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COMPARATIVE ASSESSMENT OF COMPUTER PROGRAMS FOR TRAFFIC SIGNAL PLANNING, DESIGN, AND OPERATIONS

Volume I
Study Approach, Analysis, and Recommendations

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16. ABSTRACT

The main goal of this study was to comparatively assess a group of selected computer programs for traffic signal planning, design, and operations. A comprehensive inventory was conducted and a detailed list of the currently available computer software was developed. A short description of individual software was provided, and a comparative processor software, and network software. The final recommendation of software included seven programs for isolated intersections, three preprocessor software, and five network software.

Volume 1 Study Approach, Analysis and Recommendations
Volume 2 Software Descriptions
Volume 3 Recommended Software Output

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EXECUTIVE SUMMARY

Capacity analysis of signalized intersections and the development of signal timing plans are two significant traffic engineering activities. Analysis and design techniques of signals have been fully developed and tested by numerous agencies, and computer software programs have been developed to facilitate the analysis and design processes. With the advancement in microcomputer technology, large numbers of software programs have become available to the user community. The main goal of this research project was to comparatively assess a group of selected computer programs for traffic signal planning, design, and operations.

A comprehensive inventory was conducted and a detailed list of currently available computer software pertaining to this study was developed (documented in Volume 1). A total of 35 programs were selected covering the following categories: 1) Isolated Intersections, 2) Arterial Streets, 3) Diamond Interchanges, and 4) Grid Networks. A short description of individual software programs was provided, and a comparative assessment was performed.

Seven programs are recommended for isolated intersections. CAPCALC 85 and SIGNAL 85 are recommended for use as a capacity analysis tool using the 1985 Highway Capacity Manual procedures. CAPCALC and EZ-POSIT are recommended if the user wishes to perform the Critical Movement Analysis method of the Transportation Research Board (Circular 212 report). For those who are still interested in performing analyses documented in the 1965 Highway Capacity Manual, the SIGNAL program is recommended. As for the SOAP software group, SIAP and SOAP 84 are recommended.

Three preprocessor software are recommended, namely EDBAND, EZ-TRANSYT, and PASSETUP. They are preprocessors for the MAXBAND, TRANSYT-7F, and PASSER II-84, respectively.

As for the network software, PASSER II-84, TW-BANDWIDTH, TRANSYT-7F, and TW-SIGOP are recommended. PASSER II-84 and TW-BANDWIDTH (microcomputer version of MAXBAND) are recommended for arterial optimization, while TRANSYT-7F and TW-SIGOP (microcomputer version of SIGOP III) are recommended for grid network optimization. NETSIM is recommended for microscopic computer simulation.

INTRODUCTION

The traffic engineering field has experienced significant advancements in the development of computer models to solve numerous traffic operation and management problems. These models covered a wide spectrum of applications such as signal timing, capacity analysis, freeway operation, bus transit on urban streets, and environmental issues.

Although the research and development of traffic computer models have resulted in a respectable number of application models, practicing traffic engineers have not fully utilized the resources made available to them. Some of the reasons for this are unfamiliarity with existing models, lack of computer hardware, unfamiliarity with software and hardware interaction, difficulty in obtaining the software, and the misconception that the user has to have solid background about computer science and mathematical theories.

The models that were developed, up until four years ago, were basically designed for mainframe computers. The advent of the microcomputer in recent years resulted in several major changes in the user community. First, more engineers are able, at virtually any location, to access microcomputers or super-minicomputers. Second, with the fast advancements in the microcomputer industry, more machines are being made with larger memory and higher execution speed. Third, the different operating systems (PC-DOS, MS-DOS, P-System, CPM, UNIX, etc.) that are available on microcomputers permit the programmer and the user to run programs interactively with less complications, a feature that mainframe computers lack. Therefore, the ''fear'' of computers that most users used to have is being reduced. Programs on the microcomputers are becoming friendlier and more forgiving than before.

This has resulted in the development of a large number of application software programs to keep pace with the advancement of the hardware. Furthermore, almost all computer models that were developed for mainframe computers are downloaded to microcomputers. With all these changes, it became apparent that a software information system would be advantageous to the user community.

BACKGROUND INFORMATION

The field of traffic engineering has witnessed significant developments in the use of computer models as analytical tools for evaluating various traffic engineering projects (1). A large number of the published documentations are limited to either special software developed for solving a specific problem or a report resulted from theoretical work conducted towards a dissertation for a doctoral degree.

Recent developments and advancements in traffic computer modeling have provided the practicing engineer with the opportunity to evaluate different traffic operational strategies using the traditional methods. The practicing engineer has to be thoroughly familiar with the use and the benefits of using computer models so he/she can effectively utilize the model to its fullest potential. The Federal Highway Administration (FHWA) realized the need for such information, and the lack of documentation addressing this issue. A project was initiated by the office of Implementation of the FHWA to develop a Handbook of Computer Models for Traffic Operation Analysis (2). The Handbook provided excellent sources of information related to computer models which are available for developing and evaluating practical, day-to-day, transportation management problems. It permits the reader to understand the more significant models and to select those models which would be most beneficial considering the capability of available personnel and equipment. The Handbook included ten models which covered signal timing, arterial bus simulation, and freeway simulation. At the time the Handbook was developed, few microcomputer software programs were available, and therefore the assessment was limited to mainframe software.

As microcomputers became popular, the FHWA realized the need for user groups. Four federally-sponsored national user groups were formed for transportation professionals. One of these four, the Safety and Traffic Engineering Applications for Microcomputers (STEAM), was formed to provide a medium for practicing traffic engineers to learn more about microcomputers, meet more experienced users who could help with hardware and software selection, and obtain public domain software. One significant outcome from this effort was the development of the ''Software and Source Book'' published by the Urban Mass Transit Administration (3). The Federal Highway Administration (FHWA) combined all the federally-sponsored national user groups to new microcomputer user support center at the University of Florida Transportation Research Center, effective July 14, 1986. The new service is called the Center for Microcomputers in Transportation (McTrans).

This documentation contains information pertaining to: 1) Microcomputer references and training, and 2) descriptions of software in the areas of transit operations, transportation planning, traffic engineering, and paratransit planning and operations.

A recent study was aimed at determining the effectiveness of computer programs designed to optimize traffic signal timing (4). The specific programs evaluated were MAXBAND, SIGOP-III, and TRANSYT-7F (Release 2). Data was collected in three cities (Lawrence, Kansas; Overland Park, Kansas; and Davenport, Iowa). The results indicated that none of the programs was the best under all conditions; but rather, each has advantages and disadvantages.

STUDY OBJECTIVES

The main objective of this research project is to assess selected computer programs for traffic signal planning, design, and operations. More specifically, the study is aimed at identifying all available programs that are pertinent to traffic signal operations and design problems, develop an inventory of pertinent programs, develop a description of the capability of each program, and last but not least conduct a comparative assessment of possible programs that may be utilized for operations and design problems.

When the proposal for this study was first developed, a clear distinction between mainframe software and microcomputer software was made. With the advancement in micro-chip technology, microcomputers now have much greater storage capabilities and higher execution speed than before. This means that the gap between mainframe computers and microcomputers is diminishing.

It is important to point out though that, at least for the next decade, the user community will use both types of machines either separately or jointly.

As a start, a need exists to define the differences between mini/supermini/micro computers. A microcomputer is defined as a collection of hardware utilizing 8/16/24 bit registers and a processing speed of about 0.2 MIPs (million instructions per second) or lower. The addressable RAM (Random Access Memory) is about 3 MB (Mega Bites) or lower, though the compilers will not allow a single program to address the entire memory. The secondary storage is about 40 MB or lower on a hard disk and 1.2 MB or lower on a diskette.

