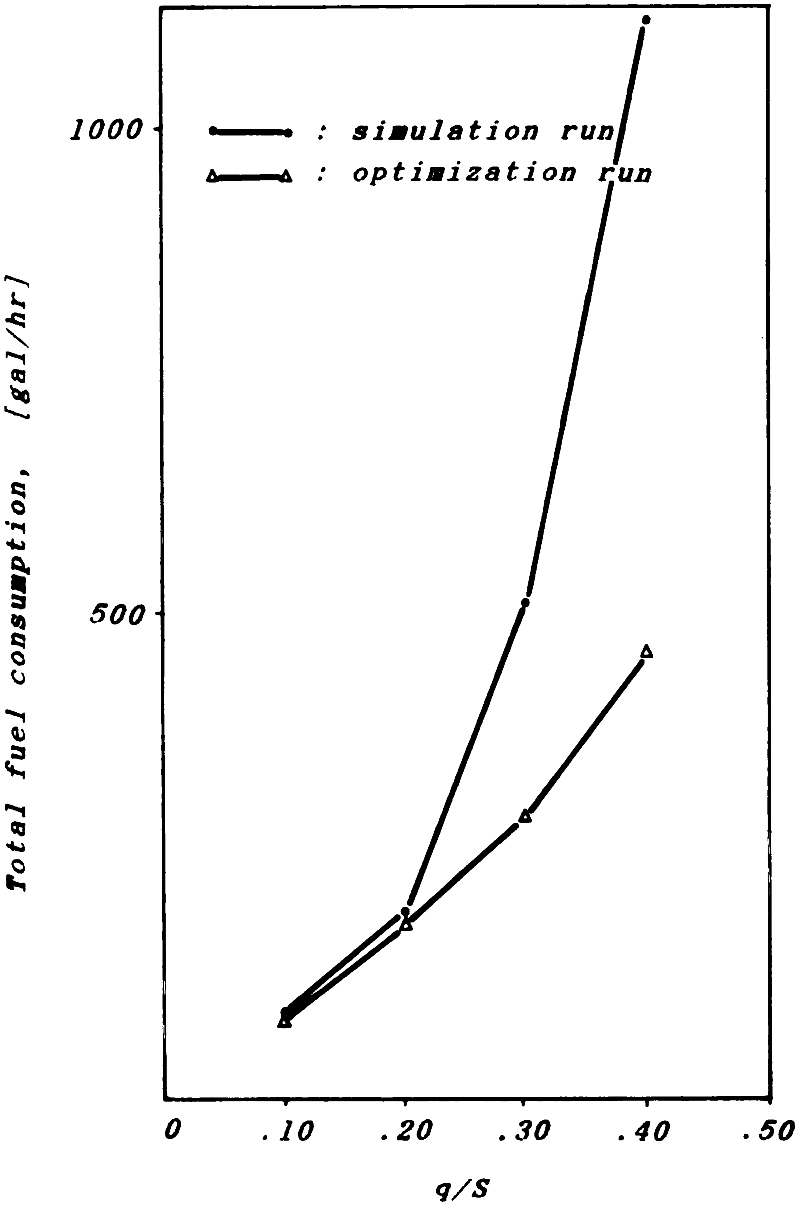
[c] Total delay vs q/S



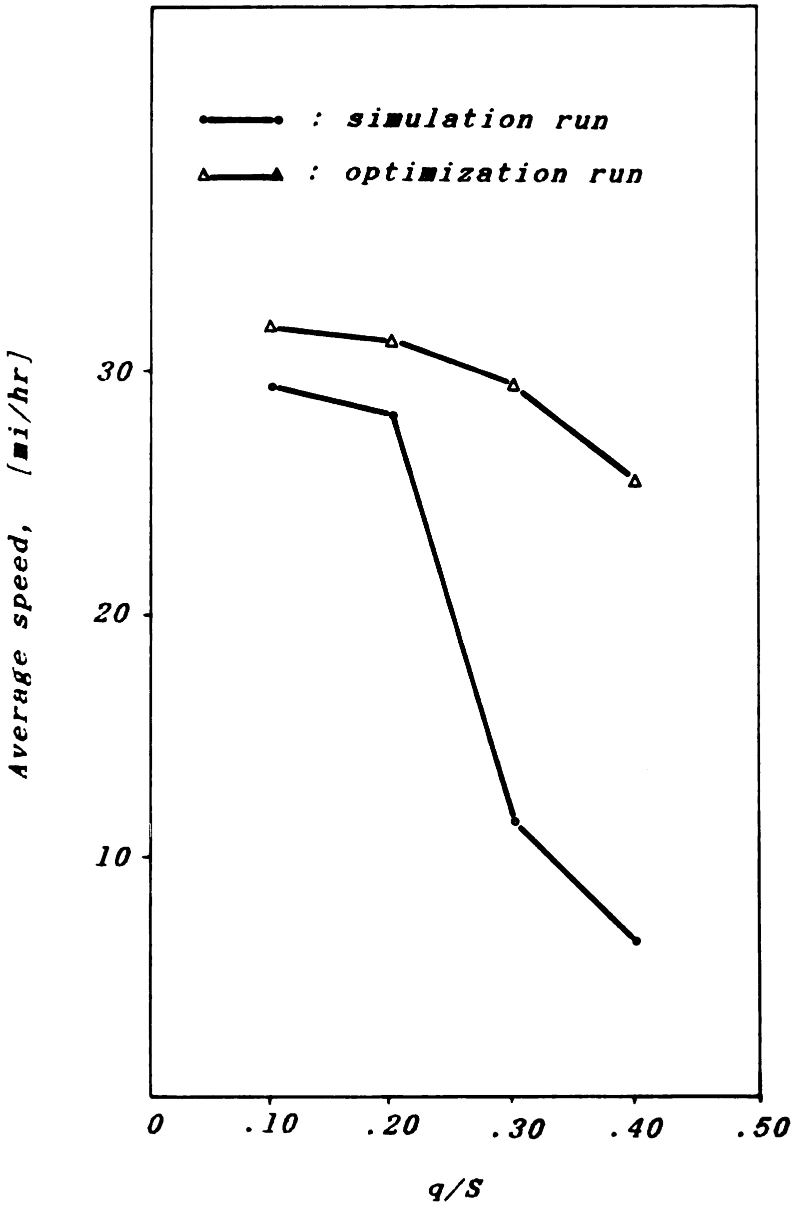
[d] Average delay vs q/S



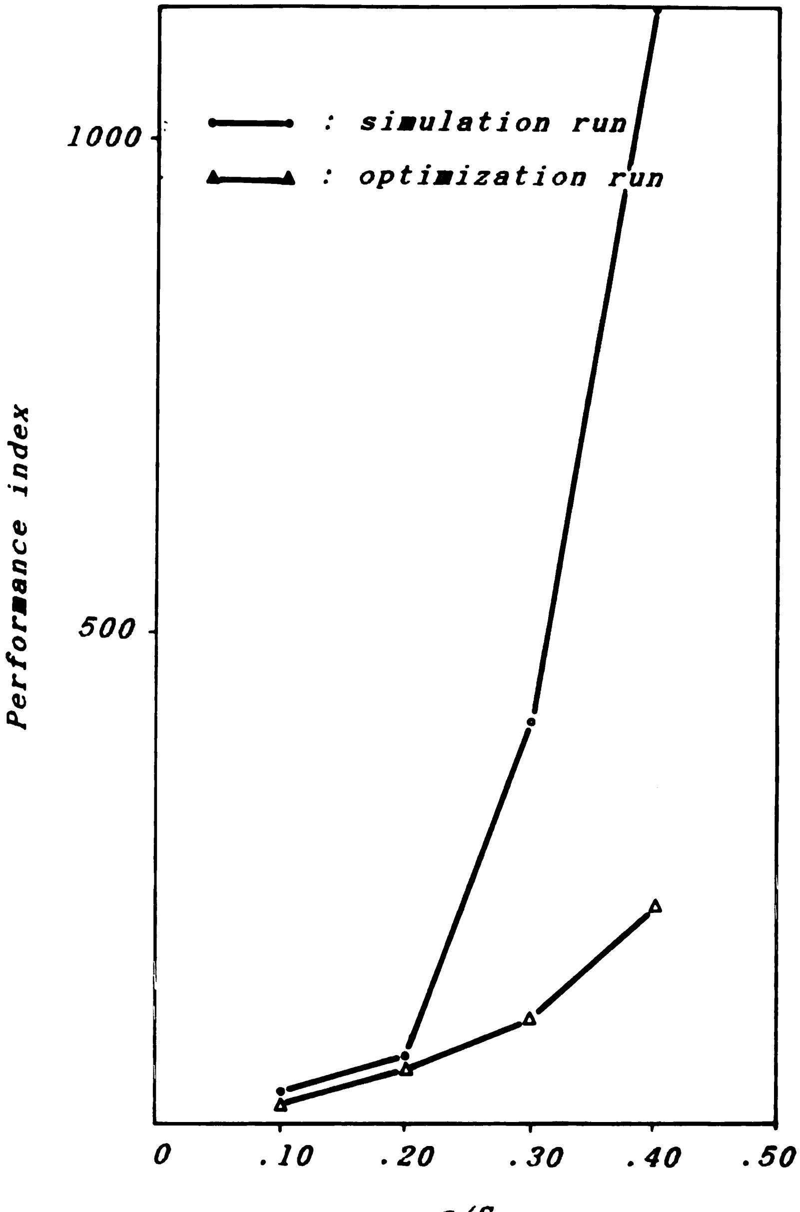
[e] Total uniform stops vs q/S



[f] Total fuel consumption vs q/S



[g] Average speed vs q/S



[h] Performance index vs q/S

where *S* is the street saturation flow. The optimization runs then were conducted to seek the optimal signal settings for the same variation of traffic flows. The complete outputs generated by both submodels are presented in APPENDIX-4. Figure V.3. a, b, c, d, e, f, g, and h, illustrate the systemwide performances predicted by both submodels. The optimization run for volume variations of .10*S* and .20*S*, does not significantly affect the traffic performance. However, as volumes increase to .30*S*, the network experiences congestion problems. Some links begin to be oversaturated. For the traffic volumes of .40*S*, the number of oversaturated links are dramatically increased and the network becomes sensitive to any additional traffic volumes. For example, an additional traffic volume from .10*S* to .20*S*, would result in an increased average delay of [(16.83 - 13.42)/(13.42) * 100 %] = 25.41 %, but as the volume increases to .30*S*, the average delay increases to [(103.28 - 16.83)/(16.83) * 100 %] = 513.67 %, a significant increase in terms of average delay !.

The intersection performance for the existing signal timing at traffic volumes greater than or equal to .40*S* deteriorates rapidly, as the number of critical intersections increases rapidly. For traffic volumes of .40*S* all of the intersections become oversaturated. Signal timing optimization could considerably improve the intersection performance as illustrated in Figure V.3. However, the benefit of optimization diminishes when the overall traffic volume increases to more than .40*S*. Though improvements exist compared to the existing condition performance under similar traffic volumes, the level of service at the intersection drastically decreases. Total stops also increase, and the optimal cycle length is relatively long. The degree of saturation remains above 85 %, which means the intersections would still be critical !. [3] Thus, unless such traffic growth could be avoided throughout the system, or other changes in travel behavior occured, another TSM strategy would be needed.

V.4. ENERGY AND COST EVALUATION

As was illustrated in Figure V.3., a signal timing optimization would improve the network performance for increasing traffic volumes under certain values of traffic flow. If we consider the case where traffic volumes increase to .30*S*, the delay would be reduced by [(358.03 - 54.75)/(358.03) * 100 %] = 84.71 %, Total stops would be increased by [(9104.40 - 9439.80)/(9104.40) * 100 %] = 3.68 %, while total travel time could be reduced by [(498.51 - 195.24)/(498.51) * 100 %] = 60.84 %. Fuel consumption would be conserved by [(512.22 - 292.01) /(512.22) * 100 %] = 42.99 %, and the average speed would be increased by [(11.47 - 29.31)/(11.47) * 100 %] = 155.54 %. Furthermore if we assume that this condition occurs only in the afternoon peak period, a simple estimation of benefits could be illustrated in Table V.1. [1][3]

By assuming that this condition would occur for two hours per day, and 300 work-days per year, then the total annual benefit would be U.S. $ 535,380.

CONSERVATION :		*[$] UNIT COST :*	*[$] COST :*
- delay saved [hrs] :	*303.28*	*2.00*	*606.56*
- stops saved [vph] :	*-335.40*	*.0016*	*- .54*
- fuel saved [glns] :	*220.21*	*1.30*	*286.27*
- [$] TOTAL COST :			*892.30/pk-hr*

Table V.1. Benefit estimated for volumes of .30S

The contribution from fuel consumption alone would account for U.S. $ 171,800. Furthermore, if we assume that the saving during the morning peak period are 75 percent of the afternoon peak, and the savings in the midday are 50 percent of those in the afternoon peak, then the total annual benefit from fuel saving only could be U.S. $ 386,500.; an attactive alternative to be considered!. Similarly, for the traffic flows of .40S, the annual benefit from savings of fuel consumption alone would be U.S. $ 644,500.

CHAPTER SIX: CONCLUSIONS

VI.1. SUMMARY

Total delay, stops and fuel consumption forecasted by TRANSYT-7F were compared with the results generated by SOAP84 in this study. The results for delays and stops were similar and consistent with what was expected. The linear regression equations presented in table IV.1. indicate that the results were strongly correllated. In the case of fuel consumption, TRANSYT-7F produced some-what higher values than those forecasted by SOAP84. This can be explained by the difference in basic computational procedure for fuel consumption in both models. TRANSYT-7F is used mainly for analyzing the signalization along an arterial street or a network. Therefore it includes the traffic flow between the nodes. SOAP84 only considers the fuel consumption at isolated intersections. One exception to these results is shown at node 16, where the total fuel consumption predicted by SOAP84 is higher than that predicted by TRANSYT-7F. This can be explained by the formulation of delay for both models, since fuel consumption is a linear function of delay. SOAP84 utilizes the Webster's model, which overestimates delay for high values of the degree of saturation. TRANSYT-7F uses a modified Webster's equation, and does not increase as rapidly as the level of saturation increases. After we recognize the limitation of Webster's model, the results from node 16 are easily understood.

As the case study of the CIREBON Network illustrated, TRANSYT-7F can be used for assessing the impacts caused by increasing traffic flows. Such evaluations are useful and can provide an indication of when traffic signal retiming would be warranted. Signal optimization is a low cost alternative for expediting traffic flow, reducing highway user costs and energy consumption. TRANSYT-7F offers the analyst the advantage of assessing impacts networkwide, instead of intersection by intersection. Several other positive features of the TRANSYT-7F program include :

- The traffic flow model traces flow patterns from link to link and incorporates a platoon model to allow one to study the effects of vehicular dispersion. This is particularly important where there is mixed vehicle traffic.
- The versatility of the optimization process in which both offsets and splits can be manipulated sequentially, and
- The consideration of both uniform and random delay to traffic in a signal network, thus considering both system coordination and the

capacity effects.

VI.2. FUTURE DEVELOPMENT

Based on the experiences gained in this study, some particular problems will be addressed in using computer models for traffic operation analysis in future model enhancements and developments. Those are:

STANDARIZATION OF THE INPUT DATA

Both models use similar input data, however each model uses different coding schemes which must be mastered by the user. This may confuse the unfamiliar users. Unnecessary effort and confusion could be reduced substantially by the development of a common input data coding scheme which can be shared by several traffic signal models.

PERSONEL TRAINING

More training is obviously required in the preparation of inputs and the mechanics of execution of various programs. Understanding how to interpret the output is also required to ensure the potential benefits of the models.

MAINTENANCE

It is natural to expect the improvement of the capability of any models as time and resources permit.

VI.3. TRANSFERABILITY OF U.S. EXPERIENCE TO INDONESIA

The recent progress achieved by the U.S. in the development of computer models for traffic operation analysis has been proven to be one of the most cost beneficial alternatives to be considered. For Indonesia, or any other third world country, where money constraints strongly influence policy, this could be an attractive conclusion. However, in order to adopt such advanced developments, current patterns and trends must be considered. A great difference exists in traffic patterns, resulting from some different environmental factors, which may limit the direct transferability of results.

In Indonesia, motorization has grown rapidly since the beginning of the 1970's, especially in the urban areas. Even-though Indonesia is an *OPEC* country, the wasting of energy will increase the government subsidy greatly. Particularly in these recent years, where the world market price of oil has dropped drastically, the conservation of domestic consumption is important.

The operation of mixed-traffic in the roadways, which is uncommon in the U.S., needs specific consideration as well. Vehicles operate in various speeds which effects the capacity of the roadway, the smoothness of flow, and the pattern of traffic flows.

Driver behavior, which is different from that in the U.S., could result in different traffic characteristic which need to be carefully studied. The factors effected might be ; the average speed, the value of headway, the conversion factors into passenger car units, etc.

Pedestrian behavior, government regulations, technology of public transportation, communication systems, and some other factors could significantly effect the traffic patterns which need to be carefully studied. By considering these kind of factors, and adjusting them wisely, the models may still be useful, and the benefit of using them can be achieved.