A minicomputer is defined as a collection of hardware utilizing 32/64 bit registers and a processing speed of between 1-4 MIPS. The operating system is a virtual memory type with an addressable space of over 16/32 MB per user. The RAM is usually over 1 MB and may run up to 16 MB or more.

The difference between mainframes and minis (or superminis) is in the number of CPU's (Central Processing Units) and the processing speed. Mainframes now have dual (or more) processors and operate at over 6 MIPS.

Superminicomputers are gaining ground against both mainframe and microcomputers. They are successfully filling in the gap between the two machines. Although the proposal did not include superminicomputers in the comparative assessment, the research team decided that for the sake of attaining a complete research effort the listed software in the proposal should be further assessed using the VAX/VM machine.

With the modified research scope, the following types of software were identified:

1) Software designed for microcomputers only.
2) Software developed for use on mainframe and now operating on microcomputers.
3) Software that still operates on mainframe only.
4) Software that can operate on supermini computers with little or no modification.

The purpose of this report is to document an inventory of software that falls under the four categories listed above. Furthermore, to report on the results of the comparative assessment of all types of software utilizing data collected for a selected arterial in Tempe, Arizona.

REPORT DESCRIPTION

The report is divided into three volumes. Volume 1 contains the executive summary, research approach, research findings and recommendations.

Volume 2 documents detailed descriptions of the software assessed in this study, and Volume 3 provides a sample run of the recommended software.

The idea behind having three volumes is first to describe the study objectives and conduct an exhaustive inventory of available software, then select the software to be assessed, and very briefly describe their functions. All this is done in Volume 1. If the reader wishes to learn more about a particular model, he is referred to Volume 2 where detailed descriptions, taken verbatim from the user's manual, are provided and a list of references is added at the end. To complement the description of the software, a sample run is provided for the recommended software in the third volume so the reader can have an idea of how the needed input parameters and output reports look.

The remainder of this volume contains the following sections:

Software Inventory

Software Selection

Software Description

Network Description

Software Comparative Assessment

Conclusions and Recommendations

The inventory section contains a list of currently available software for the user community. Following this section is a list of computer software adopted for assessment in this study, then a brief description of the software function is provided. Information related to the network used in the comparative assessment in terms of geometric data and traffic data is then documented. The software assessment section is divided into four major sections. The first section reports on the assessment of isolated intersection software; the second section contains an assessment of all preprocessors software; the third section documents the assessment of the network software (arterial and grid software combined); and the fourth section provides information pertaining to computer execution time on the mainframe computer, the supermini (VAX/VM), and microcomputer for selected software.

SOFTWARE INVENTORY

A comprehensive literature search was conducted to compile most of the traffic signal related software. Five major sources were utilized, ''The Microcomputers in Transportation: Software and Source Book'' published by U.S.D.O.T. (3); ''The I.T.E. Microcomputer Software Directory'' published by the Institute of Transportation Engineers (5); write-ups provided by software developers and distributed by mail or at conferences and professional meetings; advertisements in professional journals such as ITE and ASCE; and the STEAM Software newsletter published by DOT/Transportation Systems Center.

Traffic signal software packages were divided into three groups, namely: isolated intersection programs, arterial street programs, and grid network programs. Eighteen isolated intersection programs, 13 arterial street programs, and 12 grid network programs were recorded and they are illustrated in Tables 1, 2, and 3. Furthermore, information related to the developer, program application, and operating system environment, as published in the software resources, are provided.

It is important to point out that the list contains seven preprocessors and they are: FREESIAP, PASSLOAD, PASSETUP, EZ-PASSER, PRETRANSYT, EDBAND, EZ-SIGOP, and EZ-TRANSYT. These programs are provided to enable the user to generate an input data stream in a fixed format, by means of either screen editing or line editing, which can be used to run programs previously developed such as SOAP or PASSER or TRANSYT. Table 2 contains PASSER III as an arterial street program although the major function of this software is to develop optimum signal timing for diamond interchanges.

Table 1. ISOLATED INTERSECTION INVENTORY

NAME	DEVELOPER	APPLICATION	ENVIRONMENT
CAPCALC	Roger Creighton Associates, Inc.	Intersection Capacity Analysis and Design (Circ. 212)	Apple II+, IIe, IBM-PC, TRS II, 12, 16, 64K
CAPCALC 85	Roger Creighton Associates, Inc.	Intersection Capacity Analysis and Design (HCM 1985)	Apple II+, IIe, IBM-PC, TRS II, 12, 16, 64K
CAPACITY	Timelapse	Capacity Analysis (HCM) 1965	CP/M, Apple, IBM-PC, 64K
CAPSSI	Mohle, Grover & Associates	Comprehensive Analysis	CP/M or MS-DOS, 64K
CMA	Bather Belrose Boje, Inc.	Intersection Evaluation (Circular 212)	CP/M-80, 50K; MS-DOS, 128K, PC-DOS, 128K
CMA/M (McTRANS)	TRC, University of Florida	Intersection Evaluation (Circular 212)	Apple II+, 48K, IBM-PC with Quadlink Card
EZ-POSIT	Habih Chen	Optimizaton	IBM-PC, Apple II, MS-DOS, UCSD P-System
ICAP	Bather Belrose Boje, Inc.	Capacity Analysis HCM (1965)	CP/M-80, 50K; MS-DOS, 128K, PC-DOS, 128K
INTERCALC	Bather Belrose Boje, Inc.	Development and Analysis (Webster)	CP/M-80, 50K; MS-DOS, 128K, PC-DOS, 128K
NCAP	Professional Solution, Inc.	Capacity Analysis	Apple II/II+/IIe/IIc IBM-PC
SCA	DeShazo, Starek & Tang Incorporated	Capacity Analysis 1985 (HCM)	LOTUS 123
SIAP/FREESIAP	Transware	Optimization & Evaluation	MS-DOS, IBM-PC
SICA	Binghampton Metropolitan Transportation Study	Capacity Analysis 1985 (HCM)	MS-DOS
SIGNAL	Barton-Aschman Associates, Inc.	Intersection Capacity Analysis and Design (HCM 1965)	IBM-PC, XT, and AT with CP/M-80, 64K
SIGNAL 85	Barton-Aschman Associates, Inc.	Intersection Capacity Analysis and Design	IBM-PC, XT, AT, MS-DOS
SOAP 84	FHWA	Optimization & Evaluation	CP/M, MS-DOS, IBM-PC, Apple
SOAP/M (McTRANS)	TRC, University of Florida	Otpimization, Data Analysis, Counting	Apple II, 48K, IBM-PC with Quadlink Card
TEXAS	CTR, University of Texas	Intersection Simulation	IBM 4341 or 3081 Mainframe

Table 2. ARTERIAL STREET INVENTORY

NAME	DEVELOPER	APPLICATION	ENVIRONMENT
EZ-PASSER	Transtek Software	Interactive Signal Timing	IBM-PC, MS-DOS, Apple, UCSD P-System
NOSTOP	Barton-Aschman Associates, Inc.	Progression	CP/M-80, IBM-PC, XT, & AT, 64K
PASSER	Mohle, Grover & Associates	System Evaluation	CP/M or MS-DOS, 64K
PASSER II-80	DKS Associates	Automatic Phase Sequence Selection	IBM-PC, 256K; MS-DOS and UNIX SYSTEM
PASSER II-80	Texas State Department of Highway & Public Transp.	Arterial optimization Model	IBM-PC, MS-DOS IBM Mainframe
PASSER II-80 and PASSLOAD	Bather Belrose Boje, Inc.	An Interactive Signal Timing	CP/M-80, 50K; MS-DOS, 128K; PC-DOS, 128K
PASSER II-84 & PASSETUP	Texas State Department of Highway & Public Transp.	Upgrade of the PASSER II-80	IBM-PC, MS-DOS IBM Mainframe
PASSER III*	DKS Associates	Timing Signal at Diamond Interchanges	IBM-PC, 256K; MS-DOS and UNIX SYSTEM
PLATOON PROGRESSION Diagram	Microtrans Associates, Inc.	Traffic Signal Progression	Apple, 48K
SIGART/TIMESPACE II	Bather Belrose Boje, Inc.	Signal Timing	CP/M-80, 50K; MS-DOS, 128K; PC-DOS, 128K
SPAN (McTRANS)	TRC, University of of Florida	Traffic Signal Progression	Apple II, 48K, IBM-PC with Quadlink
TIMDIS 2	DKS Associates	Interactive Signal Progression	IBM-PC, 256K; MS-DOS and UNIX SYSTEM
TIMESPACE III	Bather Belrose Boje, Inc.	General Purpose	CP/M-80, 50K; MS-DOS, 128K; PC-DOS, 128K