APPENDICES

APPENDIX-1

TRANSYT-7F OPTIMIZATION RUN FOR STUDY CASE-I, IN MICHIGAN AVENUE, LANSING, MICHIGAN

```
1           T R A N S Y T - 7 F  --  T R A F F I C   S I G N A L   S Y S T E M   O P T I M I Z A T I O N   P R O G R A M
0RELEASE 4   JUNE, 1984                                                                                                  VERSION 2.0
0SPONSORED BY:                                                                                          DEVELOPED BY:
 FEDERAL HIGHWAY ADMINISTRATION                                                                         TRANSPORT AND ROAD RESEARCH LABORATORY
 OFFICE OF TRAFFIC OPERATIONS                                                                           UNITED KINGDOM AND
                                                                                                        TRANSPORTAION RESEARCH CENTER
0                                            -------------------------------------------------------    UNIVERSITY OF FLORIDA
                                             I N P U T   D A T A   R E P O R T   F O R   R U N   1
                                             -------------------------------------------------------

0FIELDS:  1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16
        ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
0LINE                                                              RUN  TITLE  CARD
  NO.     TITLE
0  1)     RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---
0                                                              NETWORK  CONTROL  CARD
                                                  SEC/    SEC/
 LINE     CARD     MIN     MAX   CYCLE    STEP    STEP    LOST   GREEN    STOP  OUTPUT INITIAL  PERIOD  SEC(0)  SPD(0) ENGL(0)  PUNCH
  NO.     TYPE    CYCLE   CYCLE  INCR.    CYCLE  NORMAL   TIME   EXTEN. PENALTY  LEVEL TIMINGS  LENGTH PERC(1) TIME(1) METR(1) DECK(1)

   2)      1       60     100      2       2       2       4       3      25       2       1       0       0       0       0       0
0LINE     CARD                                         LIST  OF  NODES  TO  BE  OPTIMIZED
  NO.     TYPE

   3)      2       16      67     87      89      90      91      92       0       0       0       0       0       0       0       0
0                                                              SYSTEM  MASTER  DATA
 LINE     CARD   MASTER  DEF. CLEARANCES SYSTEM  EXTERNAL SYSTEM  FUEL    VEHICLE
  NO.     TYPE    NODE   YELLOW  ALL-RED SATFLOW  SPEED    PDF   FACTOR  LENGTH

   4)     10       16       0       0       0       0       0       0       0       0       0       0       0       0       0       0
```

```
0------------------
 INTERSECTION    16
 ------------------
1RUN TITLE:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---

 FIELDS:  1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16
         ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
                                                     CONTROLLER  TIMING  DATA
 LINE    CARD    NODE  OFFSET/          INTERVAL DURATIONS (SECS. OR PERCENT) ............................................ DOUBLE
  NO.    TYPE     NO.  YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INT8    INT9    INT10   INT11  CYCLE

   5)     12      16      52       1      18       4      34       4       0       0       0       0       0       0       0       0
0                                                         PHASE  TIMING  DATA
 LINE    CARD    NODE    START  VARIAB.  YELLOW  ALL-RED  MINIM.                                                               CONT.
  NO.    TYPE     NO.    INTVL   INTVL   INTVL   INTVL    SECS.   LINKS MOVING IN THIS PHASE ................................  FLAG

   6)     21      16       1       1       2       0      22    1605    1607    1608       0       0       0       0       0       0
   7)     22      16       3       3       4       0      38    1603    1604       0       0       0       0       0       0       0
0                                                              LINK  DATA
 LINE    CARD    LINK    LINK     SAT.   TOTAL   MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....    THIRD INPUT LINK....  QUEUE
  NO.    TYPE     NO.  LENGTH    FLOW     VOL.    VOL.     NO.    VOL.   SPD/TT     NO.    VOL.   SPD/TT     NO.    VOL.   SPD/TT  CAP.

   8)     28    1603       0    3700    1361       0       0       0       0       0       0       0       0       0       0       0
   9)     28    1604       0    1200     211       0       0       0       0       0       0       0       0       0       0       0
  10)     28    1605       0    2400     812       0       0       0       0       0       0       0       0       0       0       0
  11)     28    1607     500    2400     489       0    6701      86      35    6707     403      35       0       0       0       0
  12)     28    1608     500    1200     194       0    6701      34      35    6707     160      35       0       0       0       0
0------------------
 INTERSECTION    67
 ------------------
                                                     CONTROLLER  TIMING  DATA
 LINE    CARD    NODE  OFFSET/          INTERVAL DURATIONS (SECS. OR PERCENT) ............................................ DOUBLE
  NO.    TYPE     NO.  YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INT8    INT9    INT10   INT11  CYCLE

  13)     12      67      52       1      32       4      20       4       0       0       0       0       0       0       0       0
0                                                         PHASE  TIMING  DATA
 LINE    CARD    NODE    START  VARIAB.  YELLOW  ALL-RED  MINIM.                                                               CONT.
  NO.    TYPE     NO.    INTVL   INTVL   INTVL   INTVL    SECS.   LINKS MOVING IN THIS PHASE ................................  FLAG

  14)     21      67       1       1       2       0      36    6705    6706    6707    6712       0       0       0       0       0
  15)     22      67       3       3       4       0      24    6701    6709       0       0       0       0       0       0       0
0                                                              LINK  DATA
 LINE    CARD    LINK    LINK     SAT.   TOTAL   MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....    THIRD INPUT LINK....  QUEUE
  NO.    TYPE     NO.  LENGTH    FLOW     VOL.    VOL.     NO.    VOL.   SPD/TT     NO.    VOL.   SPD/TT     NO.    VOL.   SPD/TT  CAP.

  16)     28    6701       0    3700    1095       0       0       0       0       0       0       0       0       0       0       0
  17)     28    6705     500    2400     607       0    1604     155      35    1605     452      35       0       0       0       0
  18)     28    6706     500    1200     181       0    1604      46      35    1605     135      35       0       0       0       0
  19)     28    6707    1750    1200     582       0    8701      10      35    8707     447      35    8710      78      35       0
  20)     28    6709       0    1200     126       0       0       0       0       0       0       0       0       0       0       0
  21)     28    6712    1750    1200     194       0    8707     149      35    8710      27      35       0       0       0       0
```

```
0------------------
 INTERSECTION   87
 ------------------
1RUN TITLE:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---

 FIELDS:  1        2        3        4        5        6        7        8        9       10       11       12       13       14       15       16
         ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----
                                                             CONTROLLER  TIMING  DATA
 LINE     CARD     NODE  OFFSET/              INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.     TYPE      NO.  YLD.PT.   REF INT   INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11  CYCLE

  22)      12       87       55        1       32        4       20        4        0        0        0        0        0        0        0        0
0                                                                 PHASE  TIMING  DATA
 LINE     CARD     NODE     START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                          CONT.
  NO.     TYPE      NO.     INTVL    INTVL   INTVL    INTVL  SECS.    LINKS MOVING IN THIS PHASE ................................    FLAG

  23)      21       87        1        1        2        0       36     8705     8706     8707     8708        0        0        0        0        0
  24)      22       87        3        3        4        0       24     8701     8703     8709     8710        0        0        0        0        0
0                                                                         LINK  DATA
 LINE     CARD     LINK     LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK.... QUEUE
  NO.     TYPE      NO.   LENGTH    FLOW      VOL.     VOL.      NO.     VOL.   SPD/TT      NO.     VOL.   SPD/TT      NO.     VOL.   SPD/TT  CAP.

  25)      28     8701        0     2800      468        0        0        0        0        0        0        0        0        0        0        0
  26)      28     8703        0     2800      719        0        0        0        0        0        0        0        0        0        0        0
  27)      28     8705     1750     2400      862        0     6705      591       35     6709      116       35        0        0        0        0
  28)      28     8706     1750     1200       24        0     6705       16       35     6709       10       35        0        0        0        0
  29)      28     8707     2700     2400      649        0     8901       10       35     8907      639       35        0        0        0        0
  30)      28     8708     2700     1200       10        0     8907       10       35        0        0        0        0        0        0        0
  31)      28     8709        0     1200      118        0        0        0        0        0        0        0        0        0        0        0
  32)      28     8710        0     1200      105        0        0        0        0        0        0        0        0        0        0        0
0------------------
 INTERSECTION   89
 ------------------
                                                             CONTROLLER  TIMING  DATA
 LINE     CARD     NODE  OFFSET/              INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.     TYPE      NO.  YLD.PT.   REF INT   INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11  CYCLE

  33)      12       89       55        1       34        4       18        4        0        0        0        0        0        0        0        0
0                                                                 PHASE  TIMING  DATA
 LINE     CARD     NODE     START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                          CONT.
  NO.     TYPE      NO.     INTVL    INTVL   INTVL    INTVL  SECS.    LINKS MOVING IN THIS PHASE ................................    FLAG

  34)      21       89        1        1        2        0       38     8905     8907     8908        0        0        0        0        0        0
  35)      22       89        3        3        4        0       22     8901        0        0        0        0        0        0        0        0
0                                                                         LINK  DATA
 LINE     CARD     LINK     LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK.... QUEUE
  NO.     TYPE      NO.   LENGTH    FLOW      VOL.     VOL.      NO.     VOL.   SPD/TT      NO.     VOL.   SPD/TT      NO.     VOL.   SPD/TT  CAP.

  36)      28     8901        0     1400       43        0        0        0        0        0        0        0        0        0        0        0
  37)      28     8905     2700     2400     1006        0     8701       71       35     8705      862       35        0        0        0        0
  38)      28     8907      600     2400      785        0     9201       22       35     9203       54       35     9207      580       35        0
  39)      28     8908      600     1200       30        0     9203       10       35     9207       20       35        0        0        0        0
```

```
0-----------------
 INTERSECTION   92
 -----------------
1RUN TITLE:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---

 FIELDS:  1        2        3        4        5        6        7        8        9       10       11       12       13       14       15       16
         ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----
                                                               CONTROLLER  TIMING  DATA
 LINE     CARD     NODE   OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ............................................... DOUBLE
  NO.     TYPE      NO.   YLD.PT.  REF INT  INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11   CYCLE

  40)      12       92      55        1       32        4       20        4        0        0        0        0        0        0        0        0
0                                                                PHASE  TIMING  DATA
 LINE     CARD     NODE     START  VARIAB.  YELLOW  ALL-RED  MINIM.                                                                          CONT.
  NO.     TYPE      NO.     INTVL   INTVL    INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ................................          FLAG

  41)      21       92        1        1        2        0       36     9205     9206     9207     9208        0        0        0        0        0
  42)      22       92        3        3        4        0       24     9201     9203        0        0        0        0        0        0        0
0                                                                   LINK  DATA
 LINE     CARD     LINK     LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK....   QUEUE
  NO.     TYPE      NO.   LENGTH     FLOW     VOL.     VOL.     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT   CAP.

  43)      28     9201        0     1400       75        0        0        0        0        0        0        0        0        0        0        0
  44)      28     9203        0     1400      199        0        0        0        0        0        0        0        0        0        0        0
  45)      28     9205      600     2400      979        0     8901       20       35     8905      940       35        0        0        0        0
  46)      28     9206      600     1200       66        0     8901       10       35     8905       56       35        0        0        0        0
  47)      28     9207     1000     2400      670        0     9101       60       35     9103       10       35     9107      600       35        0
  48)      28     9208     1000     1200       21        0     9107       21       35        0        0        0        0        0        0        0
0-----------------
 INTERSECTION   91
 -----------------
                                                               CONTROLLER  TIMING  DATA
 LINE     CARD     NODE   OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ............................................... DOUBLE
  NO.     TYPE      NO.   YLD.PT.  REF INT  INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11   CYCLE

  49)      12       91      26        1       31        4       21        4        0        0        0        0        0        0        0        0
0                                                                PHASE  TIMING  DATA
 LINE     CARD     NODE     START  VARIAB.  YELLOW  ALL-RED  MINIM.                                                                          CONT.
  NO.     TYPE      NO.     INTVL   INTVL    INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ................................          FLAG

  50)      21       91        1        1        2        0       35     9105     9106     9107     9108        0        0        0        0        0
  51)      22       91        3        3        4        0       25     9101     9103        0        0        0        0        0        0        0
0                                                                   LINK  DATA
 LINE     CARD     LINK     LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK....   QUEUE
  NO.     TYPE      NO.   LENGTH     FLOW     VOL.     VOL.     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT   CAP.

  52)      28     9101        0     1400      237        0        0        0        0        0        0        0        0        0        0        0
  53)      28     9103        0     1400      174        0        0        0        0        0        0        0        0        0        0        0
  54)      28     9105     1000     2400     1062        0     9201       14       35     9203       40       35     9205      948       35        0
  55)      28     9106     1000     1200       23        0     9203       10       35     9205       13       35        0        0        0        0
  56)      28     9107     1270     2400      806        0     9007      800       35        0        0        0        0        0        0        0
  57)      28     9108     1270     1200       71        0     9007       70       35        0        0        0        0        0        0        0
```

```
0-------------------
 INTERSECTION    90
 -------------------
1RUN TITLE:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---

 FIELDS:  1        2        3        4        5        6        7        8        9        10       11       12       13       14       15       16
         ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----
                                                           CONTROLLER  TIMING  DATA
 LINE    CARD     NODE   OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ........................................... DOUBLE
  NO.    TYPE      NO.   YLD.PT.  REF INT  INT1     INT2     INT3     INT4     INT5     INT6     INT7  .  INT8     INT9     INT10    INT11  CYCLE

  58)     12       90       55       1       32       4        20       4        0        0        0        0        0        0        0        0
0                                                                PHASE  TIMING  DATA
 LINE    CARD     NODE     START  VARIAB. YELLOW   ALL-RED  MINIM.                                                                          CONT.
  NO.    TYPE      NO.     INTVL   INTVL   INTVL    INTVL   SECS.   LINKS MOVING IN THIS PHASE ................................   FLAG

  59)     21       90       1        1        2        0        36     9005     9006     9007     9008       0        0        0        0        0
  60)     22       90       3        3        4        0        24     9001     9003       0        0        0        0        0        0        0
0                                                                      LINK  DATA
 LINE    CARD     LINK     LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....      SECOND INPUT LINK....     THIRD INPUT LINK....  QUEUE
  NO.    TYPE      NO.   LENGTH    FLOW     VOL.     VOL.     NO.      VOL.   SPD/TT    NO.      VOL.   SPD/TT    NO.      VOL.   SPD/TT  CAP.

  61)     28     9001       0      1400       95       0        0        0        0        0        0        0        0        0        0        0
  62)     28     9003       0      1400      111       0        0        0        0        0        0        0        0        0        0        0
  63)     28     9005     1270     2400      982       0      9103       32       35     9105      892       35     9101       58       35        0
  64)     28     9006     1270     1200       52       0      9103       10       35     9105       42       35       0        0        0        0
  65)     28     9007       0      2400      935       0        0        0        0        0        0        0        0        0        0        0
  66)     28     9008       0      1200       20       0        0        0        0        0        0        0        0        0        0        0
0                                                                GRAPH  PLOT  CARDS
 LINE    CARD     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK     LINK
  NO.    TYPE      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.      NO.

  67)     40     1603     6701     8701     8703     8901     9201     9203     9101     9103     9001     9003       0        0        0        0
  68)     40     1605     1607     6705     6707     8705     8707     8905     8907     9205     9207     9105     9107     9005     9007       0
0LINE    CARD                                               RUN  CARD
  NO.    TYPE

  69)     52        0        0        0        0        0        0        0        0        0        0        0        0        0        0        0
0--- PROGRAM NOTE --- A CARD TYPE 52 CAUSES RUN TO BE OPTIMIZED USING THE DEFAULT NORMAL OPTIMIZATION STEP SIZES.
                      IF CARD TYPE 4 WAS INPUT, IT IS IGNORED.
0                     THE ABOVE WILL BE PROCESSED AFTER THE "BEST" CYCLE LENGTH HAS BEEN SELECTED.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   7 NODES AND  41 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
1RUN TITLE:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---
```

```
0                          ------------------------------------
                           CYCLE EVALUATION SUMMARY PERFORMANCE
                           ------------------------------------
0   CYCLE    STEP    AVERAGE  PERCENT      FUEL      PERFORMANCE  NUMBER
   LENGTH    SIZE     DELAY    STOPS   CONSUMPTION      INDEX    SATURATED
    (SEC)  (STEPS) (SEC/VEH)    (%)       (GAL/HR)                 LINKS
0     60      30     27.15      55         254.3        196.3         1
0     62      31     21.47      56         235.3        170.0         1
0     64      32     16.66      57         219.2        147.8         1
0     66      33     14.17      56         209.6        135.0         1
0     68      34     13.63      56         207.6        132.3         0
0     70      35     13.37      55         205.5        129.9         0
0     72      36     13.61      54         205.2        130.0         0
0     74      37     13.59      53         204.0        128.9         0
0     76      38     13.47      52         202.5        127.4         0
0     78      39     13.62      52         202.7        127.8         0
0     80      40     13.68      52         202.7        128.0         0
0     82      41     13.79      52         202.3        127.8         0
0     84      42     13.47      50         199.5        124.6         0
0     86      43     13.52      50         199.0        124.2         0
0     88      44     13.61      50         199.5        124.7         0
0     90      45     13.90      49         200.1        125.8         0
0     92      46     13.87      49         199.9        125.5         0
0     94      47     13.93      49         200.3        125.8         0
0     96      48     14.77      49         202.2        129.1         0
0     98      49     14.93      48         202.1        129.4         0
0    100      50     15.34      48         203.3        131.3         0

      BEST CYCLE LENGTH =  86 SEC.   CYCLE SENSITIVITY =  13.0 %
0--- PROGRAM NOTE --- TRANSYT-7F OPTIMIZES THE SYSTEM USING THE BEST CYCLE LENGTH AND
                      HILL-CLIMB STEP SIZES AS INDICATED BY CARD TYPE 52.

1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0<PERFORMANCE WITH OPTIMAL SETTINGS>
0   NODE LINK    FLOW    SAT  DEGREE  TOTAL      TOTAL  -------- DELAY --------  AVERAGE   UNIFORM  MAX BACK  QUEUE     FUEL  PHASE  LINK
     NO   NO             FLOW OF SAT  TRAVEL      TIME  UNIFORM  RANDOM   TOTAL  DELAY     STOPS   OF QUEUE CAPACITY CONSUM LENGTH  NO
               (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)       (VEH-H/H)       (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

     16  1603    1361  3700    81       .00      8.22     7.36     .86    8.22    21.8  1081.8( 79%)  27   >    0    12.00    44  1603
     16  1604     211  1200    39       .00       .94      .88     .06     .94    16.0   127.8( 61%)   3   >    0     1.39    44  1604
     16  1605     812  2400    79       .00      5.28     4.57     .72    5.28    23.4   644.8( 79%)  16   >    0     7.43    42  1605
     16  1607     489  2400    47     46.19      2.64     1.23     .11    1.33     9.8   170.1( 35%)   5       20     4.04    42  1607
     16  1608     194  1200    38     18.32      1.05      .48     .06     .54    10.0    64.4( 33%)   2       20     1.58    42  1608
0    16 :        3067   MAX =  81     64.51     18.14    14.51    1.80   16.32    19.2  2089.0( 68%)                 26.45 PI =   30.8
```

```
     67  6701    1095  3700     88        .00      9.41      7.88     1.53      9.41    30.9    961.7( 88%)   24   >     0    12.21     34  6701
     67  6705     607  2400     46      57.33      3.04      1.32      .10      1.42     8.4    195.5( 32%)    5         20     4.72     52  6705
     67  6706     181  1200     28      17.10       .88       .37      .03       .39     7.9     56.8( 31%)    1         20     1.37     52  6706
     67  6707     582  1200     89     192.75      9.13      2.03     1.66      3.68    22.8    487.2( 84%)   12         70    13.76     52  6707
     67  6709     126  1200     31        .00       .75       .71      .04       .75    21.4     87.6( 70%)    2   >     0     1.03     34  6709
     67  6712     194  1200     30      64.25      2.15       .31      .03       .34     6.3     83.4( 43%)    2         70     3.33     52  6712
0    67 :        2785   MAX =   89     331.43     25.36     12.62     3.38     16.00    20.7   1872.4( 67%)                     36.42 PI =   29.0

     87  8701     468  2800     48        .00      2.85      2.74      .11      2.85    21.9    338.9( 72%)    9   >     0     3.96     35  8701
     87  8703     719  2800     74        .00      5.23      4.72      .51      5.23    26.2    584.6( 81%)   15   >     0     7.06     35  8703
     87  8705     862  2400     67     285.49     10.42      2.02      .34      2.36     9.9    400.3( 46%)   11         70    15.63     51  8705
     87  8706      24  1200      4       7.95       .29       .06      .00       .06     9.7     10.0( 41%)    0         70      .43     51  8706
     87  8707     649  2400     51     331.89     11.31      1.81      .13      1.94    10.8    260.3( 40%)    7        108    16.00     51  8707
     87  8708      10  1200      2       5.11       .17       .02      .00       .02     8.1      3.0( 30%)    0        108      .23     51  8708
     87  8709     118  1200     28        .00       .67       .64      .03       .67    20.3     79.8( 68%)    2   >     0      .93     35  8709
     87  8710     105  1200     25        .00       .58       .56      .02       .58    20.0     70.1( 67%)    2   >     0      .81     35  8710
0    87 :        2955   MAX =   74     630.44     31.52     12.58     1.14     13.72    16.7   1746.9( 59%)                     45.06 PI =   25.9

     89  8901      43  1400     16        .00       .34       .33      .01       .34    28.4     33.9( 79%)    1   >     0      .44     22  8901
     89  8905    1006  2400     61     514.46     15.50       .74      .24       .98     3.5    147.9( 15%)    4        108    21.35     64  8905
     89  8907     785  2400     48      89.26      3.05       .42      .11       .53     2.4    108.8( 14%)    3         24     4.61     64  8907
     89  8908      30  1200      4       3.41       .12       .02      .00       .02     3.0      8.2( 27%)    0         24      .32     64  8908
0    89 :        1864   MAX =   61     607.13     19.01      1.51      .36      1.87     3.6    298.8( 16%)                     26.71 PI =    3.9

     90  9001      95  1400     31        .00       .75       .72      .03       .75    28.5     75.3( 79%)    2   >     0      .97     24  9001
     90  9003     111  1400     36        .00       .90       .85      .05       .90    29.2     88.0( 79%)    2   >     0     1.15     24  9003
     90  9005     982  2400     62     236.14      8.41      1.49      .25      1.74     6.4    261.9( 27%)    7         51    12.24     62  9005
     90  9006      52  1200      7      12.50       .42       .07      .00       .07     4.9     15.4( 30%)    0         51      .64     62  9006
     90  9007     935  2400     59        .00      2.15      1.94      .21      2.15     8.3    447.3( 48%)   11   >     0     4.05     62  9007
     90  9008      20  1200      3        .00       .03       .03      .00       .03     4.9      6.1( 30%)    0          0      .05     62  9008
0    90 :        2195   MAX =   62     248.65     12.66      5.10      .54      5.64     9.3    894.0( 41%)                     19.10 PI =   11.8

     91  9101     237  1400     69        .00      2.33      1.95      .39      2.33    35.4    206.1( 87%)    5   >     0     2.85     26  9101
     91  9103     174  1400     51        .00      1.49      1.35      .13      1.49    30.7    143.6( 83%)    4   >     0     1.88     26  9103
     91  9105    1062  2400     69     201.27      8.30      2.23      .39      2.62     8.9    324.9( 31%)    8         40    12.05     60  9105
     91  9106      23  1200      3       4.36       .16       .04      .00       .04     6.0      9.9( 43%)    0         40      .27     60  9106
     91  9107     806  2400     53     193.82      7.81      2.20      .15      2.34    10.5    395.7( 49%)   10         51    12.11     60  9107
     91  9108      71  1200      9      17.07       .62       .14      .00       .14     7.2     28.2( 40%)    1         51      .97     60  9108
0    91 :        2373   MAX =   69     416.52     20.72      7.90     1.05      8.96    13.6   1108.3( 47%)                     30.12 PI =   16.7

     92  9201      75  1400     23        .00       .56       .54      .02       .56    26.8     57.7( 77%)    1   >     0      .73     25  9201
     92  9203     199  1400     61        .00      1.82      1.58      .24      1.82    32.9    167.0( 84%)    4   >     0     2.26     25  9203
     92  9205     979  2400     63     111.32      4.98      1.57      .26      1.84     6.8    230.3( 24%)    6         24     7.34     61  9205
     92  9206      66  1200      8       7.50       .31       .10      .00       .10     5.5     20.2( 31%)    0         24      .51     61  9206
     92  9207     670  2400     43     126.98      5.28      1.62      .08      1.70     9.1    323.7( 48%)    8         40     8.55     61  9207
     92  9208      21  1200      3       3.98       .15       .04      .00       .04     7.3      9.3( 44%)    0         40      .25     61  9208
0    92 :        2010   MAX =   63     249.79     13.11      5.45      .60      6.05    10.8    808.2( 40%)                     19.64 PI =   11.7
```

```
                                    <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL         TOTAL      TOTAL       TOTAL       TOTAL      AVERAGE        TOTAL         TOTAL
   DISTANCE       TRAVEL     UNIFORM     RANDOM       DELAY       DELAY        UNIFORM         FUEL    PERFORMANCE   SPEED
   TRAVELED        TIME       DELAY       DELAY                                 STOPS         CONSUM      INDEX
  (VEH-MI/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)      (VEH/H-%)        (GA/H)                  (MI/H)

0   2548.46      140.51      59.68       8.88       68.56       14.31     8817.5( 51%)     203.50      129.79      26.49 <TOTALS>
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0-----------------------------------
 TRANSYT-7F SIGNAL CONTROLLER SETTINGS
 -----------------------------------


0------------------------------
 NETWORK-WIDE SIGNAL TIMING DATA
 ------------------------------
0SYSTEM CYCLE LENGTH =   86 SECONDS
0MASTER OFFSET REFERENCE LOCATION = INTERSECTION NO.   16
0ALL OFFSETS ARE REFERENCED TO THE START OF INTERVAL NO. 1 AT THIS SIGNAL.


 ------------------------------
 INTERSECTION CONTROLLER SETTINGS
 ------------------------------



 -----------------
 INTERSECTION    16
 -----------------
0INTERVAL  NUMBER :      1   2   3   4
0INTVL LENGTH(SEC):     38   4  40   4
0INTVL LENGTH  (%):     44   5  46   5
0PIN SETTINGS  (%): 100/0  44  49  95
0PHASE START (PH#):      1       2
0INTERVAL   TYPE  :      V   Y   V   Y
0LINKS  MOVING   :    1605     1603
                      1607     1604
                      1608
0OFFSET =   0 SEC.   0 %.
0THIS IS THE MASTER CONTROLLER.
0+++ 193 +++ WARNING +
+                        THE OFFSET FALLS WITHIN 1% OF AN INTERVAL CHANGE POINT AT THE START OF INTERVAL NO  1.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
```

```
 ------------------
 INTERSECTION    67
 ------------------
0INTERVAL  NUMBER :     1   2   3   4
0INTVL LENGTH(SEC):    48   4  30   4
0INTVL LENGTH  (%):    55   5  35   5
0PIN SETTINGS  (%): 100/0  55  60  95
0PHASE START (PH#):     1       2
0INTERVAL   TYPE  :     V   Y   V   Y
0LINKS  MOVING  :    6705    6701
                     6706    6709
                     6707
                     6712
0OFFSET =  76 SEC.  88 %.


 ------------------
 INTERSECTION    87
 ------------------
0INTERVAL  NUMBER :     1   2   3   4
0INTVL LENGTH(SEC):    47   4  31   4
0INTVL LENGTH  (%):    54   5  36   5
0PIN SETTINGS  (%): 100/0  54  59  95
0PHASE START (PH#):     1       2
0INTERVAL   TYPE  :     V   Y   V   Y
0LINKS  MOVING  :    8705    8701
                     8706    8703
                     8707    8709
                     8708    8710
0OFFSET =  32 SEC.  37 %.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS


 ------------------
 INTERSECTION    89
 ------------------
0INTERVAL  NUMBER :     1   2   3   4
0INTVL LENGTH(SEC):    60   4  18   4
0INTVL LENGTH  (%):    69   5  21   5
0PIN SETTINGS  (%): 100/0  69  74  95
0PHASE START (PH#):     1       2
0INTERVAL   TYPE  :     V   Y   V   Y
0LINKS  MOVING  :    8905    8901
                     8907
                     8908
0OFFSET =  70 SEC.  81 %.
```

```
 ------------------
 INTERSECTION    90
 ------------------
OINTERVAL  NUMBER :     1   2   3   4
OINTVL LENGTH(SEC):    58   4  20   4
OINTVL LENGTH  (%):    67   5  23   5
OPIN SETTINGS  (%): 100/0  67  72  95
OPHASE START (PH#):     1       2
OINTERVAL   TYPE  :     V   Y   V   Y
OLINKS  MOVING  :    9005    9001
                     9006    9003
                     9007
                     9008
OOFFSET =   2 SEC.   2 %.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS


 ------------------
 INTERSECTION    91
 ------------------
OINTERVAL  NUMBER :     1   2   3   4
OINTVL LENGTH(SEC):    56   4  22   4
OINTVL LENGTH  (%):    64   5  26   5
OPIN SETTINGS  (%): 100/0  64  69  95
OPHASE START (PH#):     1       2
OINTERVAL   TYPE  :     V   Y   V   Y
OLINKS  MOVING  :    9105    9101
                     9106    9103
                     9107
                     9108
OOFFSET =  77 SEC.  90 %.


 ------------------
 INTERSECTION    92
 ------------------
OINTERVAL  NUMBER :     1   2   3   4
OINTVL LENGTH(SEC):    57   4  21   4
OINTVL LENGTH  (%):    66   5  24   5
OPIN SETTINGS  (%): 100/0  66  71  95
OPHASE START (PH#):     1       2
OINTERVAL   TYPE  :     V   Y   V   Y
OLINKS  MOVING  :    9205    9201
                     9206    9203
                     9207
                     9208
OOFFSET =  70 SEC.  81 %.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
```

```
0                                < T R A N S Y T - 7 F   F L O W   P R O F I L E   D I A G R A M S >


  -KEY-  I :  ARRIVALS THAT QUEUE (NORMALLY ON RED).
         S :  DEPARTURES FROM QUEUE (NORMALLY AT THE SATURATION FLOW RATE).
         O :  ARRIVALS AND DEPARTURES ON GREEN.
       -,+ :  DELINEATORS ("+" MARKS EVERY TENTH STEP).
         N :  THE NUMBERS ACROSS THE BOTTOM ARE A TIME SCALE IN UNITS OF STEPS.
ONOTE: THE FLOW PROFILE DIAGRAM SHOWS EFFECTIVE GREEN AND RED, NOT ACTUAL.
       FUTHERMORE, THE "OFFSET" TO THE LINK EFFECTIVE GREEN HAS NOT BEEN
       ADJUSTED TO THE MASTER CONTROLLER, IF THERE IS ONE.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0      LINK  1603    MAX FLOW  3700 VEH/H     PLT. INDEX  .00            LINK  6701    MAX FLOW  3700 VEH/H     PLT. INDEX  .00

       SSSSSSSS                              SSSSS                       SSSSSS                                SSSSS
       SSSSSSSS                              SSSSS                       SSSSSS                                SSSSS
       SSSSSSSS                              SSSSS                       SSSSSS                                SSSSS
       SSSSSSSS                              SSSSS                       SSSSSS                                SSSSS
       SSSSSSSS                              SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSS                              SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSS                              SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSS                              SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSS                              SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       SSSSSSSSS                             SSSSS                       SSSSSSS                               SSSSS
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       SSSSSSS                               SSSSS
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       SSSSSSS                               SSSSS
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       OOOOOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIOOOOO                       OOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIIIIOOOOO
       ---------+---------+---------+---------+---                       ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                       1234567890123456789012345678901234567890123
```

```
0      LINK  8701    MAX FLOW  2800 VEH/H     PLT. INDEX  .00             LINK  8703    MAX FLOW  2800 VEH/H     PLT. INDEX  .00
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                       SSSSS                                                              SSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                                             SSSSSSSSSS
                      SSSSSS                                              IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
                      SSSSSS                                              IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
       IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII                        IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
       IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII                        IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
       IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII                        IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
       IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII                        IIIIIIIIIIIIIII0000000000000000IIIIIIIIIIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
1TRANSYT-7F:  RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE   43 STEPS
0      LINK  8901    MAX FLOW  1400 VEH/H     PLT. INDEX  .00             LINK  9201    MAX FLOW  1400 VEH/H     PLT. INDEX  .00
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                 S
                                                S                                                                SS
                                                S                                                                SS
                                                S                                                                SS
                                                S                                                                SSS
                                                S                                                                SSS
                                                S                                                                SSS
                                                S                                                                SSS
                                                S                                                                SSS
                                                S                                                                SSS
                                                SS                                                               SSS
                                                SS                                                               SSS
       0000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII00                        0000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII0000
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
0      LINK  9203    MAX FLOW  1400 VEH/H     PLT. INDEX  .00             LINK  9101    MAX FLOW  1400 VEH/H     PLT. INDEX  .00

       S                                       SSS                        SSSSSS
       S                                       SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                      SSS                        SSSSSS
       SS                                     SSSS                        SSSSSS                                    S
       SS                                     SSSS                        SSSSSS                                    S
       SS                                     SSSS                        SSSSSS                                    S
       SS                                     SSSS                        SSSSSS                                    S
       SS                                     SSSS                        SSSSSS                                    S
       SS                                     SSSS                        SSSSSSS                                   S
       SS                                     SSSS                        SSSSSSS                                   S
       SS                                     SSSS                        SSSSSSS                                   S
       SS                                     SSSS                        0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO
       0000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII0000                        0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO
       0000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII0000                        0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO
       0000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII0000                        0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0      LINK  9103    MAX FLOW  1400 VEH/H     PLT. INDEX  .00             LINK  9001    MAX FLOW  1400 VEH/H     PLT. INDEX  .00

       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                                                     SS
       SSSS                                      S                              SS
       SSSS                                      S                              SSS
       SSSS                                      S                              SSS
       SSSS                                      S                              SSS
       SSSS                                      S                              SSS
       SSSS                                      S                              SSS
       SSSS                                      S                              SSS
       SSSSS                                     S                              SSS
       SSSSS                                     S                              SSS
       0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO                              SSS
       0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO                        IIIII0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIII
       0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIO                        IIIII0000000000IIIIIIIIIIIIIIIIIIIIIIIIIIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
0      LINK  9003    MAX FLOW  1400 VEH/H     PLT. INDEX  .00

             SS
             SS
             SS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
             SSS
       IIIIIOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIII
       IIIIIOOOOOOOOOOOIIIIIIIIIIIIIIIIIIIIIIIIIII
       ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---   86 SECOND CYCLE     43 STEPS
0      LINK  1605    MAX FLOW  2400 VEH/H     PLT. INDEX  .00             LINK  1607    MAX FLOW  2400 VEH/H     PLT. INDEX  .53

                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSS
                        SSSSSSSSSSSS                                                       SSSS
                        SSSSSSSSSSSS                                                       SSSS
                        SSSSSSSSSSSS                                                       SSSS
                        SSSSSSSSSSSS                                                       SSSS
                        SSSSSSSSSSSS                                                       SSSS
                        SSSSSSSSSSSSS                                                      SSSS
                        SSSSSSSSSSSSS                                                      SSSS
                        SSSSSSSSSSSSS                                                      SSSS
                        SSSSSSSSSSSSS                                                      SSSS
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                                         SSSOOOOOOOOOOOOOO
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                                         SOOOOOOOOOOOOOOOOO
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                                         OOOOOOOOOOOOOOOOOOO
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                                         OOOOOOOOOOOOOOOOOOOII
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                                        IOOOOOOOOOOOOOOOOOOOIII
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                         IIIIIIIIII     IOOOOOOOOOOOOOOOOOOOIIII
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                        IIIIIIIIIIII    IOOOOOOOOOOOOOOOOOOOIIIII I
       IIIIIIIIIIIIIIIIIOOOOOOOOOOOOOOOOOOOIIIIIII                        IIIIIIIIIIIIIII IOOOOOOOOOOOOOOOOOOOIIIIIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
0      LINK  6705    MAX FLOW  2400 VEH/H     PLT. INDEX  .63             LINK  6707    MAX FLOW  1200 VEH/H     PLT. INDEX  .41
                   SSS                                                                SSSSSSSSSSSSSSSSSS
                   SSS                                                            I   SSSSSSSSSSSSSSSSSS
                   SSS                                                            II  SSSSSSSSSSSSSSSSSS
                   SSS                                                            II  SSSSSSSSSSSSSSSSSS
                   SSS                                                           IIII SSSSSSSSSSSSSSSSSS
                   SSS                                                           IIIIIOSSSSSSSSSSSSSSSSS
                   SSS                                                           IIIIIOOOSSSSSSSSSSSSSSSS
                   SSS                                                          IIIIII0000SSSSSSSSSSSSSSS
                   SSS                                                          IIIIII000000SSSSSSSSSSSSS
                   SSSS                                                         IIIIII0000000SSSSSSSSSSSS
                   SSSS                                                         IIIIII000000000SSSSSSSSSS
                   SSSS          0000000                                       IIIIIII000000000000000SSSSO
                   SSSS        000000000                                       IIIIIII000000000000000SSSSOO
                   SSSS       00000000000                                      IIIIIII0000000000000000SS000
                   SSSS       00000000000                                      IIIIIII0000000000000000SS0000
                   SSSS      000000000000                                      IIIIIII00000000000000000000000
         II        SSSS      0000000000000                                    IIIIIIII000000000000000000000000
        III        SSSS      00000000000000                                   IIIIIIII000000000000000000000000I
       IIII        SSSS     0Q0000000000000I                                  IIIIIIII000000000000000000000000II
       IIIII       SSSS     000000000000000IIII  I                            IIIIIIII000000000000000000000000IIII
       IIIIII      SSSS     000000000000000IIII  I                            IIIIIIII000000000000000000000000IIIIII
       IIIIIII     SSSS     000000000000000IIIII I                        II  IIIIIIII000000000000000000000000IIIIIII
       IIIIIIIIIIII0000000  000000000000000IIIIIII                        IIIIIIIIIIII000000000000000000000000IIIIIII
       IIIIIIIIIIII000000000000000000000000IIIIIII                        IIIIIIIIIIII000000000000000000000000IIIIIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0      LINK  8705    MAX FLOW  2400 VEH/H     PLT. INDEX  .37             LINK  8707    MAX FLOW  2400 VEH/H     PLT. INDEX  .34
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
                                        SSSSSSSS                                                           SSSSS
        0000                        I   SSSSSSSSS                                                          SSSSS
       000000                      II   SSSSSSSSS                                                          SSSSS
       0000000                     III  SSSSSSSSOO                                                         SSSSS
       0000000    0                III  SSSSSSS000                                                         SSSSS   00
       00000000  000              IIIII SSSSSS0000                        0                                SSSSSS 000
       00000000 0000              IIIIIISSSSS00000                        000       000II                  SSSSSS0000
       0000000000000I             IIIIIISSSS000000                        0000    00000IIII                SSSSS00000
       0000000000000II            IIIIII0SS0000000                        0000000000000IIIII               SSSS000000
       0000000000000III          IIIIIII0000000000                        0000000000000IIIIIII           I SSS0000000
       0000000000000IIIII        IIIIIII0000000000                        0000000000000IIIIIIII          IIOS00000000
       0000000000000IIIIIII      IIIIIII0000000000                        0000000000000IIIIIIIIII       III0000000000
       0000000000000IIIIIIIIII   IIIIIII0000000000                        0000000000000IIIIIIIIIIIII    III0000000000
       0000000000000IIIIIIIIIIIIIIIIIIII0000000000                        0000000000000IIIIIIIIIIIIIIIIIIII0000000000
       0000000000000IIIIIIIIIIIIIIIIIIII0000000000                        0000000000000IIIIIIIIIIIIIIIIIIII0000000000
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
0      LINK  8905    MAX FLOW  2400 VEH/H     PLT. INDEX .46              LINK  8907    MAX FLOW  2400 VEH/H     PLT. INDEX .64

                SS                                                                 SS
                SS                                                                 SS       00
                SSS                                                                SS       00
                SSS                                                                SS      000
                SSS                                                                SS      000
                SSS                                                                SS     0000
                SSS                                                                SS     0000
                SSS      000                                                       SS     0000
                SSS     0000000000                                                 SS     00000
                SSS    0000000000000                                               SS    000000           0
                SSS    000000000000000                                             SS    000000          000
                SSS   0000000000000000000                                          SS    000000         0000
                SSS  00000000000000000000                                          SS    000000         00000
                SSS  000000000000000000000                                         SS    0000000       000000
                SSS 00000000000000000000000                                        SS   00000000       0000000
                SSS 000000000000000000000000                                       SS   00000000      00000000
                SSS 00000000000000000000000000I                                    SS   000000000     000000000
                SSS000000000000000000000000000III                                  SS   000000000    0000000000
                SSS000000000000000000000000000IIII                           I     SS   000000000    00000000000
       II       SS0000000000000000000000000000IIII                          IIIII  SS   0000000000  0000000000000
       IIIII    SS0000000000000000000000000000IIII                          IIIII  SS   00000000000 0000000000000I
       IIIIIIII SS0000000000000000000000000000IIII                          IIIIII SSS  0000000000000000000000000III
       IIIIIIIII000000000000000000000000000000IIII                         IIIIIIII00S  0000000000000000000000000IIII
       IIIIIIIII000000000000000000000000000000IIII                        IIIIIIIII000000000000000000000000000000IIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---   86 SECOND CYCLE     43 STEPS
0      LINK  9205    MAX FLOW  2400 VEH/H     PLT. INDEX .51              LINK  9207    MAX FLOW  2400 VEH/H     PLT. INDEX .55

                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS                                                               SSSSSS
                SSSS   0                                                           SSSSSS
                SSSS   0                                                           SSSSSS           0
                SSSS   0      00000000000                                          SSSSSS          000
                SSSS  00     00000000000000                                        SSSSSS         0000
                SSSS  000   0000000000000000II                                     SSSSSS         0000
                SSSS  0000 00000000000000000III                            II      SSSSSS        00000
                SSSS  0000000000000000000000IIII                          IIIII    SSSSSS        000000
                SSSS  0000000000000000000000IIIII                         IIIII    SSSSSS       0000000             I
       I        SSSS 00000000000000000000000IIIIII                        IIIII    SSSSSS       0000000            II
       I        SSSS 00000000000000000000000IIIIII                        IIIIII   SSSSSS       00000000          III
       I        SSSS 00000000000000000000000IIIIII                        IIIIII   SSSSSS      000000000          III
       I        SSSS 00000000000000000000000IIIIII                        IIIIIII  SSSSSS      0000000000        IIII
       II I     SSSS 00000000000000000000000IIIIII                        IIIIIIIII00SSSS      00000000000      IIIII
       II I     SSSS 00000000000000000000000IIIIII                        IIIIIIIII00000SS     00000000000      IIIII
       IIIII    SSSSS00000000000000000000000IIIIII                        IIIIIIIII0000000    00000000000000   IIIIII
       IIIIII   SSSSS00000000000000000000000IIIIII                        IIIIIIIII000000000  000000000000000 0IIIIII
       IIIIIIIIISSSSS00000000000000000000000IIIIII                        IIIIIIIII0000000000000000000000000000IIIIII
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
0      LINK  9105    MAX FLOW  2400 VEH/H      PLT. INDEX  .44            LINK  9107    MAX FLOW  2400 VEH/H      PLT. INDEX  .52
                    SSSSSS                                                             SSSSSS
                    SSSSSS                                                             SSSSSS
                    SSSSSS                                                             SSSSSS
                    SSSSSS                                                             SSSSSS
                    SSSSSS                                                             SSSSSS
                    SSSSSS                                                             SSSSSS                 0
                    SSSSSS 0                                                           SSSSSSS               00
                    SSSSSS 0                                                           SSSSSSS              000
                    SSSSSS 0                                                           SSSSSSS             00000
       I            SSSSSS00            0000000III                                     SSSSSSS            000000
       II           SSSSSS000  00     000000000III                                     SSSSSSS            0000000
       II           SSSSSS000000000000000000000III                                     SSSSSSS           000000000
       II          SSSSSS0000000000000000000000III                                    SSSSSSSS           000000000I
       III         SSSSSS0000000000000000000000III                                    SSSSSSSS          0000000000II
       III         SSSSSS0000000000000000000000III                        I           SSSSSSSS          0000000000III
       III         SSSSSS0000000000000000000000III                        IIIIII      SSSSSSSS         00000000000III
       IIII        SSSSSS0000000000000000000000III                        IIIIIIIIIIII00SSSSSS         00000000000III
       IIII        SSSSS00000000000000000000000III                        IIIIIIIIIIII00SSSSSS         00000000000III
       IIIIIII     SSSSS00000000000000000000000III                        IIIIIIIIIIII000SSSSS         00000000000III
       IIIIIIII    SSSSS00000000000000000000000III                        IIIIIIIIIIII0000SSSS        000000000000III
       IIIIIIIIII  SSSSS00000000000000000000000III                        IIIIIIIIIIII00000SSS        000000000000III
       IIIIIIIIIII SSSSS00000000000000000000000III                        IIIIIIIIIIII000000SS        000000000000III
       IIIIIIIIIIII00SSS00000000000000000000000III                        IIIIIIIIIIII00000000        000000000000III
       IIIIIIIIIIII0000000000000000000000000000III                        IIIIIIIIIIII000000000000    000000000000III
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0      LINK  9005    MAX FLOW  2400 VEH/H      PLT. INDEX  .38            LINK  9007    MAX FLOW  2400 VEH/H      PLT. INDEX  .00
                         SSSS                                                               SSSSSSSS
                         SSSS                                                               SSSSSSSSS
                         SSSSS                                                              SSSSSSSSS
                         SSSSS                                                              SSSSSSSSS
                         SSSSS                                                              SSSSSSSSS
                         SSSSS                                                              SSSSSSSSS
                         SSSSS                                                              SSSSSSSSS
                         SSSSS     0                                                        SSSSSSSSS
                         SSSSS    0000                                                      SSSSSSSSS
                         SSSSS    00000                                                     SSSSSSSSS
                         SSSSS   0000000                                                    SSSSSSSSS
            II           SSSSS  00000000000                                                 SSSSSSSSS
       0000III           SSSSS  00000000000000   0                                          SSSSSSSSS
       0000III           SSSSS  000000000000000000                                          SSSSSSSSS
       0000IIII          SSSSS 0000000000000000000                                          SSSSSSSSS
       0000IIII          SSSSS 0000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIII         SSSSS 0000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIII         SSSSS00000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIII   SSSSS00000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIIII  SSSSS00000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIIIIIISSSSS00000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIIIII0SSS0000000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIIIII000S0000000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       0000IIIIIIIIIIIII00000000000000000000000000                        0000IIIIIIIIIIIIII0000000000000000000000000
       ---------+---------+---------+---------+---                        ---------+---------+---------+---------+---
       1234567890123456789012345678901234567890123                        1234567890123456789012345678901234567890123
```

```
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS

  -KEY-  I :  ARRIVALS THAT QUEUE (NORMALLY ON RED).
         S :  DEPARTURES FROM QUEUE (NORMALLY AT THE SATURATION FLOW RATE).
         O :  ARRIVALS AND DEPARTURES ON GREEN.
       -,+ :  DELINEATORS ("+" MARKS EVERY TENTH STEP).



         N :  THE NUMBERS ACROSS THE BOTTOM ARE A TIME SCALE IN UNITS OF STEPS.
0NOTE: THE FLOW PROFILE DIAGRAM SHOWS EFFECTIVE GREEN AND RED, NOT ACTUAL.
       FUTHERMORE, THE "OFFSET" TO THE LINK EFFECTIVE GREEN HAS NOT BEEN
       ADJUSTED TO THE MASTER CONTROLLER, IF THERE IS ONE.
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0--- PROGRAM NOTE --- THIS IS THE INPUT DATA REPORT FOR TIME-SPACE DIAGRAM NO.   1
0                                                        TIME-SPACE  DIAGRAM  DATA
 LINE    CARD     NO.    TIME    TIME   DIST.
  NO.    TYPE    NODES   FLAG    SCALE  SCALE

  70)     60       7      0       0     300      0       0       0       0       0       0       0       0       0       0       0
0LINE
  NO.     TITLE                                          PLOT  TITLE  CARD
0 71)             PLOT NODES : 16, 67, 87, 89, 92, 91, 90.
0                                                         PLOT  LINK  STREAM  CARD
 LINE    CARD    LINK PAIRS ALTERNATING BY DIRECTION
  NO.    TYPE    DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP

  72)     61    1605    1607    6705    6707    8705    8707    8905    8907    9205    9207    9105    9107    9005    9007       0
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
```

```
0                                 < T R A N S Y T - 7 F    T I M E - S P A C E   D I A G R A M >
0                    PLOT NO.  1  PLOT TITLE:           PLOT NODES : 16, 67, 87, 89, 92, 91, 90.
0                    TIME AXIS IS IN: SEC          TIME SCALE =   3 SEC/CHAR,  DIST. SCALE =  300 FT/LINE
0                  1         2         3         4         5         6         7         8         9        10        11
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
          --------------------------------------------------------------------------------------------------------------
      16 :              ***************              **************              ***************              **********    0 FT
      67 :              ***********                  ***********                 ************                 **********  500 FT
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
      87 :***********                 ***********                 ************                 ************              2250 FT
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
      89 :                *******                      *******                     ********                     *******  4950 FT
         :                            :                           :                            :
      92 :               ********                     ********                    *********                    ********  5550 FT
         :                            :                           :                            :
         :                            :                           :                            :
      91 :                 *********                    ********                    *********                    ******* 6550 FT
         :                            :                           :                            :
         :                            :                           :                            :
         :                            :                           :                            :
      90 :*                    ********                     ********                     ********                    *** 7820 FT
         :--------------------------------------------------------------------------------------------------------------
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
0         SCALE CONVERSIONS:                                 +++ GREEN IN DOWN DIRECTION                  AVG. TIME DISPLACEMENT:
          TIME/INCH =  3 * 10 (AT 10 CHAR/INCH)                  GREEN IN BOTH DIRECTIONS                  1777.27 / SPEED
          DIST/INCH = 300 * 6 (AT 6 LINES/INCH)              --- GREEN IN UP   DIRECTION
                                                             *** RED   IN BOTH DIRECTIONS
1TRANSYT-7F: RUN---[SS/MI.AVE/T7F/CH99]---OPTIMIZATION RUN FOR THE ARTERIAL SIGNAL TIMINGS---  86 SECOND CYCLE    43 STEPS
0LINE    CARD                                                 TERMINATION CARD


  NO.    TYPE


  73)     90       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0--- PROGRAM NOTE --- END OF JOB!
```