* Diamond Interchange Software

Table 3. GRID NETWORK INVENTORY

NAME	DEVELOPER	APPLICATION	ENVIRONMENT
EDBAND	Transware	Preprocessor for TW BANDWIDTH and MAXBAND	MS-DOS
EZ-TRANSYT	Transtek Software	Transyt 7F Preprocessor	IBM-PC under MS-DOS
NETSIM	FHWA	Arterial and Grid Simulation	MS-DOS
PPD	FHWA	Post Processor for TRANSYT 7F	MS-DOS
PRETRANSYT	Barton-Aschman Associates, Inc.	Transyt Preprocessor	IBM-PC, XT, and AT with CP/M-80
SIGOP III	FHWA	Grid network optimization	MS-DOS
SIGRID	Bather Belrose Boje, Inc.	Grid Signal Timing	CP/M-80, 50K, MS-DOS, 128K; PC-DOS, 128K
TRANSYT-7F	FHWA	Arterial and Grid Optimization	CP/M, MS-DOS, IBM-PC, Apple
TRANSYT 7 PLUS	Mohle, Grover & Associates	Arterial and Grid Optimization	CP/M-80 or MS-DOS, 64K
TRANSYT/7 and TRANSYT/7F	Bather Belrose Boje, Inc.	Arterial and Grid Optimization	CP/M-80, 50K, MS-DOS, 128K; PC-DOS, 128K
TW BANDWIDTH	Transware	Arterial and Grid network	MS-DOS
TWSIGOP	Transware	Grid network optimization	MS-DOS
EZ-SIGOP	Transtek Software	SIGOP Preprocessor	IBM-PC under MS-DOS

SOFTWARE SELECTION:

Closer examination of Tables 1, 2, and 3 reveals that the majority of the software operate under the MS-DOS environment for IBM-PCs. Therefore, the selection of the software to be assessed was limited to IBM-PC or IBM-PC compatibles with MS-DOS operating system. Three exceptions were made to this rule and they were:

1) The use of the p-system to run the CAPCALC software
2) The use of the Baby-Blue card to emulate the CP/M-80 environment to run the SIGNAL, NOSTOP, and PRETRANSYT of the TEAPAC System.
3) The use of a Quadlink card to emulate the Apple II environment to run the SPAN, and CMA/M of the McTran System.

The final list of software assessed is as follows:

Isolated Intersections:

1) CAPCALC
2) CAPCALC 85
3) CAPSSI
4) CMA
5) CMA/M
6) EZ-POSIT
7) ICAP
8) INTERCALC
9) SCA
10) SIAP & FREESIAP
11) SICA
12) SIGNAL
13) SIGNAL 85
14) SOAP 84

15) SOAP/M

16) TEXAS

Arterial Streets:

17) EDBAND

18) EZ-PASSER

19) MAXBAND

20) NOSTOP

21) PASSER II-80 & PASSLOAD

22) PASSER II-84 & PASSETUP (version 2.3B)

23) SIGART & TIMESPACE II

24) SPAN

25) TIMDIS 2

26) TW-BANDWIDTH

Diamond Interchanges:

27) PASSER III

Grid Networks:

28) EZ-TRANSYT

29) NETSIM

30) PPD

31) PRETRANSYT

32) SIGOP III

33) SIGRID

34) TRANSYT-7F

35) TW-SIGOP

SOFTWARE DESCRIPTION

In this section, a brief description is provided for all the software assessed in the study. The first group of software is the isolated intersection group. Sixteen programs are presented in alphabetical order.

Isolated Intersection Software:

CAPCALC (intersection CAPacity and CALCulation) and CAPCALC 85 are two programs developed by Roger Creighton Associates (RCA) to perform capacity analyses of signalized intersections on microcomputers. The first program uses procedures outlined in the Circular 212 report, and the second program applies techniques documented in Chapter 9 of the 1985 Highway Capacity Manual. Both programs run under the P operating system, and a special partition is needed on the hard disk to permit the use of the program.

CAPSSI is a microcomputer program which stands for ''Comprehensive Analysis Program for Single Signalized Intersections.'' It aids the engineer in optimizing traffic signal settings and/or measuring the performance of a single signalized intersection when a specific set of data is given. Webster's delay and optimum cycle expressions are used in this model.

CMA and CMA/M are two microcomputer programs that use Critical lane Movement Analysis procedures, documented in the Circular 212 report, to examine the capacity and level of service at signalized intersections. CMA is developed by Bather, Belrose, and Boje, Inc., and CMA/M is developed, as part of the McTRANS system, by the University of Florida's Transportation Research Center. CMA operates under the MS-DOS environment, while CMA/M runs on Apple II computers only. An appropriate quadlink card was installed on an IBM-PC/XT to emulate the Apple II environment.

EZ-POSIT is a microcomputer program developed by Hobih Chen to produce an optimal signal setting, including cycle time and phasing pattern, that can minimize fuel consumption for a given intersection. The program is written in UCSD-PASCAL, and its logic is based on the Circular 212 procedure for determining critical lane volumes and Webster's delay expressions for estimating excess fuel consumption.

The ICAP microcomputer programs, which abbreviates Intersection CAPacity, are developed by Bather, Belrose, and Boje, Inc. (BBBI). They perform intersection approach capacity analyses in accordance with the definitions and procedures of the 1965 Highway Capacity Manual.

INTERCALC is a microcomputer program which considers intersection geometry, traffic volumes, and traffic signal operation to determine the performance of an isolated intersection based upon analytical research performed by Dr. Webster of the Transportation and Road Research Laboratory (TRRL) and upon recent FHWA sponsored research. Different sets of traffic and signal conditions can be assessed, and various traffic engineering Measures of Effectiveness (MOE) are produced.

The Signalized Capacity Analysis (SCA) microcomputer software is developed by DeShazo, Starek Tang, Inc. (DSTI). It is a spreadsheet software to be used with Lotus 123 that incorporates the worksheet calculations contained in Chapter 9 of the 1985 Highway Capacity Manual.

SOAP, which is an acronym for Signalized Operation Analysis Package, is a traffic signal controller optimizing tool which enables the user to design the signal timing for any three or four legged intersection. The program was originally developed for the IBM 370/165 mainframe computer by the University of Florida Transportation Research Center. SOAP 84 is the most recent version of the program. With the advancements of the microcomputer technology, several versions of SOAP were downloaded to microcomputers. SIAP & FREESIAP, SOAP 84 & SOAPDIM, and SOAP/M are three examples of microcomputer versions of SOAP.

SIAP (the Signalized Intersection Analysis Program) and its preprocessor FREESIAP, were developed by TRANSWARE to allow quick evaluation of an existing or alternative signal timing control plan for an isolated intersection. Both programs operate under the MS-DOS environment of IBM-PC or compatibles.