APPENDIX-2

SOAP84 SIMULATION RUN OF TRANSYT-7F OPTIMAL TIMINGS FOR STUDY CASE-I, IN MICHIGAN AVENUE, LANSING, MICHIGAN

```
 ********************************************************************************************************************************
 VERSION: 84.03                                                                                              RELEASE:  JUNE, 1985
                               S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E

                                    OFFICE OF IMPLEMENTATION ...FEDERAL HIGHWAY ADMINISTRATION

                                        TECHNICAL SUPPORT MESSAGE CENTER:  (904) 392-0378

 ********************************************************************************************************************************


    -----------------------------
    S O A P   I N P U T   E C H O
    -----------------------------


     NO.  CARD ID A    B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
      3 :BEGIN           1600 1700   60        25               MI AVE. AT NN16          :
      4 :CONTROL 60 1600    1   86   86    0                                             :
      5 :HEADWAY     4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2  2.5                         :
      6 :VOLUME  60 1600           1361  211  812       489  194                         :
      7 :CAPACITY60 1600              3    1    2         2    1                         :
      8 :LEFT                              2                   2                         :
      9 :TIMING  60 1600   44   42                                                       :
     10 :SEQUENCE                                               T    T                   :
     11 :RUN      1                                                       NN16 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     NO.  CARD ID A    B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT

        *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                   MOVEMENT NO.  1   NORTHBOUND THRU.
                   MOVEMENT NO.  2   NORTHBOUND LEFT.
                   MOVEMENT NO.  6   EASTBOUND  LEFT.

        *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.


       ------------------------------------------------------
       L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
       ------------------------------------------------------

 PERIOD    NORTHBOUND     SOUTHBOUND     EASTBOUND      WESTBOUND
NO. TIME   VOL    CAP     VOL    CAP     VOL    CAP     VOL    CAP
-------------------------------------------------------------------
 1  1600   0.      0.    211.   820.      0.      0.    194.  205.
-------------------------------------------------------------------
```

```
                                                         CONTROLLER      SEQUENCE                   LOST TIME
INTERSECTION  NAME        RUN NO. AND TITLE             TYPE     DIAL    N/S  E/W       PHASES      /PH TOTAL
------------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN16            1:           NN16 SOAP84 RUN PRETIMED   1     T     T           2        4.0   8.0    TIMINGS INPUT
------------------------------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                                  S E Q U E N C E
              DELAY    STOPS  EXC FUEL  EXC LEFT  MAXIMUM     V/C     LEFT TURN TREATMENT
 MOVEMENTS: (VEH-HRS)   (%)    (GAL)    (VEH)     QUEUE     RATIO    PROTECTION  VEH/CYC   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
------------------------------------------------------------------------------------------------------------------------------

 SB THRU  :     6.65   74.0   14.06               24.1      .60                                 XXXX
    LEFT  :      .57   50.4    1.40      .0     2.5      .26      NONE       2.0     XXXX

 EB THRU  :     4.20   74.2    8.55               14.4      .56                                       XXXX

 WB THRU  :     2.18   65.6    4.52                7.7      .34                                       XXXX
    LEFT  :     4.62   99.1    4.70      .0     4.6      .95      NONE       2.0           XXXX
------------------------------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S                    S I G N A L   T I M I N G
  ANALYSIS:   DELAY    STOPS  EX. FUEL  EX. LEFT  MAXIMUM     V/C    ALL RED   DIAL CYCLE   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
   PERIOD : (VEH-HRS)   (%)    (GAL)    (VEH)     QUEUE     RATIO    (SEC)     NO. (SEC)     (%)   (%)   (%)   (%)   (%)   (%)
------------------------------------------------------------------------------------------------------------------------------
 1600-1700:    18.23   72.7   33.23      .0    24.1      .95       .0     1  86.0: 51.2  48.8
------------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :    18.23   72.7   33.23      .0    24.1      .95     TIMINGS WERE INPUT BY THE USER.

     NO.  CARD ID A   B  NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     12 :BEGIN           1600 1700   60         25               MI AVE. AT NN67          :
     13 :CONTROL 60 1600    1   86   86    0                                             :
     14 :HEADWAY     4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2  2.5                         :
     15 :VOLUME  60 1600 1221                 607  181  776                              :
     16 :CAPACITY60 1600    4                   2    1    2                              :
     17 :LEFT                                        2                                   :
     18 :TIMING  60 1600   34   52                                                       :
     19 :SEQUENCE                                               T    T                   :
     20 :RUN      1                                                       NN67 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     NO.  CARD ID A   B  NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT

        *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                  MOVEMENT NO.  2  NORTHBOUND LEFT.
                  MOVEMENT NO.  3  SOUTHBOUND THRU.
                  MOVEMENT NO.  4  SOUTHBOUND LEFT.
                  MOVEMENT NO.  8  WESTBOUND  LEFT

        *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.
```

```
<S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E>

      ---------------------------------------------------
      L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
      ---------------------------------------------------

 PERIOD    NORTHBOUND     SOUTHBOUND     EASTBOUND      WESTBOUND
NO. TIME   VOL     CAP    VOL     CAP    VOL     CAP    VOL     CAP
--------------------------------------------------------------------
 1 1600    0.      0.     0.      0.     181.    292.   0.      0.
--------------------------------------------------------------------


                                                    CONTROLLER      SEQUENCE                  LOST TIME
INTERSECTION  NAME          RUN NO. AND TITLE       TYPE      DIAL   N/S   E/W      PHASES     /PH TOTAL
---------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN67             1:           NN67 SOAP84 RUN PRETIMED  1    T     T          2         4.0   8.0    TIMINGS INPUT
---------------------------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                            S E Q U E N C E
              DELAY      STOPS  EXC FUEL  EXC LEFT  MAXIMUM    V/C     LEFT TURN TREATMENT
MOVEMENTS: (VEH-HRS)     (%)     (GAL)     (VEH)     QUEUE    RATIO    PROTECTION  VEH/CYC    PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
---------------------------------------------------------------------------------------------------------------------------
 NB THRU  :     7.76     80.0    14.43               23.3      .53                            XXXX

 EB THRU  :     1.78     54.2     4.36                7.9      .33                                  XXXX
    LEFT  :     1.82     91.2     2.74       .0       3.9      .62     NONE         2.0             XXXX

 WB THRU  :     2.45     57.9     5.96               10.7      .42                                  XXXX
---------------------------------------------------------------------------------------------------------------------------


          M E A S U R E S   O F   E F F E C T I V E N E S S                 S I G N A L   T I M I N G
  ANALYSIS:  DELAY       STOPS  EX. FUEL  EX. LEFT  MAXIMUM    V/C     ALL RED    DIAL CYCLE   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
   PERIOD : (VEH-HRS)     (%)     (GAL)     (VEH)     QUEUE    RATIO    (SEC)      NO. (SEC)    (%)   (%)   (%)   (%)   (%)   (%)
---------------------------------------------------------------------------------------------------------------------------
 1600-1700:    13.81     69.0    27.50       .0      23.3      .62       .0        1   86.0:   39.5  60.5
---------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :    13.81     69.0    27.50       .0      23.3      .62     TIMINGS WERE INPUT BY THE USER.
```

```
< S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E >


    -----------------------------
    S O A P   I N P U T   E C H O
    -----------------------------


     NO.  CARD ID A    B  NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL             COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     21 :BEGIN           1600 1700   60          25                MI AVE. AT NN87           :
     22 :CONTROL 60 1600    1   86   86    0                                              :
     23 :HEADWAY     4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2  2.5                          :
     24 :VOLUME  60 1600  586       824       862   24  649   10                          :
     25 :CAPACITY60 1600    2         2         2    1    2    1                          :
     26 :LEFT                                        2         2                          :
     27 :TIMING  60 1600   35   51                                                        :
     28 :SEQUENCE                                                T    T                   :
     29 :RUN       1                                                        NN87 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     NO.  CARD ID A    B  NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL             COMMENT

        *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                   MOVEMENT NO.  2   NORTHBOUND LEFT.
                   MOVEMENT NO.  4   SOUTHBOUND LEFT.

        *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.


       -------------------------------------------------------
       L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
       -------------------------------------------------------


 PERIOD   NORTHBOUND      SOUTHBOUND      EASTBOUND       WESTBOUND
NO. TIME  VOL     CAP     VOL     CAP     VOL     CAP     VOL     CAP
--------------------------------------------------------------------
 1  1600   0.      0.      0.      0.     24.    341.     10.    252.
--------------------------------------------------------------------
```

```
     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT   WBL             COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     30 :BEGIN          1600 1700   60          25                MI AVE. AT NN89            :
     31 :CONTROL 60 1600   1   86   86    0                                                  :
     32 :HEADWAY    4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2   2.5                             :
     33 :VOLUME  60 1600  43                  1006       785    30                            :
     34 :CAPACITY60 1600   1                     2         2     1                            :
     35 :LEFT                                                    2                            :
     36 :TIMING  60 1600  22   64                                                             :
     37 :SEQUENCE                                                  T    T                     :
     38 :RUN       1                                                         NN89 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT   WBL             COMMENT

     *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                MOVEMENT NO.  2   NORTHBOUND LEFT.
                MOVEMENT NO.  3   SOUTHBOUND THRU.
                MOVEMENT NO.  4   SOUTHBOUND LEFT.
                MOVEMENT NO.  6   EASTBOUND  LEFT.

     *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.

                                                         CONTROLLER       SEQUENCE                 LOST TIME
INTERSECTION  NAME          RUN NO. AND TITLE           TYPE     DIAL    N/S   E/W       PHASES     /PH TOTAL
-------------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN87              1:           NN87 SOAP84 RUN PRETIMED   1     T     T           2        4.0   8.0     TIMINGS INPUT
-------------------------------------------------------------------------------------------------------------------------------

           M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                                   S E Q U E N C E
              DELAY     STOPS  EXC FUEL  EXC LEFT  MAXIMUM    V/C     LEFT TURN TREATMENT
 MOVEMENTS: (VEH-HRS)    (%)     (GAL)     (VEH)    QUEUE    RATIO    PROTECTION  VEH/CYC     PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
-------------------------------------------------------------------------------------------------------------------------------
 NB THRU  :     3.61    77.9     6.73               10.9      .50                            XXXX

 SB THRU  :     5.78    85.5    10.51               16.8      .70                            XXXX

 EB THRU  :     2.99    61.6     7.10               12.7      .48                                  XXXX
    LEFT  :      .17    77.6      .29       .0        .4      .07       NONE       2.0             XXXX

 WB THRU  :     2.04    56.6     4.90                8.8      .36                                  XXXX
    LEFT  :      .08    83.0      .13       .0        .2      .04       NONE       2.0             XXXX
-------------------------------------------------------------------------------------------------------------------------------

           M E A S U R E S   O F   E F F E C T I V E N E S S                S I G N A L   T I M I N G
  ANALYSIS:   DELAY     STOPS  EX. FUEL  EX. LEFT  MAXIMUM    V/C     ALL RED    DIAL CYCLE   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
   PERIOD : (VEH-HRS)    (%)     (GAL)     (VEH)    QUEUE    RATIO     (SEC)      NO. (SEC)    (%)   (%)   (%)   (%)   (%)   (%)
-------------------------------------------------------------------------------------------------------------------------------
 1600-1700:    14.67    70.6    29.66       .0      16.8      .70        .0        1   86.0:  40.7  59.3
-------------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :    14.67    70.6    29.66       .0      16.8      .70     TIMINGS WERE INPUT BY THE USER.
```

```
<SIGNAL OPERATIONS ANALYSIS PACKAGE>

        ------------------------------------------------
        LEFT TURN CHECK  (PER 60 MINUTE PERIOD)
        ------------------------------------------------

PERIOD    NORTHBOUND      SOUTHBOUND      EASTBOUND       WESTBOUND
NO. TIME  VOL    CAP      VOL    CAP      VOL    CAP      VOL    CAP
----------------------------------------------------------------------
 1  1600  0.     0.       0.     0.       0.     0.       30.    286.
----------------------------------------------------------------------


                                                         CONTROLLER      SEQUENCE                  LOST TIME
INTERSECTION  NAME          RUN NO. AND TITLE            TYPE      DIAL  N/S   E/W      PHASES     /PH TOTAL
--------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN89             1:          NN89 SOAP84 RUN PRETIMED    1     T     T          2        4.0   8.0    TIMINGS INPUT
--------------------------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                            S E Q U E N C E
            DELAY      STOPS  EXC FUEL  EXC LEFT  MAXIMUM    V/C      LEFT TURN TREATMENT
MOVEMENTS: (VEH-HRS)   (%)     (GAL)     (VEH)    QUEUE     RATIO     PROTECTION  VEH/CYC    PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
--------------------------------------------------------------------------------------------------------------------------
 NB THRU  :      .33   81.2      .55                  .8      .13                             XXXX

 EB THRU  :     1.67   43.7     5.39                10.5      .44                                   XXXX

 WB THRU  :     1.17   39.8     3.83                 7.5      .34                                   XXXX
    LEFT  :      .24   81.9      .39        .0        .6      .10        NONE       2.0             XXXX
--------------------------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S                 S I G N A L   T I M I N G
 ANALYSIS:  DELAY      STOPS  EX. FUEL  EX. LEFT  MAXIMUM    V/C      ALL RED    DIAL CYCLE  PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
  PERIOD : (VEH-HRS)   (%)     (GAL)     (VEH)    QUEUE     RATIO     (SEC)      NO. (SEC)   (%)   (%)   (%)   (%)   (%)   (%)
--------------------------------------------------------------------------------------------------------------------------
 1600-1700:     3.42   43.5    10.16        .0     10.5       .44        .0        1  86.0:  25.6  74.4
--------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :     3.42   43.5    10.16        .0     10.5       .44      TIMINGS WERE INPUT BY THE USER.
```

```
< S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E >


       ---------------------------------------------------
       L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
       ---------------------------------------------------

 PERIOD   NORTHBOUND      SOUTHBOUND      EASTBOUND       WESTBOUND
NO. TIME  VOL     CAP     VOL     CAP     VOL     CAP     VOL     CAP
-----------------------------------------------------------------------
 1  1600   0.      0.      0.      0.     66.    415.     21.    277.
-----------------------------------------------------------------------

 NO. CARD ID  A  B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL           COMMENT
----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
 39 :BEGIN           1600 1700   60        25               MI AVE. AT NN92          :
 40 :CONTROL 60 1600    1   86   86    0                                             :
 41 :HEADWAY     4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2  2.5                         :
 42 :VOLUME  60 1600   75       199       979   66  670   21                         :
 43 :CAPACITY60 1600    1         1         2    1    2    1                         :
 44 :LEFT                                        2         2                         :
 45 :TIMING  60 1600   25   61                                                       :
 46 :SEQUENCE                                               T    T                   :
 47 :RUN      1                                                       NN92 SOAP84 RUN:
----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
 NO. CARD ID  A  B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL           COMMENT

   *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

             MOVEMENT NO.  2   NORTHBOUND LEFT.
             MOVEMENT NO.  4   SOUTHBOUND LEFT.

   *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.
```

```
                                                          CONTROLLER       SEQUENCE                    LOST TIME
INTERSECTION  NAME         RUN NO. AND TITLE             TYPE      DIAL    N/S   E/W         PHASES     /PH TOTAL
----------------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN92             1:           NN92 SOAP84 RUN PRETIMED    1     T     T            2         4.0   8.0     TIMINGS INPUT
----------------------------------------------------------------------------------------------------------------------------------

           M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                                     S E Q U E N C E
              DELAY     STOPS  EXC FUEL   EXC LEFT  MAXIMUM     V/C     LEFT TURN TREATMENT
 MOVEMENTS: (VEH-HRS)    (%)     (GAL)     (VEH)     QUEUE     RATIO    PROTECTION VEH/CYC     PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
----------------------------------------------------------------------------------------------------------------------------------
 NB THRU  :      .55    79.2       .92                 1.4       .19                            XXXX

 SB THRU  :     1.67    86.0      2.71                 4.1       .50                            XXXX

 EB THRU  :     1.99    48.1      5.90                11.3       .45                                  XXXX
    LEFT  :      .43    74.6       .75        .0       1.2       .16        NONE        2.0           XXXX

 WB THRU  :     1.18    42.4      3.55                 6.8       .31                                  XXXX
    LEFT  :      .17    82.0       .27        .0        .4       .08        NONE        2.0           XXXX
----------------------------------------------------------------------------------------------------------------------------------

           M E A S U R E S   O F   E F F E C T I V E N E S S                     S I G N A L   T I M I N G
  ANALYSIS:   DELAY     STOPS  EX. FUEL   EX. LEFT  MAXIMUM     V/C    ALL RED   DIAL CYCLE    PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
   PERIOD : (VEH-HRS)    (%)     (GAL)     (VEH)     QUEUE     RATIO    (SEC)     NO. (SEC)     (%)   (%)   (%)   (%)   (%)   (%)
----------------------------------------------------------------------------------------------------------------------------------
 1600-1700:     5.98    52.3     14.11        .0      11.3       .50      .0        1   86.0:   29.1  70.9
----------------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :     5.98    52.3     14.11        .0      11.3       .50      TIMINGS WERE INPUT BY THE USER.

     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL             COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     48 :BEGIN           1600 1700   60          25                MI AVE. AT NN91            :
     49 :CONTROL 60 1600    1   86   86     0                                                 :
     50 :HEADWAY     4.0  2.2  2.5  2.2   2.5  2.2  2.5  2.2  2.5                           :
     51 :VOLUME  60 1600  237       174       1062   23  806   71                           :
     52 :CAPACITY60 1600    1         1          2    1    2    1                           :
     53 :LEFT                                          2         2                           :
     54 :TIMING  60 1600   26   60                                                          :
     55 :SEQUENCE                                                         T    T                    :
     56 :RUN      1                                                            NN91 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++-----------------:
     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL             COMMENT

        *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                   MOVEMENT NO.  2   NORTHBOUND LEFT.
                   MOVEMENT NO.  4   SOUTHBOUND LEFT.

        *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.
```

```
<SIGNAL OPERATIONS ANALYSIS PACKAGE>


      -----------------------------------------------------
      L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
      -----------------------------------------------------

 PERIOD   NORTHBOUND     SOUTHBOUND     EASTBOUND      WESTBOUND
NO. TIME  VOL    CAP     VOL    CAP     VOL    CAP     VOL    CAP
-----------------------------------------------------------------
 1 1600   0.      0.      0.     0.     23.   339.     71.   244.
-----------------------------------------------------------------


                                                   CONTROLLER     SEQUENCE                LOST TIME
INTERSECTION  NAME        RUN NO. AND TITLE        TYPE      DIAL  N/S   E/W     PHASES    /PH TOTAL
----------------------------------------------------------------------------------------------------------
MI AVE. AT NN91           1:         NN91 SOAP84 RUN PRETIMED   1    T     T           2       4.0   8.0    TIMINGS INPUT
----------------------------------------------------------------------------------------------------------

          M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                    S E Q U E N C E
          DELAY      STOPS  EXC FUEL  EXC LEFT  MAXIMUM    V/C    LEFT TURN TREATMENT
MOVEMENTS: (VEH-HRS)  (%)    (GAL)     (VEH)     QUEUE    RATIO   PROTECTION  VEH/CYC   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
----------------------------------------------------------------------------------------------------------
 NB THRU  :     2.02   87.0     3.27                4.9      .57                        XXXX

 SB THRU  :     1.36   83.3     2.27                3.5      .42                        XXXX

 EB THRU  :     2.41   51.6     6.93               13.1      .50                              XXXX
    LEFT  :      .16   77.7      .28        .0       .4      .07     NONE       2.0           XXXX

 WB THRU  :     1.61   46.3     4.70                8.9      .38                              XXXX
    LEFT  :      .64   87.4     1.01        .0      1.5      .29     NONE       2.0           XXXX
----------------------------------------------------------------------------------------------------------


          M E A S U R E S   O F   E F F E C T I V E N E S S           S I G N A L   T I M I N G
 ANALYSIS:  DELAY      STOPS  EX. FUEL  EX. LEFT  MAXIMUM    V/C     ALL RED    DIAL CYCLE   PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
  PERIOD : (VEH-HRS)    (%)    (GAL)     (VEH)     QUEUE    RATIO    (SEC)      NO. (SEC)    (%)   (%)   (%)   (%)   (%)   (%)
----------------------------------------------------------------------------------------------------------
1600-1700:     8.21    57.0    18.45       .0      13.1      .57        .0       1   86.0:   30.2  69.8
----------------------------------------------------------------------------------------------------------

 SUMMARY  :    8.21    57.0    18.45       .0      13.1      .57     TIMINGS WERE INPUT BY THE USER.
```

```
< S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E >


    ----------------------------
    S O A P   I N P U T   E C H O
    ----------------------------


     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     57 :BEGIN           1600 1700   60        25               MI AVE. AT NN90          :
     58 :CONTROL 60 1600    1   86   86    0                                             :
     59 :HEADWAY     4.0  2.2  2.5  2.2  2.5  2.2  2.5  2.2  2.5                         :
     60 :VOLUME  60 1600   95       111       982   52  935   20                         :
     61 :CAPACITY60 1600    1         1         2    1    2    1                         :
     62 :LEFT                                        2         2                         :
     63 :TIMING  60 1600   24   62                                                       :
     64 :SEQUENCE                                               T    T                   :
     65 :RUN      1                                                       NN90 SOAP84 RUN:
    ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT

        *** WARNING: THE FOLLOWING MOVEMENTS ARE ASSUMED NOT TO EXIST:

                   MOVEMENT NO.  2   NORTHBOUND LEFT.
                   MOVEMENT NO.  4   SOUTHBOUND LEFT.

        *** NOTE ... CYCLE LENGTH COMPUTED FROM TIMING CARD.


       ------------------------------------------------------
       L E F T   T U R N   C H E C K   (PER 60 MINUTE PERIOD)
       ------------------------------------------------------

 PERIOD    NORTHBOUND     SOUTHBOUND     EASTBOUND      WESTBOUND
NO. TIME   VOL    CAP     VOL    CAP     VOL   CAP      VOL    CAP
-------------------------------------------------------------------
 1  1600    0.     0.      0.     0.     52.   299.     20.   282.
-------------------------------------------------------------------
```

```
< S I G N A L   O P E R A T I O N S   A N A L Y S I S   P A C K A G E >


-----------------------------
DESIGN AND EVALUATION SUMMARY
-----------------------------


                                                         CONTROLLER      SEQUENCE                    LOST TIME
INTERSECTION  NAME        RUN NO. AND TITLE             TYPE     DIAL    N/S   E/W      PHASES       /PH TOTAL
-------------------------------------------------------------------------------------------------------------------------------
MI AVE. AT NN90           1:            NN90 SOAP84 RUN PRETIMED   1     T     T            2        4.0   8.0    TIMINGS INPUT
-------------------------------------------------------------------------------------------------------------------------------

           M E A S U R E S   O F   E F F E C T I V E N E S S
                                                                                                   S E Q U E N C E
              DELAY     STOPS  EXC FUEL  EXC LEFT  MAXIMUM    V/C      LEFT TURN TREATMENT
MOVEMENTS: (VEH-HRS)     (%)     (GAL)     (VEH)     QUEUE    RATIO    PROTECTION   VEH/CYC     PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
-------------------------------------------------------------------------------------------------------------------------------
 NB THRU  :      .73    81.5      1.21                1.8       .25                             XXXX

 SB THRU  :      .87    82.3      1.43                2.2       .29                             XXXX

 EB THRU  :     1.87    46.5      5.69               10.9       .44                                   XXXX
    LEFT  :      .41    82.2       .68        .0      1.0       .17       NONE         2.0            XXXX

 WB THRU  :     1.74    45.6      5.30               10.2       .42                                   XXXX
    LEFT  :      .16    81.5       .26        .0       .4       .07       NONE         2.0            XXXX
-------------------------------------------------------------------------------------------------------------------------------


           M E A S U R E S   O F   E F F E C T I V E N E S S                 S I G N A L   T I M I N G
  ANALYSIS:   DELAY     STOPS  EX. FUEL  EX. LEFT  MAXIMUM    V/C     ALL RED   DIAL CYCLE    PH 1  PH 2  PH 3  PH 4  PH 5  PH 6
   PERIOD : (VEH-HRS)    (%)     (GAL)     (VEH)     QUEUE    RATIO    (SEC)     NO. (SEC)     (%)   (%)   (%)   (%)   (%)   (%)
-------------------------------------------------------------------------------------------------------------------------------
 1600-1700:     5.77    50.6     14.57        .0     10.9       .44       .0       1   86.0:  27.9  72.1
-------------------------------------------------------------------------------------------------------------------------------

 SUMMARY  :     5.77    50.6     14.57        .0     10.9       .44     TIMINGS WERE INPUT BY THE USER.


     NO.  CARD ID A   B   NBT  NBL  SBT  SBL  EBT  EBL  WBT  WBL            COMMENT
     ----:-------- - ---- ---- ---- ---- ---- ---- ---- ---- ----++++-++++----------------:
     66 :END                                                                               :


        +++ END OF SOAP JOB +++

        +++ GOOD NEWS: NO ERRORS ENCOUNTERED DURING THIS JOB +++
```

APPENDIX-3

REGRESSION ANALYSIS - PROGRAM IN BASIC

```
1 REM [SS/REGR-AN.BAS/CH99/APPENDIX-3]
2 REM BUI     03-86
3 REM
4 REM VARIABLES
5 REM B(I)      ESTIMATED COEFFICIENTS
6 REM B1        ESTIMATED CONSTANT
7 REM C(I,J)    MULTIPLE CORRELATION COEFFICIENTS
8 REM E         SUM SQUARE OF ERRORS
9 REM F         FISHER TEST
10 REM M        TOTAL NUMBER OF VARIABLES
11 REM N        NUMBER OF PERIODS OF OBSERVATION
12 REM R(I)     RESIDUAL VALUES
13 REM R2       CORRELATION COEFFICIENT
14 REM S(I,J)   VARIANCE-COVARIANCE MATRIX
15 REM V(I)     VECTOR OF STANDARD ESTIMATED ERRORS
16 REM X(I,J)   MATRIX OF INPUT VALUES
17 REM Y(I)     ESTIMATED Y-VALUES
18 REM
19 REM
20 PRINT : PRINT : PRINT
30 PRINT "MULTIPLE LINEAR REGRESSION"
40 PRINT "**************************"
50 PRINT : PRINT : PRINT
60 INPUT "NUMBER OF VARIABLES?   ";M: PRINT
70 INPUT "NUMBER OF OBSERVATIONS? ";N: PRINT
80 DIM A$(M),X(M,N),X1(M),S(M,M),S2(M,M),S3(M,M)
90 DIM B(M),Y(N),R(N),V(M),C(M,M)
100 FOR I=1 TO M: PRINT "NAME OF VARIABLE #";I;" ";
110 INPUT A$(I): NEXT I: PRINT
120 FOR I=1 TO M
130 PRINT "DATA GATHERED FOR VARIABLE ";A$(I);":"
140 FOR J=1 TO N
150 PRINT"- OBSERVATION #";J; TAB( 14);
160 INPUT X(I,J)
170 NEXT J
180 PRINT
190 NEXT I
200 REM      MEAN, STANDARD DEVIATION.
210 FOR I=1 TO M:T=0:FOR J=1 TO N
220 T=T+X(I,J)
230 NEXT J
240 X1(I)=T/N
250 NEXT I
260 FOR I=1 TO M:FOR K=1 TO M
270 S1=0
280 FOR J=1 TO N
290 S1=S1 + (X(I,J) - X1(I)) * (X(K,J) - X1(K))
300 NEXT J
310 S(I,K)=S1/(N-1)
320 S(K,I)=S(I,K)
330 NEXT K,I
340 M1=M-1
350 FOR J=1 TO M1: FOR K=1 TO M1:S2(J,K)=S(J+1,K+1): NEXT K,J
360 FOR I=1 TO M1: FOR J=1 TO M1
370 IF I< >J GOTO 400
380 S3(I,J)=1
390 GOTO 410
400 S3(I,J)=0
410 NEXT J,I
420 GOSUB 1330
```

```
430 REM        CALCULATE THE COEFFICIENTS B(I)
440 FOR I=1 TO M1
450 B(I)=0
460 FOR J=1 TO M1
470 B(I)=B(I)+S(1,J+1)*S2(J,I)
480 NEXT J,I
490 B1=0
500 FOR I=1 TO M1:B1=B1+X1(I+1)*B(I):NEXT I
510 B1=X1(1)-B1
520 REM        R2, ESTIMATIONS, SEE, F-TEST, CORRELATION
530 S3=0
540 FOR I=1 TO N: Y(I)=0
550 FOR J=2 TO M: Y(I)=Y(I)+B(J-1)*X(J,I): NEXT J
560 Y(I)=Y(I)+B1
570 R(I)=X(1,I)-Y(I)
580 S3=S3+R(I)^2
590 NEXT I
600 S(1,1)=(N-1)*S(1,1)
610 R2=(S(1,1)-S3)/S(1,1)
620 IF R2=1 GOTO 640
630 F=(R2/M1)/((1-R2)/(N-M))
640 E=SQR(S3/(N-M))
650 FOR J=1 TO M1
660 V(J)=E*SQR(S2(J,J)/(N-1))
670 NEXT J
680 S(1,1)=S(1,1)/(N-1)
690 C(1,1)=1
700 FOR J=2 TO M
710 C(J,J)=1
720 J1=J-1
730 FOR I=1 TO J1
740 C(I,J)=S(I,J)/SQR(S(I,I)*S(J,J))
750 C(J,I)=C(I,J)
760 NEXT I,J
770 FOR I=1 TO M
780 S(I,I)=SQR (S(I,I))
790 NEXT I
800 REM        OUTPUT
810 PRINT : PRINT : PRINT
820 PRINT "CORRELATION MATRIX"
830 PRINT "******************"
840 FOR I=1 TO M: FOR J=1 TO M
850 IF I<J THEN 870
860 PRINT INT(100*C(I,J))/100; TAB(10*J)
870 NEXT J: PRINT
880 NEXT I
890 PRINT : PRINT : PRINT
900 PRINT "VARIABLE      MEAN       STD DEVIATION"
910 PRINT "**************************************"
920 FOR I=1 TO M
923 PRINT A$(I); TAB( 14);X1(I); TAB( 27);S(I,I)
925 NEXT I
930 PRINT : PRINT
940 INPUT "CONTINUE? ";C$
950 PRINT : PRINT
960 PRINT "REGRESSION EQUATION"
970 PRINT "**************************************"
990 PRINT "DEPENDENT VARIABLE: ";A$(1)
1000 PRINT "**************************************"
1020 PRINT "INDEPNDNT  EST   BETA   ERRORS  T-TEST"
```

```
1030 PRINT "VARIABLE   COEF   %"
1040 PRINT "**************************************"
1050 PRINT
1060 FOR I=1 TO M1
1070 PRINT A$(I+1); TAB( 11); INT(100*B(I)+.5)/100; TAB( 18);
1080 PRINT INT(10000*(B(I)*(X1(I+1)/X1(1))))/100;
1090 PRINT TAB( 25); INT(100*V(I)+.5)/100;
1095 PRINT TAB( 35); INT(100*(B(I)/V(I))+.5)/100
1100 NEXT I
1110 PRINT "CONSTANT"; TAB( 11);B1
1120 PRINT "**********************************************"
1125 DEF FN A(Z)=INT(100*Z+.5)/100
1130 REM            STATISTICS
1140 PRINT "DETERMINATION COEFFICIENT    = "; FN A(R2)
1150 PRINT "CORRELATION COEFFICIENT      = "; FN A(SQR(R2))
1160 PRINT "F-TEST                       = "; FN A(F)
1170 PRINT "DEGREES OF FREEDOM           = "; FN A(N-K)
1180 PRINT "SUM SQUARE OF ERRORS         = "; FN A(E)
1190 PRINT "**********************************************"
1200 REM          RESIDUALS
1210 PRINT : PRINT
1220 INPUT "CONTINUE? ";C$
1230 PRINT : PRINT
1240 PRINT "TABLE OF RESIDUAL VALUES"
1250 PRINT "*************************************"
1260 PRINT " #  OBSERVATION  ESTIMATION RESIDUAL   "
1270 PRINT "*************************************"
1280 FOR I=1 TO N
1290 PRINT " ";I; TAB( 8); INT(100*(X(1,I))+.5)/100;
1293 PRINT TAB( 18); INT(100*Y(I)+.5)/100;
1295 PRINT TAB( 30); INT(100*R(I)+.5)/100
1300 NEXT I
1310 PRINT "*************************************"
1320 END
1330 REM           MATRIX INVERSION
1340 FOR K=1 TO M1: FOR I=1 TO M1
1350 IF I>K THEN 1420
1360 PP=S2(K,K)
1370 FOR J=1 TO M1
1380 S2(K,J)=S2(K,J)/PP
1390 S3(K,J)=S3(K,J)/PP
1400 NEXT J
1410 IF I=K GOTO 1470
1420 PP=S2(I,K)
1430 FOR J=1 TO M1
1440 S2(I,J)=S2(I,J)-S2(K,J)*PP
1450 S3(I,J)=S3(I,J)-S3(K,J)*PP
1460 NEXT J
1470 NEXT I
1480 NEXT K
1490 FOR I=1 TO M1: FOR J=1 TO M1: S2(I,J)=S3(I,J): NEXT J,I
1500 RETURN
```

APPENDIX-4

TRANSYT-7F SIMULATION RUNS FOR THE STUDY CASE-II, IN CIREBON, INDONESIA

NOTE :