The SOAP 84 microcomputer version of SOAP and its preprocessor SOAPDIM were developed for the FHWA to be used on IBM-PC and IBM compatibles. The SOAP/M program is developed by the University of Florida Transportation Research Center. It is part of the McTRAN system, and it requires an Apple II computer to run. SOAP/M is the older version of SOAP on the mainframe, and therefore it does not contain the new delay model used in SOAP 84 (TRANSYT 7F delay model).

The SICA software (an acronym for Signalized Intersection Capacity Analysis) is a program developed by Binghampton Metropolitan Transportation Study (BMTS) of the state of New York. It is intended for use by traffic engineers who are analyzing signalized intersections to determine average stopped delay per vehicle and level of service. It is a computerized reproduction of the methodology adopted in the 1985 Highway Capacity Manual.

SIGNAL and SIGNAL 85 were developed by Barton-Aschman & Associates (BAA) as part of the Traffic Engineering Application PACkage (TEAPAC system). They analyze individual intersection control needs based upon approach capacity, lane usage, pedestrian and clearance constraints, and multi-phase signal control. The methodology used in SIGNAL is based on procedures documented in the 1965 Highway Capacity Manual. It was developed to operate under CP/M environment. The SIGNAL 85 was introduced to the user community in March, 1986. The intention was twofold, the first was to switch gradually from the CP/M operating system to MS-DOS, and the second reason was to introduce the new procedures endorsed in the 1985 Highway Capacity Manual.

The TEXAS (Traffic EXperimental and Analysis Simulation) model was developed by the University of Texas Transportation Research Center. It is a microscopic computer simulation program for isolated intersections. The user can simulate a wide spectrum of intersection combinations ranging from two uncontrolled one-way streets to complex intersections (more than four apporaches) with multi-phase control. The model was developed for both IBM and CDC mainframe computers. It is probably the only signalized computer software that has not been downloaded to microcomputers yet. Currently, the Transportation Research Center of the University of Texas, under a contract with the FHWA, is developing a microcomputer version of TEXAS. TEXAS software is used for evaluating signal plans of isolated intersections by means of simulating traffic flows on streets second by second. This software cannot optimize signal settings, and the user has to run the program repeatedly with different signal settings to search for optimum solution. For more information related to the 16 isolated intersection software described in this section, the reader is referred to Volume 2.

Arterial Streets Software:

In this section, nine software programs are briefly described, eight of which are related to arterial streets and the ninth is a diamond interchange software.

The PASSER II Computer model was developed at Texas Transportation Institute of Texas A&M University for use in the Dallas Corridor

Project sponsored by the FHWA and the Texas State Department of Highway and Public Transportation (TSDHPT). PASSER is an acronym for Progression Analysis and Signal System Evaluation Routine. The basic purpose of the model is to assist the traffic engineer in determining optimal traffic signal timings for progression along an arterial considering various multiphase sequences. An enhanced version of the PASSER II-80 was recently introduced to the user community as PASSER II-84. Three different versions of PASSER II were assessed in this study, and they were EZ-PASSER, PASSER II-80 & PASSLOAD, and PASSER II-84 & PASSETUP.

EZ-PASSER is an interactive microcomputer optimized implementation of the PASSER II-80 program. It is composed of a preprocessor designed for data entry, and an adapted PASSER II-80 version written in PASCAL language. The program operates under MS-DOS system for an IBM-PC/XT, and the Apple II+ system.

PASSER II-80 and its preprocessor PASSLOAD were developed by BBBI. The program was developed for microcomputers and is available for CP/M-80, PC-DOS, and MS-DOS operating systems.

PASSER II-84 Version 2.3B and its preprocessor PASSETUP were developed by the TSDHPT for use on an IBM-PC or compatible computers. The complete system fits on the floppy disk leaving the other disk free for storage of problem data and 132 column output. Due to disk size limitations, the system is currently limited to analyzing no more than ten signals.

The NOSTOP program is part of the TEAPAC system developed by BAA. It provides a means of presenting to the user a graph of the variation of arterial street progression efficiency over a complete range of cycle lengths and progression speeds. NOSTOP is available for both MS-DOS and CP/M operating systems.

SIGART (for SIGnal along an ARTerial) and TIMESPACE II are two programs which, when operated together, can produce timing plans for typical arterial type traffic signal systems. SIGART is a stand-alone program which can be operated separately if graphical output is not desired. The original program was developed for mainframe computers, and the version assessed in this study is the microcomputer version.

SPAN (The Signal Progression ANalysis) program is part of the McTRANS system developed by the University of Florida. It operates on Apple II computers, or IBM-PC equipped with a Quadlink card. SPAN performs a complete analysis of an arterial signal system using a simple optimization of offsets. The input stream for SPAN has to be in the form of the SOAP/M data input. In other words, the user has to run SOAP/M for every intersection of the arterial prior to using SPAN.

TIMDIS 2 is an interactive microcomputer program which draws detailed TIMe-DIStance diagrams and an interactive time location diagram for use in the design and presentation of traffic signal coordination plans. It also produces a formatted digital record of signal timing at each intersection, can automatically adjust offsets for one-way progression, and enables modification of variables such as phase times, offsets, phase sequence, cycle length, and speeds. The program was developed by DKS & Associates (DKSA).

MAXBAND, or MAXimal BANDwidth traffic signal setting optimization program is a software which finds traffic signal settings on arterials or certain loops composed of three arterials, which result in maximal bandwidth. Problems are formulated as mixed integer programs which provide global optimum solution. MAXBAND is based on the traffic signal model developed by J. D. C. Little of the Massachusetts Institute of Technology for the FHWA. MAXBAND is written in FORTRAN and runs on IBM mainframe computers. TW-BANDWIDTH is the microcomputer version of MAXBAND adapted by TRANSWARE to operate on IBM microcomputers or IBM compatibles. It requires an MS-DOS operating system.

EDBAND is an interactive data processor that assists the user in creating input data files for the arterial case of TW-BANDWIDTH or MAXBAND. EDBAND was developed to operate on microcomputers under the MS-DOS environment.

PASSER III was developed to assist the traffic engineer in determining the optimal traffic signal timings for signalized diamond interchanges. It was developed at the Texas Transportation Institute for use in the Dallas Corridor Project which was sponsored by the FHWA and TSDHT in cooperation with the City of Dallas. PASSER III which is an acronym for Progressive Analysis and Signal System Evaluation Routine, Model III (Diamond Interchange), determines the optimal phase patterns, splits and internal offsets at single interchanges (for a given cycle length) and additionally the optimal system cycle length and progression offsets for the frontage road progression. It is written in FORTRAN, and developed originally for mainframe computers. The microcomputer version of PASSER III was introduced to the user community by DKS & Associates. The microcomputer version runs on an IBM-PC under the MS-DOS and UNIX systems.

Grid Network Software:

Eight programs are described under the general heading of grid network software. They can be grouped under four main programs: NETSIM, TRANSYT, SIGOP III, and SIGRID.

NETSIM, which is an abbreviation for NETwork SIMulation model was developed by KLD Associates for the FHWA. It is a microscopic simulation model which provides the traffic engineer with a tool to evaluate a wide mix of traffic control and traffic management strategies, including fixed or actuated signal control, and sign control; special-use for turn and general-use lanes; and standard or channelized geometrics. NETSIM is developed for both IBM and CDC mainframe computers. The microcomputer version of NETSIM was recently introduced to run on IBM-PC/XT or compatibles with a minimum memory of 512K bytes and a mathematical coprocessor 8087.