- Simulation runs were established for traffic volume variation of .10*S*; .20*S*; .30*S*; and .40*S*.
- A set of output is presented for traffic - volume of .30*S*.
- Only the system-wide performances are presented for traffic volumes of .10*S*; .20*S*; and .40*S*.

```
1          T R A N S Y T - 7 F  --  T R A F F I C   S I G N A L   S Y S T E M   O P T I M I Z A T I O N   P R O G R A M
0RELEASE 4   JUNE, 1984                                                                                            VERSION 2.0
0SPONSORED BY:                                                                                    DEVELOPED BY:
 FEDERAL HIGHWAY ADMINISTRATION                                                                   TRANSPORT AND ROAD RESEARCH LABORATORY
 OFFICE OF TRAFFIC OPERATIONS                                                                     UNITED KINGDOM AND
                                                                                                  TRANSPORTAION RESEARCH CENTER
0                                             ----------------------------------------------------- UNIVERSITY OF FLORIDA
                                              I N P U T   D A T A   R E P O R T   F O R   R U N   1
                                              -----------------------------------------------------

0FIELDS:  1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16
        ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
0LINE                                                           RUN  TITLE  CARD
  NO.     TITLE
0  1)     RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30
0                                                            NETWORK  CONTROL  CARD
                                              SEC/    SEC/
 LINE     CARD     MIN     MAX    CYCLE    STEP    STEP    LOST    GREEN    STOP  OUTPUT INITIAL  PERIOD  SEC(0)  SPD(0) ENGL(0)  PUNCH
  NO.     TYPE    CYCLE   CYCLE   INCR.    CYCLE  NORMAL   TIME    EXTEN. PENALTY  LEVEL TIMINGS  LENGTH PERC(1) TIME(1) METR(1) DECK(1)

   2)      1       62      62      0        0       0       4       3      20       0       0       0       0       0       0       0
0+++ 106 +++ WARNING +
+                          THE SEC/STEPS FACTOR IN FIELD 6 IS TOO SMALL FOR CYCLE LENGTHS ABOVE  60 SECONDS.
                           IT WILL BE INCREASED TO ALLOW A MAXIMUM OF 60 STEPS/CYCLE.
0LINE     CARD                                              LIST  OF  NODES  TO  BE  OPTIMIZED
  NO.     TYPE

   3)      2       1       2       3       4       0       0       0       0       0       0       0       0       0       0       0
0                                                       SYSTEM  MASTER  DATA
 LINE     CARD   MASTER  DEF. CLEARANCES SYSTEM  EXTERNAL SYSTEM  FUEL   VEHICLE
  NO.     TYPE    NODE   YELLOW  ALL-RED SATFLOW  SPEED    PDF   FACTOR  LENGTH

   4)     10       1       0       0       0       0       0       0       0       0       0       0       0       0       0       0
```

```
0------------------
 INTERSECTION     1
 ------------------
                                                   CONTROLLER  TIMING  DATA
 LINE     CARD     NODE  OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.     TYPE      NO.  YLD.PT.   REF INT  INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11  CYCLE

   5)      12        1       0        1      16        5        1       16        5        1        0        0        0        0        0      0
0+++ 135 +++ WARNING +
+                         THE SUM OF THE INTERVAL LENGTHS,  44 (SEC OR %), IS LESS THAN THE
                          CYCLE LENGTH,  62 (SEC OR %).
0                                                    PHASE  TIMING  DATA
 LINE     CARD     NODE    START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                         CONT.
  NO.     TYPE      NO.    INTVL   INTVL   INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ................................            FLAG

   6)      21        1       1        1       2        3      22      101      103        0        0        0        0        0        0      0
   7)      22        1       4        4       5        6      22      105      107        0        0        0        0        0        0      0
0                                                            LINK  DATA
 LINE     CARD     LINK    LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK....  QUEUE
  NO.     TYPE      NO.  LENGTH`    FLOW     VOL.     VOL.     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT  CAP.

   8)      28      101       0     1300     390        0        0        0        0        0        0        0        0        0        0      0
   9)      28      103    2600     2900     870        0      203      522       35      205      174       35      207       78       35      0
  10)      28      105       0     2900     870        0        0        0        0        0        0        0        0        0        0      0
  11)      28      107       0     2900     870        0        0        0        0        0        0        0        0        0        0      0
0------------------
 INTERSECTION     2
 ------------------
                                                   CONTROLLER  TIMING  DATA
 LINE     CARD     NODE  OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.     TYPE      NO.  YLD.PT.   REF INT  INT1     INT2     INT3     INT4     INT5     INT6     INT7     INT8     INT9    INT10    INT11  CYCLE

  12)      12        2      20        1      16        5        1       16        5        1        0        0        0        0        0      0
0+++ 135 +++ WARNING +
+                         THE SUM OF THE INTERVAL LENGTHS,  44 (SEC OR %), IS LESS THAN THE
                          CYCLE LENGTH,  62 (SEC OR %).
0                                                    PHASE  TIMING  DATA
 LINE     CARD     NODE    START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                         CONT.
  NO.     TYPE      NO.    INTVL   INTVL   INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ................................            FLAG

  13)      21        2       1        1       2        3      22      201      203        0        0        0        0        0        0      0
  14)      22        2       4        4       5        6      22      205      207        0        0        0        0        0        0      0
1RUN TITLE:  RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30

 FIELDS:  1        2        3        4        5        6        7        8        9       10       11       12       13       14       15      16
         ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----     ----    ----
0                                                            LINK  DATA
 LINE     CARD     LINK    LINK     SAT.    TOTAL   MID-BLK. FIRST INPUT LINK....     SECOND INPUT LINK....     THIRD INPUT LINK....  QUEUE
  NO.     TYPE      NO.  LENGTH     FLOW     VOL.     VOL.     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT     NO.     VOL.   SPD/TT  CAP.

  15)      28      201    2600     2900     870        0      101      234       35      105      174       35      107      174       35      0
  16)      28      203    2600     2900     870        0      303      522       35      305      174       35      307       78       35      0
  17)      28      205    5600     2900     870        0      403      522       35      405      174       35      407      174       35      0
  18)      28      207       0     1300     390        0        0        0        0        0        0        0        0        0        0      0
```

```
0------------------
 INTERSECTION     3
 ------------------
                                                                     CONTROLLER  TIMING  DATA
 LINE      CARD      NODE  OFFSET/                 INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.      TYPE       NO.  YLD.PT.   REF INT   INT1      INT2      INT3      INT4      INT5      INT6      INT7      INT8      INT9      INT10     INT11     CYCLE

  19)       12         3     40         1       25         5         1        25         5         1         0         0         0         0         Q         0
0                                                                        PHASE  TIMING  DATA
 LINE      CARD      NODE    START   VARIAB.  YELLOW   ALL-RED   MINIM.                                                                                   CONT.
  NO.      TYPE       NO.    INTVL    INTVL    INTVL    INTVL    SECS.    LINKS MOVING IN THIS PHASE ...................................                   FLAG

  20)       21         3       1         1        2         3       31       301       303         0         0         0         0         0         0         0
  21)       22         3       4         4        5         6       31       305       307         0         0         0         0         0         0         0
0                                                                                LINK  DATA
 LINE      CARD      LINK    LINK      SAT.    TOTAL    MID-BLK.  FIRST INPUT LINK....       SECOND INPUT LINK....       THIRD INPUT LINK....   QUEUE
  NO.      TYPE       NO.   LENGTH     FLOW     VOL.      VOL.     NO.       VOL.     SPD/TT     NO.      VOL.     SPD/TT    NO.       VOL.    SPD/TT   CAP.

  22)       28       301     2600      2900     870        0       201       522        35       205       174        35       207        78        35         0
  23)       28       303        0      2900     870        0         0         0         0         0         0         0         0         0         0         0
  24)       28       305     4300      2900     870        0       401       174        35       403       174        35       405       522        35         0
  25)       28       307        0      1300     390        0         0         0         0         0         0         0         0         0         0         0
0------------------
 INTERSECTION     4
 ------------------
                                                                     CONTROLLER  TIMING  DATA
 LINE      CARD      NODE  OFFSET/                 INTERVAL DURATIONS (SECS. OR PERCENT) ............................................. DOUBLE
  NO.      TYPE       NO.  YLD.PT.   RRF INT   INT1      INT2      INT3      INT4      INT5      INT6      INT7      INT8      INT9      INT10     INT11     CYCLE

  26)       12         4     15         1       25         5         1        25         5         1         0         0         0         0         0         0
0                                                                        PHASE  TIMING  DATA
 LINE      CARD      NODE    START   VARIAB.  YELLOW   ALL-RED   MINIM.                                                                                   CONT.
  NO.      TYPE       NO.    INTVL    INTVL    INTVL    INTVL    SECS.    LINKS MOVING IN THIS PHASE ...................................                   FLAG

  27)       21         4       1         1        2         3       31       401       403         0         0         0         0         0         0         0
  28)       22         4       4         4        5         6       31       405       407         0         0         0         0         0         0         0
0                                                                                LINK  DATA
 LINE      CARD      LINK    LINK      SAT.    TOTAL    MID-BLK.  FIRST INPUT LINK....       SECOND INPUT LINK....       THIRD INPUT LINK....   QUEUE
  NO.      TYPE       NO.   LENGTH     FLOW     VOL.      VOL.     NO.       VOL.     SPD/TT     NO.      VOL.     SPD/TT    NO.       VOL.    SPD/TT   CAP.

1RUN TITLE:  RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30

 FIELDS:  1         2         3         4         5         6         7         8         9        10        11        12        13        14        15        16
        ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----      ----
  29)     28       401      5600      2900       870         0       201        78        35       203       174        35       207       522        35         0
  30)     28       403         0      2900       870         0         0         0         0         0         0         0         0         0         0         0
  31)     28       405         0      2900       870         0         0         0         0         0         0         0         0         0         0         0
  32)     28       407      4300      2900       870         0       301       174        35       303       174        35       307       234        35         0
0LINE     CARD                                                    RUN  CARD
  NO.     TYPE

  33)     51         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0
```

```
0--- PROGRAM NOTE --- A CARD TYPE 51 CAUSES JOB TO BE EXECUTED AS A SIMULATION RUN,
                      DELETING ANY OPTIMIZATION VALUES INPUT.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   4 NODES AND  16 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
0--- PROGRAM NOTE --- THERE WERE A TOTAL OF   3 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30   62 SECOND CYCLE    60 STEPS
0<PERFORMANCE WITH INITIAL SETTINGS>
0   NODE LINK   FLOW    SAT  DEGREE  TOTAL      TOTAL   -------- DELAY --------  AVERAGE   UNIFORM  MAX BACK  QUEUE    FUEL  PHASE  LINK
     NO   NO           FLOW  OF SAT  TRAVEL     TIME    UNIFORM  RANDOM    TOTAL  DELAY     STOPS    OF QUEUE CAPACITY CONSUM LENGTH  NO
              (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)      (VEH-H/H)         (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

      1   101    390  1300   124*      .00     42.29     3.55   38.74    42.29  390.4   314.5( 81%)   11    >     0   32.71    22    101
      1   103    870  2900   124*   428.15    102.74     5.44   85.22    90.65  375.1   660.2( 76%)   21        208   87.71    22    103
      1   105    870  2900    56       .00      2.49     2.30     .18     2.49   10.3   519.4( 60%)   10    >     0    4.69    40    105
      1   107    870  2900    56       .00      2.49     2.30     .18     2.49   10.3   519.4( 60%)   10    >     0    4.69    40    107
0     1 :       3000   MAX = 124*   428.15    150.00    13.59  124.32   137.92  165.5  2013.5( 67%)                  129.80 PI =  149.1

      2   201    870  2900   124*   428.15    102.90     5.60   85.22    90.81  375.8   700.9( 81%)   18        208   88.13    22    201
      2   203    870  2900   124*   428.15    104.26     6.96   85.22    92.17  381.4   699.2( 80%)   21        208   89.12    22    203
      2   205    870  2900    56    922.79     28.35     2.11     .18     2.29    9.5   469.2( 54%)    9        448   40.26    40    205
      2   207    390  1300    56       .00      1.19     1.01     .18     1.19   11.0   229.9( 59%)    4    >     0    2.14    40    207
0     2 :       3000   MAX = 124*  1779.09    236.70    15.67  170.80   186.47  223.8  2099.2( 70%)                  219.66 PI =  198.1

      3   301    870  2900    77    428.15     17.16     4.41     .66     5.07   21.0   668.2( 77%)   12        208   25.09    31    301
      3   303    870  2900    77       .00      4.64     3.98     .66     4.64   19.2   700.6( 81%)   13    >     0    7.27    31    303
      3   305    870  2900    78    708.72     24.41     3.74     .66     4.40   18.2   689.6( 79%)   13        344   35.39    31    305
      3   307    390  1300    78       .00      2.44     1.78     .66     2.44   22.5   314.1( 81%)    6    >     0    3.52    31    307
0     3 :       3000   MAX =  78   1136.87     48.65    13.91    2.64    16.55   19.9  2372.5( 79%)                   71.27 PI =   29.7

      4   401    870  2900    78    922.79     29.91     3.20     .66     3.86   16.0   616.1( 71%)   12        448   42.54    31    401
      4   403    870  2900    78       .00      4.60     3.93     .66     4.60   19.0   696.4( 80%)   13    >     0    7.22    31    403
      4   405    870  2900    77       .00      4.60     3.93     .66     4.60   19.0   696.4( 80%)   13    >     0    7.22    31    405
      4   407    870  2900    77    708.72     24.05     3.38     .66     4.04   16.7   610.3( 70%)   12        344   34.52    31    407
0     4 :       3480   MAX =  78   1631.51     63.16    14.44    2.65    17.09   17.7  2619.2( 75%)                   91.49 PI =   31.6

                                       <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>


0    TOTAL     - TOTAL     TOTAL      TOTAL      TOTAL     AVERAGE       TOTAL        TOTAL
   DISTANCE    TRAVEL    UNIFORM     RANDOM      DELAY      DELAY       UNIFORM        FUEL    PERFORMANCE   SPEED
   TRAVELED     TIME      DELAY      DELAY                               STOPS        CONSUM      INDEX
  (VEH-MI/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)    (VEH/H-%)      (GA/H)               (MI/H)

0   4975.62    498.51     57.62      300.41     358.03     103.28     9104.4( 73%)    512.22     408.61      11.47 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30   62 SECOND CYCLE    60 STEPS
```

```
0--- PROGRAM NOTE --- THIS IS THE INPUT DATA REPORT FOR TIME-SPACE DIAGRAM NO.   1
0                                                       TIME-SPACE  DIAGRAM  DATA
 LINE    CARD     NO.    TIME    TIME   DIST.
  NO.    TYPE    NODES   FLAG    SCALE  SCALE

  34)     60       3       0       0     200       0       0       0       0       0       0       0       0       0       0       0
0LINE
  NO.     TITLE                                             PLOT  TITLE  CARD
0 35)        PLOT NODES : 01, 02, 03.
0                                                        PLOT  LINK  STREAM  CARD
 LINE    CARD    LINK PAIRS ALTERNATING BY DIRECTION
  NO.    TYPE    DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP

  36)     61     103     101     203     201     303     301       0       0       0       0       0       0       0       0       0
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30   62 SECOND CYCLE    60 STEPS
```

```
0                                  < T R A N S Y T - 7 F   T I M E - S P A C E   D I A G R A M >
0                    PLOT NO.  1  PLOT TITLE:     PLOT NODES : 01, 02, 03.
0                    TIME AXIS IS IN: SEC          TIME SCALE =   3 SEC/CHAR,  DIST. SCALE =  200 FT/LINE
0                  1         2         3         4         5         6         7         8         9        10        11
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
          --------------------------------------------------------------------------------------------------------------
       1 :       **************       *************        *************       **************       *************           0 FT
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
       2 :*******       *************        *************       **************       *************        ************* 2600 FT
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
         :                    :                   :                    :                    :                   :
       3 :   **********           **********          ***********          **********           **********          **** 5200 FT
         :--------------------------------------------------------------------------------------------------------------
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
0         SCALE CONVERSIONS:                                 +++ GREEN IN DOWN DIRECTION                  AVG. TIME DISPLACEMENT:
          TIME/INCH =  3 * 10 (AT 10 CHAR/INCH)                  GREEN IN BOTH DIRECTIONS                   590.91 / SPEED
          DIST/INCH = 200 * 6 (AT 6 LINES/INCH)              --- GREEN IN UP   DIRECTION
                                                             *** RED   IN BOTH DIRECTIONS
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .30   62 SECOND CYCLE    60 STEPS
0LINE    CARD                                                 TERMINATION CARD
  NO.    TYPE

  37)     90       0       0               0       0       0       0       0       0       0       0       0       0       0
0--- PROGRAM NOTE --- END OF JOB!
```

```
0--- PROGRAM NOTE --- A CARD TYPE 51 CAUSES JOB TO BE EXECUTED AS A SIMULATION RUN,
                      DELETING ANY OPTIMIZATION VALUES INPUT.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   4 NODES AND  16 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
0--- PROGRAM NOTE --- THERE WERE A TOTAL OF   3 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .10   62 SECOND CYCLE    60 STEPS
0<PERFORMANCE WITH INITIAL SETTINGS>
0   NODE LINK   FLOW    SAT  DEGREE  TOTAL      TOTAL  -------- DELAY --------  AVERAGE   UNIFORM   MAX BACK  QUEUE    FUEL  PHASE  LINK
     NO   NO            FLOW OF SAT  TRAVEL     TIME   UNIFORM  RANDOM   TOTAL   DELAY     STOPS    OF QUEUE CAPACITY CONSUM LENGTH  NO
             (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)     (VEH-H/H)          (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK) (GA/H) (SEC)

      1  101    130  1300    41      .00      .77      .70     .07     .77    21.3   101.2( 78%)    2    >    0     1.12    22    101
      1  103    290  2900    41   142.72     5.48     1.38     .07    1.45    18.1   176.9( 61%)    3       208     7.84    22    103
      1  105    290  2900    19      .00      .58      .57     .01     .58     7.2   131.4( 45%)    3    >    0     1.15    40    105
      1  107    290  2900    19      .00      .58      .57     .01     .58     7.2   131.4( 45%)    3    >    0     1.15    40    107
0     1 :      1000   MAX =  41   142.72     7.41     3.22     .17    3.38    12.2   540.8( 54%)                     11.26 PI =    6.4

      2  201    290  2900    41   142.72     5.72     1.61     .07    1.69    20.9   242.5( 84%)    4       208     8.51    22    201
      2  203    290  2900    41   142.72     5.52     1.42     .07    1.49    18.6   193.8( 67%)    4       208     8.00    22    203
      2  205    290  2900    19   307.60     9.26      .56     .01     .57     7.1   122.3( 42%)    2       448    13.02    40    205
      2  207    130  1300    19      .00      .27      .26     .01     .27     7.5    59.8( 46%)    1    >    0      .53    40    207
0     2 :      1000   MAX =  41   593.03    20.77     3.86     .17    4.03    14.5   618.4( 62%)                     30.06 PI =    7.5

      3  301    290  2900    26   142.72     5.58     1.53     .02    1.55    19.3   226.6( 78%)    4       208     8.29    31    301
      3  303    290  2900    26      .00     1.05     1.03     .02    1.05    13.1   181.9( 63%)    3    >    0     1.78    31    303
      3  305    290  2900    26   236.24     7.65      .96     .02     .98    12.2   181.8( 63%)    3       344    11.07    31    305
      3  307    130  1300    26      .00      .48      .46     .02     .48    13.4    81.5( 63%)    1    >    0      .81    31    307
0     3 :      1000   MAX =  26   378.96    14.77     3.98     .09    4.07    14.7   671.8( 67%)                     21.94 PI =    7.8

      4  401    290  2900    26   307.60     9.66      .95     .02     .98    12.1   178.8( 62%)    3       448    13.75    31    401
      4  403    290  2900    26      .00     1.04     1.02     .02    1.04    12.9   181.3( 63%)    3    >    0     1.77    31    403
      4  405    290  2900    26      .00     1.04     1.02     .02    1.04    12.9   181.3( 63%)    3    >    0     1.77    31    405
      4  407    290  2900    26   236.24     7.64      .95     .02     .97    12.0   161.6( 56%)    3       344    10.91    31    407
0     4 :      1160   MAX =  26   543.84    19.38     3.94     .09    4.03    12.5   702.8( 61%)                     28.19 PI =    7.9

                                <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0   TOTAL       TOTAL     TOTAL     TOTAL     TOTAL     AVERAGE      TOTAL       TOTAL
  DISTANCE     TRAVEL    UNIFORM   RANDOM     DELAY     DELAY       UNIFORM      FUEL    PERFORMANCE   SPEED
  TRAVELED      TIME      DELAY    DELAY                             STOPS      CONSUM      INDEX
 (VEH-MI/H)  (VEH-H/H)  (VEH-H/H) (VEH-H/H)  (VEH-H/H)  (SEC/VEH)   (VEH/H-%)    (GA/H)                (MI/H)

0   1658.54     62.34     14.99       .51      15.51      13.42    2533.8( 61%)    91.44      29.59      29.35 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .10   62 SECOND CYCLE    60 STEPS
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0--- PROGRAM NOTE --- A CARD TYPE 51 CAUSES JOB TO BE EXECUTED AS A SIMULATION RUN,
                      DELETING ANY OPTIMIZATION VALUES INPUT.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   4 NODES AND  16 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
0--- PROGRAM NOTE --- THERE WERE A TOTAL OF   3 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .20   62 SECOND CYCLE    60 STEPS
0<PERFORMANCE WITH INITIAL SETTINGS>
0   NODE LINK   FLOW    SAT  DEGREE  TOTAL      TOTAL  -------- DELAY --------  AVERAGE   UNIFORM   MAX BACK  QUEUE    FUEL  PHASE  LINK
     NO   NO            FLOW OF SAT  TRAVEL     TIME   UNIFORM  RANDOM   TOTAL  DELAY      STOPS    OF QUEUE CAPACITY CONSUM LENGTH  NO
              (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)       (VEH-H/H)       (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

      1   101    260  1300    83       .00     2.50     1.57     .94    2.50   34.7   227.8( 88%)   4   >    0     3.09    22   101
      1   103    580  2900    83    285.43    12.27     3.25     .96    4.22   26.2   433.5( 75%)   9      208    17.24    22   103
      1   105    580  2900    38       .00     1.38     1.33     .06    1.38    8.6   300.5( 52%)   6   >    0     2.67    40   105
      1   107    580  2900    38       .00     1.38     1.33     .06    1.38    8.6   300.5( 52%)   6   >    0     2.67    40   107
0     1 :       2000   MAX =  83    285.43    17.55     7.47    2.02    9.49   17.1  1262.2( 63%)                 25.69 PI =  16.5

      2   201    580  2900    83    285.43    12.47     3.45     .96    4.42   27.4   529.6( 91%)   9      208    18.13    22   201
      2   203    580  2900    83    285.43    12.29     3.27     .96    4.23   26.3   462.9( 80%)   9      208    17.48    22   203
      2   205    580  2900    38    615.19    18.70     1.27     .06    1.33    8.3   276.9( 48%)   5      448    26.42    40   205
      2   207    260  1300    38       .00      .64      .59     .06     .64    8.9   134.3( 52%)   3   >    0     1.21    40   207
0     2 :       2000   MAX =  83   1186.06    44.11     8.58    2.04   10.62   19.1  1403.8( 70%)                 63.25 PI =  18.4

      3   301    580 .2900    52    285.43    11.57     3.38     .14    3.51   21.8   498.3( 86%)   9      208    17.23    31   301
      3   303    580  2900    52       .00     2.46     2.32     .14    2.46   15.3   409.1( 71%)   7   >    0     4.06    31   303
      3   305    580  2900    52    472.48    15.66     2.18     .14    2.32   14.4   409.8( 71%)   7      344    22.76    31   305
      3   307    260  1300    52       .00     1.18     1.04     .14    1.18   16.3   183.4( 71%)   3   >    0     1.88    31   307
0     3 :       2000   MAX =  52    757.91    30.87     8.92     .55    9.47   17.0  1500.7( 75%)                 45.93 PI =  17.8

      4   401    580  2900    52    615.19    19.59     2.09     .14    2.22   13.8   399.3( 69%)   7      448    28.02    31   401
      4   403    580  2900    52       .00     2.43     2.30     .14    2.43   15.1   407.2( 70%)   7   >    0     4.03    31   403
      4   405    580  2900    52       .00     2.43     2.30     .14    2.43   15.1   407.2( 70%)   7   >    0     4.03    31   405
      4   407    580  2900    52    472.48    15.56     2.08     .14    2.22   13.8   365.9( 63%)   7      344    22.35    31   407
0     4 :       2320   MAX =  52   1087.67    40.02     8.76     .55    9.31   14.5  1579.5( 68%)                 58.43 PI =  18.1

                                   <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL        TOTAL      TOTAL       TOTAL       TOTAL     AVERAGE        TOTAL         TOTAL
   DISTANCE      TRAVEL     UNIFORM     RANDOM       DELAY      DELAY        UNIFORM         FUEL     PERFORMANCE   SPEED
   TRAVELED       TIME       DELAY       DELAY                                STOPS         CONSUM       INDEX
   (VEH-MI/H)   (VEH-H/H)   (VEH-H/H)   (VEH-H/H)   (VEH-H/H)  (SEC/VEH)    (VEH/H-%)       (GA/H)                 (MI/H)

0   3317.08      132.55      33.73        5.16       38.89      16.83     5746.2( 69%)     193.29       70.82      28.08 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .20   62 SECOND CYCLE    60 STEPS
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```
0--- PROGRAM NOTE --- A CARD TYPE 51 CAUSES JOB TO BE EXECUTED AS A SIMULATION RUN,
                      DELETING ANY OPTIMIZATION VALUES INPUT.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   4 NODES AND  16 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
0--- PROGRAM NOTE --- THERE WERE A TOTAL OF   3 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S= .40    62 SECOND CYCLE    60 STEPS
0<PERFORMANCE WITH INITIAL SETTINGS>
0    NODE LINK    FLOW    SAT   DEGREE  TOTAL      TOTAL   -------- DELAY ---- ---  AVERAGE   UNIFORM   MAX BACK  QUEUE     FUEL  PHASE  LINK
      NO   NO            FLOW  OF SAT  TRAVEL      TIME   UNIFORM  RANDOM   TOTAL   DELAY     STOPS    OF QUEUE CAPACITY CONSUM LENGTH  NO
                (VEH/H)(VEH/H)  (%)  (VEH-MI/H)(VEH-H/H)          (VEH-H/H)        (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

       1  101     520  1300   165*       .00    109.34     6.22  103.12  109.34  757.0   314.5( 60%)   15    >    0   81.82    22    101
       1  103    1160  2900   165*    570.87    252.82     7.13  229.57  236.70  734.6   695.3( 60%)   24       208  200.35    22    103
       1  105    1160  2900    75        .00      4.17     3.61     .57    4.17   12.9   810.7( 70%)   15    >    0    7.53    40    105
       1  107    1160  2900    75        .00      4.17     3.61     .57    4.17   12.9   810.7( 70%)   15    >    0    7.53    40    107
0      1 :       4000    MAX = 165*   570.87    370.51    20.56  333.83  354.39  318.9  2631.1( 66%)                   297.24 PI =  369.0

       2  201    1160  2900   165*    570.87    253.52     7.82  229.57  237.40  736.8   701.6( 60%)   22       208  200.91    22    201
       2  203    1160  2900   165*    570.87    256.92    11.23  229.57  240.80  747.3   701.6( 60%)   27       208  203.40    22    203
       2  205    1160  2900    75    1230.39     38.31     3.04     .57    3.61   11.2   687.6( 59%)   13       448   54.56    40    205
       2  207     520  1300    75        .00      2.13     1.57     .56    2.13   14.8   357.5( 69%)    7    >    0    3.54    40    207
0      2 :       4000    MAX = 165*  2372.12    550.91    23.66  460.28  483.94  435.5  2448.3( 61%)                   462.41 PI =  497.5

       3  301    1160  2900   103*    570.87     45.23     4.76   24.36   29.12   90.4   746.6( 64%)   13       208   48.71    31    301
       3  303    1160  2900   103*       .00     31.13     6.77   24.36   31.13   96.6  1079.0( 93%)   38    >    0   28.76    31    303
       3  305    1160  2900   103*    944.96     56.49     5.46   24.36   29.81   92.5  1001.3( 86%)   18       344   65.36    31    305
       3  307     520  1300   103*       .00     15.93     2.89   13.04   15.93  110.3   483.7( 93%)   13    >    0   14.34    31    307
0      3 :       4000    MAX = 103*  1515.82    148.78    19.88   86.10  105.98   95.4  3310.6( 83%)                   157.16 PI =  124.4

       4  401    1160  2900   103*   1230.39     63.45     4.35   24.36   28.71   89.1   837.2( 72%)   16       448   74.10    31    401
       4  403    1160  2900   103*       .00     30.68     6.32   24.36   30.68   95.2  1076.0( 93%)   26    >    0   28.41    31    403
       4  405    1160  2900   103*       .00     31.00     6.64   24.36   31.00   96.2  1076.0( 93%)   36    >    0   28.65    31    405
       4  407    1160  2900   103*    944.96     55.75     4.71   24.36   29.07   90.2   869.2( 75%)   16       344   63.80    31    407
0      4 :       4640    MAX = 103*  2175.35    180.88    22.03   97.42  119.46   92.7  3858.4( 83%)                   194.96 PI =  140.9

                                          <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL       TOTAL     TOTAL      TOTAL      TOTAL     AVERAGE       TOTAL        TOTAL
   DISTANCE      TRAVEL   UNIFORM     RANDOM     DELAY      DELAY       UNIFORM        FUEL    PERFORMANCE   SPEED
   TRAVELED      TIME      DELAY      DELAY                             STOPS        CONSUM      INDEX
   (VEH-MI/H)  (VEH-H/H) (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)    (VEH/H-%)      (GA/H)                (MI/H)

0   6634.16     1251.07     86.13     977.63    1063.76     230.14    12248.5( 74%)   1111.77    1131.81       6.49 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---SIMULATION RUN OF THE EXISTING SIGNAL FOR V/S  .40   62 SECOND CYCLE    60 STEPS
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APPENDIX-5

TRANSYT-7F OPTIMIZATION RUNS FOR THE STUDY CASE-II, IN CIREBON, INDONESIA

NOTE :

- Optimization runs were established for traffic volume variation of .10*S*; .20*S*; .30*S*; and .40*S*.

- A set of output is presented for traffic - volume of .30*S*.

- Only the system-wide performances are presented for traffic volumes of .10*S*; .20*S*; and .40*S*.