The TRANSYT model is a macroscopic, deterministic, time scan optimization model. It is used for optimizing the signalization on arterials and grid networks. The model is developed by the Transportation and Road Research Laboratory of England (TRRL). The TRANSYT 7F model (the Americanized version) was adapted from TRANSYT 7 model by the University of Florida Research Center. It operates on IBM 370, CDC 7700, VAX and HONEYWELL computers. TRANSYT 7F has been downloaded to the microcomputer level to operate on IBM and IBM compatibles with the aid of the 8087 math coprocessor. Two preprocessors and one post-processor are available for the TRANSYT model. EZ-TRANSYT and PRETRANSYT are the preprocessors and PPD is the postprocessor.

EZ-TRANSYT is developed by Hobih Chen (formerly TRANSTEK) to assist programmers in translating the TRANSYT-7F program-specific notations into terms understood by traffic engineers. It is written in PASCAL language, and it operates under the MS-DOS environment of an IBM-PC.

PRETRANSYT is developed by BAA to be used as a preprocessor in conjunction with the TRANSYT program. It is available for both MS-DOS and CP/M operating systems for IBM microcomputers or IBM compatibles. PRETRANSYT interacts with TRANSYT-7F version 3 or less.

The PPD program is an acronym for Platoon Progression Diagram. It produces platoon progression diagrams similar in function to traditional time-space diagrams. The PPD program and its documentation were originally developed for the Apple microcomputer by Courage and Wallace of Micro-Trans Associates, Inc., Gainesville, Florida. It was converted by the FHWA for processing on the IBM-PC/XT (and compatibles) microcomputers for the MS-DOS operating system.

The SIGOP III model is a macroscopic signal timing design and analysis model. It was developed by KLD & Associates for the FHWA. It is an acronym for Traffic SIGnal OPtimization Model, version III. The program is written in FORTRAN and has been successfully run on both IBM and CDC mainframe computers. The model deals exclusively with mixed-flow traffic on a signalized arterial network. Multiple approaches (e.g. diagonal streets) are permissible and signal timing is assumed to be fixed time, but with multiple phasing. SIGOP III uses the underlying principles of the TRANSYT model, namely to minimze a disutility function composed of stopped delay and number of stops.

TW-SIGOP is the microcomputer version of the mainframe SIGOP III version. It was downloaded by TRANSWARE to fit on IBM-PC/XT (and compatible) microcomputers for the MS-DOS operating system.

The SIGRID program was developed by BBBI to aid traffic engineers in determining the optimum offsets for interconnected traffic signal networks with primary emphasis on grids. It permits the evaluation and comparison of the effects of altering any of the variables describing the system (e.g., cycle length, location and number of signals, coordination priorities, etc.). The program calculates the optimum signal offsets to minimize delay and produces delay propensity parameters that indicate the calculated difference between the existing network offset plan and the optimized offset plan. The program is available for CP/M, MS-DOS, and PC-DOS operating systems of a microcomputer.

Detailed descriptions pertaining to all the software are provided in Volume 2.

NETWORK DESCRIPTION

For the purpose of conducting a comparative assessment of the software, a six intersection arterial located in Tempe, Arizona was selected. The Broadway arterial geometric description is displayed in Figure 1. Two out of the six intersections are of the T-intersection type. The PM-Peak traffic volumes (4:30 to 5:30) are documented in Table 4. These data were inputted to most of the software consistently with some other assumptions such as:

- o a saturation flow rate of 1,700 passenger cars per hour of green
- o a lost time per phase of three seconds
- o a clearance interval of three seconds
- o few pedestrian activities during the AM-peak
- o an average truck percentage of 5 percent

The Broadway-Mill intersection data were used in the isolated intersection assessment section, while all six intersections were used in the network assessment section. A sample of the recommended computer software in this study is documented in Volume 3.

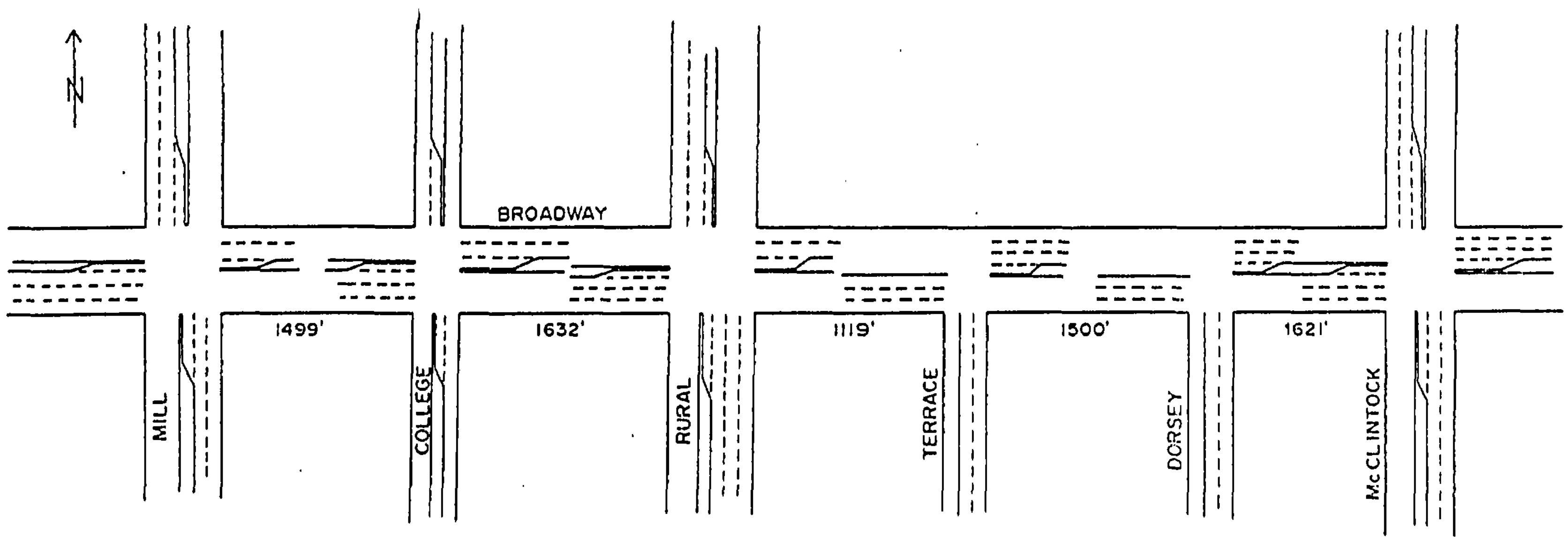

Figure 1 The Broadway Arterial Street Diagram

Table 4 Traffic Volumes for the Broadway Arterial

	North-Bound			South-Bound			East-Bound			West-Bound		
	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
Mill	120	929	48	80	398	130	120	544	68	80	900	99
College	60	526	20	93	238	120	120	527	25	80	899	205
Rural	140	990	61	93	538	120	130	440	70	80	924	40
Terrace	60	-	40	-	-	-	-	554	40	40	984	-
Dorsey	150	-	20	-	-	-	-	574	20	40	874	-
McClintock	160	990	80	100	411	74	110	404	80	70	680	250

PM-Peak traffic volumes (4:30 to 5:30)

SOFTWARE COMPARATIVE ASSESSMENT

As discussed earlier, this section reports on four activities. The first activity was the assessment of the isolated intersection software. Before coding the Mill-Broadway data for all the 16 software assessed in this study, the major functions of the programs were identified. Three general functions were defined, namely optimization, design, and analysis. Optimization meant that the program determines the best cycle length and phase splits from a given cycle range, design meant that the cycle length is inputted and phase splits are calculated by the program, and analysis meant that both cycle length and splits are inputted.

Out of the 16 single intersection software, some are capable of doing one or more of the three defined functions. Three comparative assessments were conducted for the three functions defined earlier, and they are discussed in the next section. A summary table covering all operational characteristics, and documenting recommendations for the 16 software is also included.

The second activity involved the assessment of five preprocessor software used for running the TRANSYT, the PASSER, and the MAXBAND programs. A table showing the comparative assessment is provided.

The third activity was aimed at coding the Broadway arterial data to run 12 network software. A comparative assessment of four selected software results was conducted, and a general assessment table for the 12 software was developed. The details are documented in the following sections.

The fourth activity was conducted to assess the speed of execution on mainframe, supermini, and microcomputers.

Isolated Intersection Software

The first comparative assessment of isolated intersection software was aimed at implementing the optimization function. Only six programs provided this function. The attained cycle length, phasing duration per phase, average delay per vehicle per movement, average delay per vehicle for the intersection, and intersection level of service are all shown in Table 5. Since EZ-POSIT is the only software that selects the phasing scheme, it was decided to use EZ-POSIT's phasing (four phase operation) for assessing the other five software. The results were grouped in four major categories, and they were:

1. Software based on the 1985 HCM procedures (CAPCALC 85)
2. Software based on Webster's procedures (CAPSSI)
3. Software based on the SOAP program (SIAP, SOAP 84, and SOAP/M)
4. Software based on Circular 212 (EZ-POSIT)

As the results showed, SIAP and SOAP 84 produced very close settings and MOE's, while SOAP/M produced different results. The reason for the differences is that SOAP/M is based on the original SOAP which does not include the modified delay formulation (the TRANSYT 7F delay expression). It is interesting to notice the big difference between the 1985 HCM procedure (CAPCALC 85) and the remaining software. Furthermore, the results attained from the Webster procedure are not that different from the SOAP category. After all the SOAP logic is based on Webster's optimum settings.

It can be also concluded from this table that the signal settings and the MOE's are sensitive to variations in the delay models and more calibrations of delay expressions are desired.

The design option was implemented for eight programs. The four categories that the results were classified by were:

Table 5 Isolated Intersection Software Results for the Optimization Option

Computer Software	Cycle Length (Seconds)	Phasing Duration (seconds)				Average Delay per Vehicle per Movement (second/vehicle)								Intersection	
		NBL SBL	NBT SBT	EBL WBL	EBT WBT	NBL	NBT	SBL	SBT	EBL	EBT	WBL	WBT	Delay	Los
CAPCALC 85	120	10	63	12	35	76.4	19.9	42	14.6	60.7	33.4	41.6	1468.6	489.4	F
CAPSSI	77	11	32	11	36	68	31	68	31	68	29	68	29	33.2	C+
SIAP	70	8.67	26.07	8.67	26.59	76.4	25.7	40.8	16.7	76.4	15.2	40.8	25.3	25.92	--
SOAP 84	70	8.67	26.07	8.67	26.59	76.7	29.13	40.64	19.48	76.75	17.86	40.64	28.71	29.55	--
SOAP/M	120	13.6	45	12.6	48.9	80.9	40.2	60	30.4	108	26.3	63.8	35.4	39	--
EZ-POSIT	90	8	31	9	42	417.1	120	57.4	25.4	357.2	15.5	69.2	90.5	90	E

NBL = North Bound Left Turn
SBL = South Bound Left Turn
EBL = East Bound Left Turn
WBL = West Bound Left Turn

NBT = North Bound Through
SBT = South Bound Through
EBT = East Bound Through
WBT = West Bound Through

1. Software based on the 1985 HCM procedures (SIGNAL 85)

2. Software based on the 1965 HCM procedures (SIGNAL)

3. Software based on the Webster's procedures (INTERCALC)

4. Software based on the SOAP program (SIAP, SOAP 84, and SOAP/M)

5. Software based on the Circular 212 procedures (EZ-POSIT, CAPCALC)

Under this design option, a six phase signal plan waS adopted. The results revealed (as shown in Table 6) that the third and fourth category programs produced similar results, a conclusion previously reached under the optimization option. It is also interesting to find significant differences among the intersection delay for the three capacity manual procedures, namely, 1965 HCM, Circular 212, and 1985 HCM.

The third option exercised was the analysis option. Thirteen programs were run using the Broadway-Mill intersection data for a predetermined signal plan and the delay and level of service results are documented in Table 7. The first four programs are grouped under one category (1985 HCM). Significant differences were noticed among delay as well as level of service. The reason is that the saturation flow adjustment factors used for left turns and right turns are estimated from a series of complicated mathematical expressions. Any round off error could affect the saturation flow rate and consequently affect the delay values significantly.

As expected, ICAP and SIGNAL results were observed to be close (the 1965 HCM procedure), and CAPSSI and the SOAP group were similar. The Circular 212 category included three programs (CMA, EZ-POSIT, and CMA/M). Only EZ-POSIT provided delay estimates. The LOS for the three programs agreed.

Two general observations were attained from this analysis. The first observation was made earlier and it is related to the major differences

Table 6 Isolated Intersection Software Results for the Design Option

Computer Software	Phasing Duration (seconds)						Average Delay per Vehicle per Movement (seconds/vehicle)								Intersection	
	NB&SB LT	NBL NBT	NBT SBT	EB&WB LT	EBL EBT	EBT WBT	NBL	NBT	SBL	SBT	EBL	EBT	WBL	WBT	Delay	LOS
SIGNAL 85	10.3	0	31.2	11.5	0	37	40.3	74.9	42.4	20.7	42.4	16	40.4	71.1	51.4	E
SIGNAL	9.92	0	32.77	9.92	0	37.38	64.1	275	70.3	28.8	64.1	21.9	70.3	272.9	165.74	--
INTERCALC	8.3	6.4	28.6	11	0	35.7	40.7	29.4	91.3	28.2	70.1	21.1	44.8	28.9	30.45	C
SIAP	8.25	2.62	32.45	8.25	2.63	35.80	67.2	26.1	80.6	21.4	67.2	16.2	80.6	25.6	28.15	--
SOAP 84	8.25	2.62	32.44	8.25	2.62	35.80	67.21	30.1	80.46	25.02	67.21	19.09	80.46	29.58	32.28	--
SOAP/M	8.3	2.6	32.4	8.3	2.6	35.8	68.6	30.2	82.3	25.1	68.6	19.1	82.3	29.7	32.0	--
EZ-POSIT	5	14	18	7	2	43	30.9	119.5	603.3	203.3	357.2	13.6	471.1	90	122	E
CAPCALC*	8	3	32	8	3	35	113	38	113	38	113	36	113	36	44.5	D

*The Planning Analysis Option of CMA Method

Table 7 Isolated Intersection Software Results for the Analysis Option

	Average Delay per Vehicle (seconds/vehicle) & Level of Service									
Computer Software	NBL	NBT	SBL	SBT	EBL	EBT	WBL	WBT	Intersection Delay	Intersection LOS
CAPCALC 85*	101.6 F	77.0 F	79.4 F	21.1 C	209.8 F	16.1 C	211.1 F	313.7 F	144.3	F
SIGNAL 85*	43 E^+	44.1 E^+	68.1 F	20.5 C	61.9 F	15.2 C^+	106.8 F	121.3 F	61.1	F
SICA*	105.9 F	86.04 F	81.4 F	20.94 C	216.4 OS	16.15 C	220.4 OS	327.5 OS	N.A.	OS
SCA*	26.35 D	27.05 D	28.39 D	18.05 C	26.35 D	13.55 B	28.39 D	134.60 F	58.64	E
ICAP/TCAP	N.A. C	N.A. E	N.A. C	N.A. A	N.A. C	N.A. A	N.A. C	N.A. F	N.A.	N.A.
SIGNAL	51.1 C^+	165.1 F	197.5 F	29.9 A	51.1 C^+	20.7 A	197.5 F	334.3 F	161.4	F
CAPSSI	68 E	31 C^+	68 E	31 C^+	68 E	29 B^-	68 E	29 B^-	34	C^+
SOAP 84	64.82	30.19	91.76	25.42	64.82	18.68	91.76	29.25	33.34	N.A.
SOAP	64.9	26.2	91.3	21.7	64.9	15.9	91.3	25.3	29.1	N.A.
SOAP/M	64.3	30.2	93.8	25.4	64.3	18.7	93.8	29.2	32.76	N.A.
CMA	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	E
EZ-POSIT	54.9	59.2	57.4	24.3	85.4	17.7	116.4	93.3	52.22	E
CMA/M	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	E

N.A. = Not Available

* 1985 HCM Software

among the available capacity procedures. The second observation is that the majority of the isolated intersection software do not explicitly provide timing for pedestrian signals.