```
1           T R A N S Y T - 7.F  --  T R A F F I C   S I G N A L   S Y S T E M   O P T I M I Z A T I O N   P R O G R A M
0RELEASE 4  JUNE, 1984                                                                                                    VERSION 2.0
0SPONSORED BY:                                                                                 DEVELOPED BY:
 FEDERAL HIGHWAY ADMINISTRATION                                                                TRANSPORT AND ROAD RESEARCH LABORATORY
 OFFICE OF TRAFFIC OPERATIONS                                                                  UNITED KINGDOM AND
                                                                                               TRANSPORTAION RESEARCH CENTER
0                                    ------------------------------------------------------    UNIVERSITY OF FLORIDA
                                     I N P U T   D A T A   R E P O R T   F O R   R U N   1
                                     ------------------------------------------------------

0FIELDS:  1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16
         ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
0LINE                                                       RUN  TITLE  CARD
  NO.     TITLE
0  1)     RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30
0                                                  NETWORK  CONTROL  CARD
                                         SEC/    SEC/
 LINE    CARD     MIN     MAX   CYCLE    STEP    STEP    LOST   GREEN    STOP  OUTPUT INITIAL  PERIOD  SEC(0)  SPD(0) ENGL(0)   PUNCH
  NO.    TYPE   CYCLE   CYCLE   INCR.   CYCLE  NORMAL    TIME  EXTEN. PENALTY   LEVEL TIMINGS  LENGTH PERC(1) TIME(1) METR(1) DECK(1)

   2)       1      38      68       2       2       2       4       3      20       1       0       0       0       0       0       0
0+++ 114 +++ WARNING +
+                      INITIAL TIMING FLAG IS SET TO 1 FOR CYCLE RANGE EVALUATION.
0LINE    CARD                                      LIST  OF  NODES  TO  BE  OPTIMIZED
  NO.    TYPE

   3)       2       1       2       3       4       0       0       0       0       0       0       0       0       0       0       0
0                                                      SYSTEM  MASTER  DATA
 LINE    CARD  MASTER  DRF. CLEARANCES SYSTEM  EXTERNAL SYSTEM  FUEL    VEHICLE
  NO.    TYPE    NODE  YELLOW  ALL-RED SATFLOW  SPEED     PDF   FACTOR  LENGTH

   4)      10       1       0       0       0       0       0       0       0       0       0       0       0       0       0       0
```

```
0-----------------
 INTERSECTION    1
 -----------------
                                                        CONTROLLER  TIMING  DATA
 LINE   CARD    NODE  OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ........................................ DOUBLE
  NO.   TYPE     NO.  YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INT8    INT9   INT10   INT11  CYCLE

  5)     12      1       0       1      13       5      15       5       0       0       0       0       0       0       0      0
0                                                       PHASE  TIMING  DATA
 LINE   CARD    NODE    START  VARIAB. YELLOW ALL-RED  MINIM.                                                                  CONT.
  NO.   TYPE     NO.    INTVL   INTVL   INTVL   INTVL  SECS.   LINKS MOVING IN THIS PHASE ..............................       FLAG

  6)     21      1       1       1       2       0      18     101     103       0       0       0       0       0       0      0
  7)     22      1       3       3       4       0      20     105     107       0       0       0       0       0       0      0
0                                                           LINK  DATA
 LINE   CARD    LINK    LINK    SAT.   TOTAL  MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....    THIRD INPUT LINK....  QUEUE
  NO.   TYPE     NO.  LENGTH    FLOW    VOL.    VOL.    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT  CAP.

  8)     28     101      0     1300     390      0       0       0       0       0       0       0       0       0       0      0
  9)     28     103   2600     2900     870      0     203     522      35     205     174      35     207      78      35      0
 10)     28     105      0     2900     870      0       0       0       0       0       0       0       0       0       0      0
 11)     28     107      0     2900     870      0       0       0       0       0       0       0       0       0       0      0
0-----------------
 INTERSECTION    2
 -----------------
                                                        CONTROLLER  TIMING  DATA
 LINE   CARD    NODE  OFFSET/           INTERVAL DURATIONS (SECS. OR PERCENT) ........................................ DOUBLE
  NO.   TYPE     NO.  YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INT8    INT9   INT10   INT11  CYCLE

 12)     12      2      34       1      15       5      13       5       0       0       0       0       0       0       0      0
0                                                       PHASE  TIMING  DATA
 LINE   CARD    NODE    START  VARIAB. YELLOW ALL-RED  MINIM.                                                                  CONT.
  NO.   TYPE     NO.    INTVL   INTVL   INTVL   INTVL  SECS.   LINKS MOVING IN THIS PHASE ..............................       FLAG

 13)     21      2       1       1       2       0      20     201     203       0       0       0       0       0       0      0
 14)     22      2       3       3       4       0      18     205     207       0       0       0       0       0       0      0
0                                                           LINK  DATA
 LINE   CARD    LINK    LINK    SAT.   TOTAL  MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....    THIRD INPUT LINK....  QUEUE
  NO.   TYPE     NO.  LENGTH    FLOW    VOL.    VOL.    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT  CAP.

 15)     28     201   2600     2900     870      0     101     234      35     105     174      35     107     174      35      0
 16)     28     203   2600     2900     870      0     303     522      35     305     174      35     307      78      35      0
 17)     28     205   5600     2900     870      0     403     522      35     405     174      35     407     174      35      0
 18)     28     207      0     1300     390      0       0       0       0       0       0       0       0       0       0      0
```

```
0-------------------
 INTERSECTION     3
 -------------------
1RUN TITLE:  RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30

 FIELDS:  1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16
         ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
                                                        CONTROLLER  TIMING  DATA
 LINE    CARD    NODE   OFFSET/         INTERVAL DURATIONS (SECS. OR PERCENT) ........................................... DOUBLE
  NO.    TYPE     NO.   YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INTR    INT9   INT10   INT11  CYCLE

  19)     12       3      34       1      15       5      13       5       0       0       0       0       0       0       0       0
0                                                               PHASE  TIMING  DATA
 LINE    CARD    NODE    START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                CONT.
  NO.    TYPE     NO.    INTVL   INTVL   INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ..............................  FLAG

  20)     21       3       1       1       2       0      20     301     303       0       0       0       0       0       0       0
  21)     22       3       3       3       4       0      18     305     307       0       0       0       0       0       0       0
0                                                                  LINK  DATA
 LINE    CARD    LINK    LINK     SAT.   TOTAL  MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....   THIRD  INPUT LINK....  QUEUE
  NO.    TYPE     NO.   LENGTH    FLOW    VOL.    VOL.     NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT  CAP.

  22)     28     301    2600    2900     870       0     201     522      35     205     174      35     207      78      35       0
  23)     28     303       0    2900     870       0       0       0       0       0       0       0       0       0       0       0
  24)     28     305    4300    2900     870       0     401     174      35     403     174      35     405     522      35       0
  25)     28     307       0    1300     390       0       0       0       0       0       0       0       0       0       0       0
0-------------------
 INTERSECTION     4
 -------------------
                                                        CONTROLLER  TIMING  DATA
 LINE    CARD    NODE   OFFSET/         INTERVAL DURATIONS (SECS. OR PERCENT) ........................................... DOUBLE
  NO.    TYPE     NO.   YLD.PT.  REF INT  INT1    INT2    INT3    INT4    INT5    INT6    INT7    INT8    INT9   INT10   INT11  CYCLE

  26)     12       4       6       1      14       5      14       5       0       0       0       0       0       0       0       0
0                                                               PHASE  TIMING  DATA
 LINE    CARD    NODE    START  VARIAB. YELLOW  ALL-RED  MINIM.                                                                CONT.
  NO.    TYPE     NO.    INTVL   INTVL   INTVL   INTVL   SECS.   LINKS MOVING IN THIS PHASE ..............................  FLAG

  27)     21       4       1       1       2       0      19     401     403       0       0       0       0       0       0       0
  28)     22       4       3       3       4       0      19     405     407       0       0       0       0       0       0       0
0                                                                  LINK  DATA
 LINE    CARD    LINK    LINK     SAT.   TOTAL  MID-BLK. FIRST INPUT LINK....    SECOND INPUT LINK....   THIRD  INPUT LINK....  QUEUE
  NO.    TYPE     NO.   LENGTH    FLOW    VOL.    VOL.     NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT    NO.    VOL.   SPD/TT  CAP.

  29)     28     401    5600    2900     870       0     201      78      35     203     174      35     207     522      35       0
  30)     28     403       0    2900     870       0       0       0       0       0       0       0       0       0       0       0
  31)     28     405       0    2900     870       0       0       0       0       0       0       0       0       0       0       0
  32)     28     407    4300    2900     870       0     301     174      35     303     174      35     307     234      35       0
0LINE    CARD                                           RUN  CARD
  NO.    TYPE

  33)     52       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
```

```
0--- PROGRAM NOTE --- A CARD TYPE 52 CAUSES RUN TO BE OPTIMIZED USING THE DEFAULT NORMAL OPTIMIZATION STEP SIZES.
                      IF CARD TYPE 4 WAS INPUT, IT IS IGNORED.
0                     THE ABOVE WILL BE PROCESSED AFTER THE "BEST" CYCLE LENGTH HAS BEEN SELECTED.
0--- PROGRAM NOTE --- NO ERRORS DETECTED. TRANSYT-7F NOW BEGINS FINAL PROCESSING.
                      IF ERRORS ARE DETECTED, FURTHER PROCESSING IS SUSPENDED.
0--- PROGRAM NOTE --- THERE ARE A TOTAL OF   4 NODES AND  16 LINKS (INCLUDING BOTTLENECKS, IF ANY) IN THIS RUN.
1RUN TITLE:  RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30

 FIELDS:  1       2       3   .   4       5       6       7       8       9      10      11      12      13      14      15      16
        ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----    ----
0--- PROGRAM NOTE --- THERE WERE A TOTAL OF    1 WARNING MESSAGES ISSUED IN THE ABOVE REPORT.
1RUN TITLE:  RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30

0                    ------------------------------------
                     CYCLE EVALUATION SUMMARY PERFORMANCE
                     ------------------------------------
0    CYCLE   STEP   AVERAGE  PERCENT     FUEL      PERFORMANCE  NUMBER
    LENGTH   SIZE    DELAY    STOPS   CONSUMPTION     INDEX    SATURATED
     (SEC) (STEPS) (SEC/VEH)   (%)      (GAL/HR)                 LINKS
0     38     19     19.93     77        304.1        122.8         6
0     40     20     16.54     77        295.1        110.7         0
0     42     21     16.51     78        296.1        111.5         0
0     44     22     15.76     77        292.9        107.8         0
0     46     23     16.07     78        295.2        110.0         0
0     48     24     15.71     77        293.1        107.8         0
0     50     25     16.18     77        294.1        109.5         0
0     52     26     15.99     76        292.8        108.1         0
0     54     27     16.32     76        293.5        109.2         0
0     56     28     16.32     76        293.5        109.1         0
0     58     29     16.72     76        294.7        110.7         0
0     60     30     16.48     75        293.2        109.1         0
0     62     31     17.22     74        294.6        111.3         0
0     64     32     17.43     74        295.0        111.9         0
0     66     33     17.60     74        295.1        112.2         0
0     68     34     17.85     74        295.7        113.0         0
```

```
     BEST CYCLE LENGTH =  48 SEC.   CYCLE SENSITIVITY =    3.2 %
0--- PROGRAM NOTE --- TRANSYT-7F OPTIMIZES THE SYSTEM USING THE BEST CYCLE LENGTH AND
                      HILL-CLIMB STEP SIZES AS INDICATED BY CARD TYPE 52.