A summary table (Table 8) showing the 16 programs assessed for 14 possible characteristics is provided. The software were grouped into six major categories by their theoretical background. These categories are:

1. The 1985 HCM procedures
2. The CMA procedure of Circular 212
3. The 1965 HCM procedures
4. Webster delay and optimum cycle length expressions
5. The modified expressions of Webster delay model used in SOAP 84
6. Microscopic computer simulation

An overall assessment of the 14 characteristics resulted in seven software recommended for use. In the first category, CAPCALC 85 was recommended because of the following reasons:

1. It provided an extra function over the basic analysis option (either optimization or design).
2. Its diagnostic messages are either good or fair, and it is more user friendly than SIGNAL 85, SICA and SCA.
3 It resulted in the average delay and level of service very close to the results of hand calculation.

As for the Circular 212 category, CAPCALC and EZ-POSIT are recommended. CAPCALC is recommended because it gives the user the option to either conduct the planning analysis or operation and design analysis. Furthermore, the model is user friendly, and it has a good documentation. EZ-POSIT is recommended because it provides the user with the three functions and it has a short input data requirement.

Table 8 Isolated Intersection Software Assessment

Characteristics	CAPCALC 85	SIGNAL 85	SICA	SCA	CMA	CMA/M	CAPCALC	EZ-POSIT
Theoretical Background	1985 HCM	1985 HCM	1985 HCM	1985 HCM	Circ. 212	Circ. 212	Circ. 212	Circ. 212
Input Data Requirement	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Short
Method of Data Input	Interactive	Free or Interactive	Interactive	Interactive	Interactive	Interactive	Interactive	Interactive
Modifying the Data	Line	Line	Line	Screen	Line	Line	Line	Screen
Capability of Multiple Runs	No	No	No	No	No	No	No	No
Functions	Opt. + Anl.	Des. + Anl.	Analysis	Analysis	Analysis	Analysis	Design	Opt.+Des.+ Anl.
Diagnostic Messages	Fair	Good	Poor	Poor	Poor	Fair	Fair	Fair
Graphical Presentation	No	Yes	No	No	No	No	No	No
User Friendly Level	Good	Fair	Fair	Poor	Fair	Fair	Good	Good
Help File	None	Good	None	None	None	None	None	Fair
Documentation	Good	Poor	Fair	Poor	Fair	Fair	Good	Poor
Operating System	P-System	MS-DOS/CPM	MS-DOS	LOTUS 123	MS-DOS	APPLE II	P-System	MS-DOS
Developer	RCA	BAA	BMTS	DSTI	BBBI	U. of FL.	RCA	Hobih Chen
Cost	$845	$600	N.C.	$150	$300	$35	$485	N.C.
Recommendation	Yes	Yes	No	No	No	No	Yes	Yes

Table 8 Isolated Intersection Software Assessment (continued)

Characteristics	ICAP	SIGNAL	CAPSSI	INTERCALC	SIAP	SOAP 84	SOAP/M	TEXAS
Theoretical Background	1965 HCM	1965 HCM	Webster	Webster	Mod. Webs.	Mod. Webs.	Mod. Webs.	Simulation
Input Data Requirement	Moderate	Moderate	Short	Short	Moderate	Moderate	Moderate	Long
Method of Data Input	Interactive	Interactive	Interactive	Interactive	Free	Free	Interactive	Fixed
Modifying the Data	Line	Line	Line	Screen	Line	Line	Line	N.A.
Capability of Multiple Runs	No	No	No	No	Yes	Yes	No	Yes
Functions	Analysis	Des. + Anl.	Opt. + Anl.	Design	Opt.+Des.+ Anl.	Opt.+Des.+ Anl.	Opt.+Des.+ Anl.	Analysis
Diagnostic Messages	Good	Good	Poor	Good	Good	Good	Fair	Good
Graphical Presentation	No	Yes	No	Yes	Yes	No	No	Yes
User Friendly Level	Good	Fair	Good	Good	Fair	Fair	Fair	N.A.
Help File	Fair	Good	None	Fair	Good	Good	None	N.A.
Documentation	Good	Poor	Good	Good	Good	Good	Fair	Good
Operating System	MS-DOS	MS-DOS/CPM	MS-DOS	MS-DOS	MS-DOS	MS-DOS	APPLE II	MainFrame
Developer	BBBI	BAA	MGA	BBBI	Transware	FHWA	U. of FL.	U. of Texas
Cost	$300	$600	$400	$500	$60	N.C.	$35	N.C.
Recommendation	No	Yes	No	No	Yes	Yes	No	No

The SIGNAL program is recommended for the 1965 HCM category because it provides design and analysis functions, and it provides a good help command. None of the Webster category software is recommended. The SIAP and the SOAP 84 programs are recommended because they provide the three operational functions, they have good diagnostic messages, they contain good help files, and they have good documentation.

The TEXAS model is a good simulation model for isolated intersections; however, it is our recommendation that the NETSIM program be used if the user decides to conduct traffic simulation. NETSIM has been validated and calibrated by numerous state highway departments, research agencies, and universities around the U.S., and it has been proven to be a powerful and reliable simulation tool.

Preprocessor Software Assessment:

During the course of coding the Broadway network data to run the MAXBAND, the TRANSYT, and the PASSER programs, five preprocessors were extensively used and evaluated. Table 9 contains the five preprocessors assessed in this study. EIBAND is the preprocessor of MAXBAND and TW-BANDWIDTH. EZ-TRANSYT, and PRETRANSYT are preprocessors for the TRANSYT-7F program. PASSETUP is the preprocessor developed by the TDHPT for the PASSER II-84 version 2.3 program, and PASSLOAD is the preprocessor developed by BBBI for the PASSER II-80 program. The assessment clearly indicates that EIBAND, EZ-TRANSYT, and PASSETUP are the recommended preprocessors.

Table 9 Preprocessor Software Assessment

Characteristics	ED BAND	EZ-TRANSYT	PASSETUP	PASSLOAD	PRETRANSYT
Program to interact with	TW-BAND MAXBAND	TRANSYT 7F Version 4	PASSER II-84	PASSER II-80	TRANSYT7F Version 3 or less
Input Data Requirement	Moderate	Moderate	Moderate	Moderate	Moderate
Method of Data Input	Interactive	Interactive	Interactive	Interactive	Free Format & Interactive
Modifying the data	Screen Editing	Screen Editing	Line Editing	Line Editing	Line Editing
Diagnostic Messages	Good	Good	Good	Good	Fair
User Friendly Level	Good	Good	Good	Good	Poor
Documentation	Good	Good	Good	Good	Fair
Help File Level	Very Good	Very Good	None	None	Fair
Level of Default Parameters	Moderate	Moderate	Low	Low	High
Developer	Transware	Hobih Chen (Transtek)	Texas Dept. of Hwy & Pub. Transp.	Bather, Belrose, and Boje, Inc.	Barton-Aschman Associates
System	MS-DOS	MS-DOS	MS-DOS	MS-DOS	MS-DOS/ CPM
Price	$100	$95	N.C.	$900	$950
Recommendation	Yes	Yes	Yes	No	No

N.C.: No charge

Network Software Assessment:

The Broadway network data was coded for 12 network software programs and a comparative assessment, similar to the one performed for the isolated intersection software, was conducted. Table 10 contains the characteristics considered in the assessment. Based on the 14 different assessment characteristics, five programs are recommended.