1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS
0<PERFORMANCE WITH OPTIMAL SETTINGS>
0   NODE LINK    FLOW    SAT  DEGREE  TOTAL      TOTAL  -------- DELAY --------  AVERAGE   UNIFORM  MAX BACK  QUEUE     FUEL  PHASE   LINK
     NO   NO            FLOW  OF SAT  TRAVEL     TIME   UNIFORM  RANDOM    TOTAL  DELAY     STOPS   OF QUEUE CAPACITY CONSUM LENGTH  NO
                (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)        (VEH-H/H)       (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)


      1   101     390  1300     80       .00      2.14     1.35     .78     2.14   19.7    304.1( 78%)    4    >    0     3.24     24    101
      1   103     870  2900     80    428.15     15.75     2.87     .79     3.66   15.1    588.8( 68%)    9       208    23.44     24    103
      1   105     870  2900     80       .00      3.81     3.02     .79     3.81   15.8    678.4( 78%)   10    >    0     6.54     24    105
      1   107     870  2900     80       .00      3.81     3.02     .79     3.81   15.8    678.4( 78%)   10    >    0     6.54     24    107
0     1 :        3000   MAX =   80    428.15     25.51    10.26    3.16    13.42   16.1   2249.6( 75%)                     39.77 PI =    25.9

      2   201     870  2900     80    428.15     15.75     2.87     .79     3.66   15.2    615.3( 71%)    9       208    23.65     24    201
      2   203     870  2900     80    428.15     15.65     2.77     .79     3.56   14.7    689.7( 79%)   10       208    24.15     24    203
      2   205     870  2900     80    922.79     29.72     2.88     .79     3.67   15.2    651.8( 75%)    9       448    42.68     24    205
      2   207     390  1300     80       .00      2.14     1.35     .78     2.14   19.7    304.1( 78%)    4    >    0     3.24     24    207
0     2 :        3000   MAX =   80   1779.09     63.26     9.87    3.16    13.03   15.6   2260.9( 75%)                     93.72 PI =    25.6

      3   301     870  2900     80    428.15     15.48     2.60     .79     3.39   14.0    597.1( 69%)    9       208    23.31     24    301
      3   303     870  2900     80       .00      3.81     3.02     .79     3.81   15.8    678.4( 78%)   10    >    0     6.54     24    303
      3   305     870  2900     80    708.72     23.96     3.16     .79     3.95   16.3    672.1( 77%)    9       344    34.93     24    305
      3   307     390  1300     80       .00      2.14     1.35     .78     2.14   19.7    304.1( 78%)    4    >    0     3.24     24    307
0     3 :        3000   MAX =   80   1136.87     45.38    10.13    3.16    13.28   15.9   2251.6( 75%)                     68.02 PI =    25.8

      4   401     870  2900     80    922.79     29.71     2.86     .79     3.65   15.1    678.3( 78%)   10       448    42.87     24    401
      4   403     870  2900     80       .00      3.81     3.02     .79     3.81   15.8    678.4( 78%)   10    >    0     6.54     24    403
      4   405     870  2900     80       .00      3.81     3.02     .79     3.81   15.8    678.4( 78%)   10    >    0     6.54     24    405
      4   407     870  2900     80    708.72     23.76     2.96     .79     3.75   15.5    642.7( 74%)    9       344    34.55     24    407
0     4 :        3480   MAX =   80   1631.51     61.09    11.86    3.17    15.02   15.5   2677.7( 77%)                     90.50 PI =    29.9

1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS


                                         <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL         TOTAL     TOTAL      TOTAL      TOTAL     AVERAGE        TOTAL          TOTAL
   DISTANCE       TRAVEL    UNIFORM    RANDOM      DELAY      DELAY        UNIFORM          FUEL     PERFORMANCE   SPEED
   TRAVELED        TIME      DELAY      DELAY                               STOPS          CONSUM       INDEX
  (VEH-MI/H)    (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)     (VEH/H-%)       (GA/H)                 (MI/H)

0    4975.62       195.24      42.12      12.63      54.75      15.79     9439.8( 76%)     292.01       107.20      29.31 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS
```

```
0------------------------------------
 TRANSYT-7F SIGNAL CONTROLLER SETTINGS
 ------------------------------------


0------------------------------
 NETWORK-WIDE SIGNAL TIMING DATA
 ------------------------------
0SYSTEM CYCLE LENGTH =   48 SECONDS
0MASTER OFFSET REFERENCE LOCATION = INTERSECTION NO.    1
0ALL OFFSETS ARE REFERENCED TO THE START OF INTERVAL NO. 1 AT THIS SIGNAL.


 -------------------------------
 INTERSECTION CONTROLLER SETTINGS
 -------------------------------


 -----------------
 INTERSECTION     1
 -----------------
0INTERVAL  NUMBER :     1   2   3   4
0INTVL LENGTH(SEC):    19   5  19   5
0INTVL LENGTH  (%):    40  10  40  10
0PIN SETTINGS  (%): 100/0  40  50  90
0PHASE START (PH#):     1       2
0INTERVAL   TYPE  :     V   Y   V   Y
0LINKS  MOVING  :     101     105
                      103     107
0OFFSET =    0 SEC.   0 %.
0THIS IS THE MASTER CONTROLLER.
0+++ 193 +++ WARNING +
+                      THE OFFSET FALLS WITHIN 1% OF AN INTERVAL CHANGE POINT AT THE START OF INTERVAL NO  1.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS


 -----------------
 INTERSECTION     2
 -----------------
0INTERVAL  NUMBER :     1   2   3   4
0INTVL LENGTH(SEC):    19   5  19   5
0INTVL LENGTH  (%):    40  10  40  10
0PIN SETTINGS  (%): 100/0  40  50  90
0PHASE START (PH#):     1       2
0INTERVAL   TYPE  :     V   Y   V   Y
0LINKS  MOVING  :     201     205
                      203     207
0OFFSET =  12 SEC.  25 %.
```

```
 ------------------
 INTERSECTION     3
 ------------------
0INTERVAL  NUMBER :      1   2   3   4
0INTVL LENGTH(SEC):     19   5  19   5
0INTVL LENGTH  (%):     40  10  40  10
0PIN SETTINGS  (%): 100/0  40  50  90
0PHASE START (PH#):      1       2
0INTERVAL   TYPE  :      V   Y   V   Y
0LINKS  MOVING  :      301     305
                       303     307
0OFFSET =   6 SEC.  12 %.
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS


 ------------------
 INTERSECTION     4
 ------------------
0INTERVAL  NUMBER :      1   2   3   4
0INTVL LENGTH(SEC):     19   5  19   5
0INTVL LENGTH  (%):     40  10  40  10
0PIN SETTINGS  (%): 100/0  40  50  90
0PHASE START (PH#):      1       2
0INTERVAL   TYPE  :      V   Y   V   Y
0LINKS  MOVING  :      401     405
                       403     407
0OFFSET =  44 SEC.  92 %.



1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .30   48 SECOND CYCLE    24 STEPS
0LINE    CARD                                                  TERMINATION CARD
  NO.    TYPE
```

```
0--- PROGRAM NOTE --- THIS IS THE INPUT DATA REPORT FOR TIME-SPACE DIAGRAM NO.   1


0                                                      TIME-SPACE  DIAGRAM  DATA
 LINE    CARD     NO.    TIME    TIME   DIST.
  NO.    TYPE    NODES   FLAG   SCALE   SCALE

  34)     60       3       0       0     200       0       0       0       0       0       0       0       0       0       0       0
0LINE
  NO.     TITLE                                         PLOT  TITLE  CARD
0 35)        PLOT NODES : 01, 02, 03.
0                                                        PLOT  LINK  STREAM  CARD
 LINE    CARD    LINK PAIRS ALTERNATING BY DIRECTION
  NO.    TYPE    DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP     DOWN AND UP

  36)     61      103     101     203     201     303     301       0       0       0       0       0       0       0       0       0
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE EXISTING SIGNAL FOR V/S= .3  48 SECOND CYCLE    24 STEPS
```

```
0                                  < T R A N S Y T - 7 F   T I M E - S P A C E   D I A G R A M >
0                    PLOT NO.  1  PLOT TITLE:      PLOT NODES : 01, 02, 03.
0                    TIME AXIS IS IN: SEC           TIME SCALE =   3 SEC/CHAR,  DIST. SCALE =  200 FT/LINE
0                  1         2         3         4         5         6         7         8         9        10        11
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
          --------------------------------------------------------------------------------------------------------------
       1 :        ********        ********        ********        ********        ********        ********        ******     0 FT
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
       2 :****        ********        ********        ********        ********        ********        ********        ** 2600 FT
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
         :               :               :               :               :               :               :
       3 :**        ********        ********        ********        ********        ********        ********        **** 5200 FT
         :
          --------------------------------------------------------------------------------------------------------------
    NODE  12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890  DISTANCE
0         SCALE CONVERSIONS:                                   +++ GREEN IN DOWN DIRECTION                AVG. TIME DISPLACEMENT:
          TIME/INCH =  3 * 10 (AT 10 CHAR/INCH)                    GREEN IN BOTH DIRECTIONS                 590.91 / SPEED
          DIST/INCH = 200 * 6 (AT 6 LINES/INCH)                --- GREEN IN UP   DIRECTION
                                                               *** RED   IN BOTH DIRECTIONS
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE EXISTING SIGNAL FOR V/S= .3  48 SECOND CYCLE    24 STEPS
OLINE    CARD                                                  TERMINATION CARD
  NO.    TYPE

 37)      90       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0--- PROGRAM NOTE --- END OF JOB!
```

```
     BEST CYCLE LENGTH =  36 SEC.   CYCLE SENSITIVITY =   2.2 %
0--- PROGRAM NOTE --- TRANSYT-7F OPTIMIZES THE SYSTEM USING THE BEST CYCLE LENGTH AND
                      HILL-CLIMB STEP SIZES AS INDICATED BY CARD TYPE 52.

1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]--OPTIMIZATION RUN OF THE EXISTING SIGNAL FOR V/S= .10  36 SECOND CYCLE    18 STEPS
0<PERFORMANCE WITH OPTIMAL SETTINGS>
0   NODE LINK   FLOW   SAT  DEGREE  TOTAL     TOTAL  -------- DELAY --------  AVERAGE   UNIFORM  MAX BACK  QUEUE    FUEL  PHASE  LINK
     NO   NO          FLOW  OF SAT  TRAVEL    TIME   UNIFORM  RANDOM   TOTAL  DELAY     STOPS   OF QUEUE CAPACITY CONSUM LENGTH  NO
               (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)      (VEH-H/H)        (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

     1  101    130  1300    36       .00      .40      .35      .05     .40   11.0    87.3( 67%)   1    >    0     .77    16   101
     1  103    290  2900    36    142.72     4.81      .73      .05     .78    9.7   195.3( 67%)   2       208    7.49    16   103
     1  105    290  2900    26       .00      .57      .55      .02     .57    7.1   162.6( 56%)   2    >    0    1.31    20   105
     1  107    290  2900    26       .00      .57      .55      .02     .57    7.1   162.6( 56%)   2    >    0    1.31    20   107
0    1 :      1000   MAX =  36    142.72     6.35     2.17      .15    2.32    8.3   607.7( 61%)                   10.89 PI =   5.7

     2  201    290  2900    26    142.72     4.55      .50      .02     .52    6.5   149.3( 51%)   2       208    6.94    20   201
     2  203    290  2900    26    142.72     4.59      .54      .02     .56    6.9   156.8( 54%)   2       208    7.03    20   203
     2  205    290  2900    36    307.60     9.49      .76      .05     .81   10.0   194.7( 67%)   2       448   13.75    16   205
     2  207    130  1300    36       .00      .40      .35      .05     .40   11.0    87.3( 67%)   1    >    0     .77    16   207
0    2 :      1000   MAX =  36    593.03    19.03     2.14      .15    2.28    8.2   588.2( 59%)                   28.49 PI =   5.6

     3  301    290  2900    26    142.72     4.55      .50      .02     .52    6.5   146.0( 50%)   2       208    6.92    20   301
     3  303    290  2900    26       .00      .57      .55      .02     .57    7.1   162.6( 56%)   2    >    0    1.31    20   303
     3  305    290  2900    36    236.24     7.46      .74      .05     .79    9.8   194.5( 67%)   2       344   11.03    16   305
     3  307    130  1300    36       .00      .40      .35      .05     .40   11.0    87.3( 67%)   1    >    0     .77    16   307
0    3 :      1000   MAX =  36    378.96    12.98     2.13      .15    2.28    8.2   590.4( 59%)                   20.03 PI =   5.6

     4  401    290  2900    30    307.60     9.36      .64      .03     .67    8.4   169.7( 59%)   2       448   13.46    18   401
     4  403    290  2900    30       .00      .69      .65      .03     .69    8.5   178.7( 62%)   2    >    0    1.49    18   403
     4  405    290  2900    30       .00      .69      .65      .03     .69    8.5   178.7( 62%)   2    >    0    1.49    18   405
     4  407    290  2900    30    236.24     7.35      .65      .03     .68    8.5   178.5( 62%)   2       344   10.83    18   407
0    4 :      1160   MAX =  30    543.84    18.08     2.60      .13    2.73    8.5   705.6( 61%)                   27.26 PI =   6.6

1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]--OPTIMIZATION RUN OF THE EXISTING SIGNAL FOR V/S= .10  36 SECOND CYCLE    18 STEPS

                                   <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL        TOTAL     TOTAL      TOTAL      TOTAL     AVERAGE        TOTAL        TOTAL
   DISTANCE      TRAVEL    UNIFORM    RANDOM      DELAY      DELAY        UNIFORM        FUEL     PERFORMANCE   SPEED
   TRAVELED       TIME      DELAY      DELAY                               STOPS        CONSUM       INDEX
  (VEH-MI/H)   (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)     (VEH/H-%)      (GA/H)                (MI/H)

0   1658.54      56.43       9.04        .57       9.61       8.31      2491.8( 60%)     86.67       23.45      31.79 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]--OPTIMIZATION RUN OF THE EXISTING SIGNAL FOR V/S= .10  36 SECOND CYCLE    18 STEPS
```

```
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .20   38 SECOND CYCLE     19 STEPS
0<PERFORMANCE WITH OPTIMAL SETTINGS>
0   NODE LINK   FLOW   SAT  DEGREE  TOTAL      TOTAL   -------- DELAY --------  AVERAGE   UNIFORM  MAX BACK  QUEUE     FUEL  PHASE  LINK
     NO   NO           FLOW  OF SAT TRAVEL     TIME   UNIFORM  RANDOM    TOTAL  DELAY     STOPS   OF QUEUE CAPACITY CONSUM LENGTH  NO
             (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)      (VEH-H/H)         (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)



        1  101     260  1300    63       .00      1.01      .74      .27     1.01   14.0    190.3( 73%)   2   >    0    1.79    18    101
        1  103     580  2900    63    285.43      9.81     1.48      .27     1.75   10.9    383.4( 66%)   5      208   15.05    18    103
        1  105     580  2900    54       .00      1.56     1.40      .16     1.56    9.7    388.3( 67%)   5   >    0    3.29    20    105
        1  107     580  2900    54       .00      1.56     1.40      .16     1.56    9.7    388.3( 67%)   5   >    0    3.29    20    107
0       1 :       2000   MAX =  63    285.43     13.94     5.02      .87     5.88   10.6   1350.4( 68%)                   23.42 PI =   13.4

        2  201     580  2900    54    285.43      9.56     1.34      .16     1.51    9.3    391.2( 67%)   4      208   14.93    20    201
        2  203     580  2900    54    285.43      9.49     1.27      .16     1.43    8.9    328.8( 57%)   4      208   14.39    20    203
        2  205     580  2900    63    615.19     19.23     1.59      .27     1.87   11.6    406.4( 70%)   5      448   27.81    18    205
        2  207     260  1300    63       .00      1.01      .74      .27     1.01   14.0    190.3( 73%)   2   >    0    1.79    18    207
0       2 :       2000   MAX =  63   1186.06     39.30     4.94      .87     5.81   10.5   1316.8( 66%)                   58.93 PI =   13.1

        3  301     580  2900    54    285.43      9.49     1.27      .16     1.43    8.9    329.8( 57%)   4      208   14.40    20    301
        3  303     580  2900    54       .00      1.56     1.40      .16     1.56    9.7    388.3( 67%)   5   >    0    3.29    20    303
        3  305     580  2900    63    472.48     15.19     1.58      .27     1.85   11.5    404.0( 70%)   5      344   22.37    18    305
        3  307     260  1300    63       .00      1.01      .74      .27     1.01   14.0    190.3( 73%)   2   >    0    1.79    18    307
0       3 :       2000   MAX =  63    757.91     27.26     4.99      .87     5.86   10.5   1312.4( 66%)                   41.86 PI =   13.1

        4  401     580  2900    58    615.19     19.17     1.60      .21     1.80   11.2    427.4( 74%)   5      448   27.93    19    401
        4  403     580  2900    58       .00      1.86     1.65      .21     1.86   11.5    424.6( 73%)   5   >    0    3.71    19    403
        4  405     580  2900    58       .00      1.73     1.53      .21     1.73   10.7    398.1( 69%)   5   >    0    3.47    19    405
        4  407     580  2900    58    472.48     14.99     1.44      .21     1.65   10.2    378.3( 65%)   4      344   22.02    19    407
0       4 :       2320   MAX =  58   1087.67     37.75     6.22      .82     7.04   10.9   1628.3( 70%)                   57.13 PI =   16.1
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .20   38 SECOND CYCLE     19 STEPS

                              <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL        TOTAL     TOTAL      TOTAL      TOTAL     AVERAGE       TOTAL        TOTAL
    DISTANCE      TRAVEL    UNIFORM    RANDOM     DELAY      DELAY       UNIFORM        FUEL    PERFORMANCE   SPEED
    TRAVELED      TIME      DELAY      DELAY                             STOPS        CONSUM       INDEX
   (VEH-MI/H)   (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (VEH-H/H)  (SEC/VEH)   (VEH/H-%)      (GA/H)                (MI/H)

0    3317.08       118.25     21.18       3.42      24.59      10.64     5607.9( 67%)     181.35       55.75       31.02 <TOTALS>
1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .20   38 SECOND CYCLE     19 STEPS
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1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .40   88 SECOND CYCLE    44 STEPS
0<PERFORMANCE WITH OPTIMAL SETTINGS>
0   NODE LINK   FLOW    SAT  DEGREE  TOTAL      TOTAL   -------- DELAY -------- AVERAGE   UNIFORM  MAX BACK  QUEUE     FUEL  PHASE  LINK
     NO   NO            FLOW OF SAT  TRAVEL     TIME   UNIFORM  RANDOM    TOTAL  DELAY     STOPS   OF QUEUE CAPACITY CONSUM LENGTH  NO
              (VEH/H)(VEH/H) (%)  (VEH-MI/H)(VEH-H/H)      (VEH-H/H)           (SEC/VEH) (VEH/H;%) (VEH/LK)(VEH/LK)  (GA/H) (SEC)

      1   101    520  1300    93        .00      5.82     3.28     2.54     5.82   40.3   454.6( 87%)   12    >    0    6.78    44   101
      1   103   1160  2900    93     570.87     24.50     5.66     2.72     8.39   26.0   922.6( 80%)   25       208   34.88    44   103
      1   105   1160  2900    93        .00     10.05     7.32     2.72    10.05   31.2  1014.1( 87%)   26    >    0   12.96    44   105
      1   107   1160  2900    93        .00     10.05     7.32     2.72    10.05   31.2  1014.1( 87%)   26    >    0   12.96    44   107
0     1 :       4000   MAX =  93     570.87     50.42    23.59    10.71    34.30   30.9  3405.5( 85%)                    67.59 PI =  53.2

      2   201   1160  2900    93     570.87     26.74     7.90     2.72    10.62   33.0  1060.0( 91%)   27       208   37.58    44   201
      2   203   1160  2900    93     570.87     24.59     5.74     2.72     8.47   26.3   957.1( 83%)   26       208   35.21    44   203
      2   205   1160  2900    93    1230.39     45.24     7.77     2.72    10.50   32.6   997.5( 86%)   25       448   62.00    44   205
      2   207    520  1300    93        .00      5.82     3.28     2.54     5.82   40.3   454.6( 87%)   12    >    0    6.78    44   207
0     2 :       4000   MAX =  93    2372.12    102.39    24.70.   10.71    35.41   31.9  3469.2( 87%)                   141.57 PI =  54.7

      3   301   1160  2900    93     570.87     24.45     5.61     2.72     8.33   25.9   882.9( 76%)   24       208   34.54    44   301
      3   303   1160  2900    93        .00     10.05     7.32     2.72    10.05   31.2  1014.1( 87%)   26    >    0   12.96    44   303
      3   305   1160  2900    93     944.96     36.03     6.63     2.72     9.35   29.0   963.4( 83%)   25       344   50.08    44   305
      3   307    520  1300    93        .00      5.82     3.28     2.54     5.82   40.3   454.6( 87%)   12    >    0    6.78    44   307
0     3 :       4000   MAX =  93    1515.82     76.35    22.84    10.71    33.56   30.2  3315.0( 83%)                   104.36 PI =  52.0

      4   401   1160  2900    93    1230.39     44.04     6.58     2.72     9.30   28.9  1015.7( 88%)   26       448   61.26    44   401
      4   403   1160  2900    93        .00     10.05     7.32     2.72    10.05   31.2  1014.1( 87%)   26    >    0   12.96    44   403
      4   405   1160  2900    93        .00     10.05     7.32     2.72    10.05   31.2  1014.1( 87%)   26    >    0   12.96    44   405
      4   407   1160  2900    93     944.96     36.13     6.73     2.72     9.45   29.3   945.4( 81%)   25       344   50.01    44   407
0     4 :       4640   MAX =  93    2175.35    100.26    27.95    10.89    38.85   30.1  3989.4( 86%)                   137.20 PI =  61.0

1TRANSYT-7F: RUN---[SS/CI.NTW/T7F/CH99]---OPTIMIZATION RUN OF THE SIGNAL TIMING FOR V/S= .40   88 SECOND CYCLE    44 STEPS

                                   <SYSTEM WIDE TOTALS INCLUDING ALL LINKS>

0    TOTAL       TOTAL     TOTAL      TOTAL      TOTAL    AVERAGE      TOTAL        TOTAL
    DISTANCE     TRAVEL   UNIFORM    RANDOM      DELAY     DELAY      UNIFORM        FUEL   PERFORMANCE   SPEED
    TRAVELED      TIME     DELAY      DELAY                            STOPS        CONSUM     INDEX
   (VEH-MI/H)  (VEH-H/H) (VEH-H/H) (VEH-H/H)  (VEH-H/H)  (SEC/VEH)   (VEH/H-%)      (GA/H)      -        (MI/H)

0    6634.16     329.43     99.09     43.03     142.12      30.75    14179.1( 85%)   450.72     220.89      25.35 <TOTALS>
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