PASSER II-84 version 2.3 is recommended for the PASSER software group because it is user friendly, its PASSETUP preprocessor is simple to use, and it is available at a nominal charge.

TW-BANDWIDTH (the microcomputer version of MAXBAND) is recommended to the users because it provides a global optimum for arterial bandwidth.

As for grid network software, both TRANSYT-7F and TW-SIGOP (the microcomputer version of SIGOP III) are recommended because they have been tested and validated in previous research studies. Furthermore, they provide the three operational functions listed in Table 10.

The NETSIM computer simulation model is recommended for performing microscopic simulation analysis of traffic movements on urban arterials and grid systems. NETSIM does not provide design and optimization functions; however, through several runs the user can attain optimization by trial and error.

It can be generally concluded that for arterial optimization, PASSER and MAXBAND are recommended and for grid networks optimization, SIGOP and TRANSYT are recommended. To better understand the features provided by the four programs, a table was adapted from the PASSER II-84 user manual and is shown as Table 11.

To comparatively assess the four recommended programs, the Broadway network data were coded, and the four programs produced optimum phasing

Table 10 Network Software Assessment

Characteristics	EZ-PASSER	PASSER II-80	PASSER II-84	NO STOP	SIGART	SPAN	TIMDIS 2
Applicable To	Arterial	Arterial	Arterial	Arterial	Arterial	Arterial	Arterial
Input Data Requirement	Short	Moderate	Moderate	Short	Short	Long	Moderate
Method of Data Input	Interactive	Interactive	Interactive	Interactive/ Free	Fixed	Fixed	Interactive
Modifying the Data	Screen	Screen	Screen	Line	*	Line	Line
Capability of Multiple Run	No	No	No	No	Yes	No	No
Diagnostic Messages	Good	Good	Good	Fair	Poor	Good	Fair
Functions	Opt. + Des.	Opt.+Des.	Opt. + Des.	Analysis	Analysis	Analysis	Analysis
User Friendly Level	Good	Good	Good	Fair	N.A.	Fair	Fair
Help File	Yes	No	No	Yes	No	No	Yes
Documentation	Good	Good	Good	Fair	Good	Fair	Fair
System	MS-DOS	MS-DOS	MS-DOS	MS-DOS/CPM	MS-DOS	APPLE II	MS-DOS
Developer	Hobih Chen	BBBI	TDHPT	BAA	BBBI	U. of FL.	DKSA
Cost	$250	$900	N.C.	$650	$500	$35	$1,000
Recommendation	No	No	Yes	No	No	No	No

* Requires an external processor

N.A. = not applicable N.C. = nominal charge

Table 10 Network Software Assessment (continued)

Characteristics	TW-BANDWIDTH	NETSIM	SIGRID	TRANSYT 7F	TW-SIGOP
Applicable To	Arterial	Art./Grid	Art./Grid	Art./Grid	Art./Grid
Input Data Requirement	Moderate	Long	Moderate	Long	Long
Method of Data Input	Fixed	Fixed	Fixed	Fixed	Fixed
Modifying the Data	*	*	*	*	*
Capability of Multiple Run	No	No	Yes	No	No
Diagnostic Messages	Good	Good	Fair	Good	Good
Functions	Opt.+Des.+Anl.	Analysis	Analysis	Opt.+Des.+Anl.	Opt.+Des.+Anl.
User Friendly Level	N.A.	N.A.	N.A.	N.A.	N.A.
Help File	N.A.	N.A.	N.A.	N.A.	N.A.
Documentation	Good	Good	Good	Good	Good
System	MS-DOS	MS-DOS	MS-DOS	MS-DOS	MS-DOS
Developer	TRANSWARE	FHWA	BBBI	FHWA	TRANSWARE
Cost	N.C.	N.C.	$500	N.C.	N.C.
Recommendation	Yes	Yes	No	Yes	Yes

* Requires an external processor

N.A. = not applicable N.C. = nominal charge

Table 11 Logics and Measure of Effectiveness for Four Computer Software

	PASSER II-84	MAXBAND	TRANSYT-7F	SIGOP III
Control Variables	Cycle Offset ϕ-Sequence ϕ-Length	Cycle Offset ϕ-Sequence ϕ-Length	Cycle Offset ϕ-Length	Cycle Offset ϕ-Length
Optimization	Max. Bandwidth Min. Interference Delay-Offset	Max. Bandwidth MPCODE	Min. Delay	Min. Delay + Min. Queue
Solution	Local Optimum	Global Optimum	Local Optimum	Local Optimum
Objective Function	Max. Efficiency Min. System Delay	Min. (Flow x Cost) Offset Split Cycle	Min. PI = (Delay + k x stops)	Min. Disutility = (Delay + k x stops + δXQueue)
Delay Measurement	Mod. Webster NCHRP-TTI-PINY	Link Performance Saturation Deterrence	Platoon Representation by Flow Profile	Platoon Representation by Flow Profile
Delay Component	1. Uniform Delay 2. Overflow Delay	1. Deterministic Queue 2. Stochastic Overflow	1. Uniform Delay 2. Random Delay 3. Saturation Delay	1. Uniform Delay 2. Random Delay
Fuel Consumption	Yes	No	Yes	Yes
Data Input Base	Node	Node	Link	Node
Phase Selection	PASSER NEMA or Combinations	Inbound Outbound	Link Movements	Link Movements

scheme and signal settings. The optimum cycle lengths were found to be 100 seconds, 70 seconds, 65 seconds, and 65 seconds, for TRANSYT-7F, TW-SIGOP, TW+BANDWIDTH, and PASSER II-84, respectively. The higher value of TRANSYT-7F was as expected since the program optimizes at a network level rather than the arterial level.

The PASSER II-84 signal splits and offsets were then inputted to SIGOP III, TRANSYT-7F, and NETSIM. The reason for using PASSER as a basis because neither SIGOP nor TRANSYT can develop optimal signal phasing scheme. MAXBAND was not included in this assessment because it does not provide delay measures for links.

Table 12 shows the results for the Broadway links first, the average delay for all arterial links second, the average delay per intersection third, and the overall network delay last. Because NETSIM is a reliable microcomputer simulation software, it was decided to use its results as a base line for the comparative assessment.

As the results show, TRANSYT 7F proved to be the closest to NETSIM on an arterial basis as well as on the overall network basis. It was noticed that PASSER II-84 tends to underestimate delay and SIGOP III tends to overestimate delay.

This general observation is based on data collected for one arterial for one time period and to generalize results, one needs to apply the models to different networks with different geometrics and varying traffic volumes.

Table 12 Network Software Results for a Selected Signal Timing Plan

Average Delay per vehicle (sec/veh)	SIGOP III	PASSER II-84	TRANSYT-7F	NETSIM
Mill to College	56.8	11.6	8.1	12.8
College to Mill	33.9	30.9	58.8	84.0
College to Rural	51.0	15.3	9.8	13.5
Rural to College	35.9	14.0	20.7	29.8
Rural to Terrace	8.4	4.1	4.7	7.0
Terrace to Rural	82.7	23.6	28.0	32.4
Terrace to Dorsey	89.8	3.9	5.6	7.7
Dorsey to Terrace	8.1	3.6	0.7	4.0
Dorsey to McClintock	115.8	20.2	17.3	13.0
McClintock to Dorsey	12.9	2.1	2.0	9.3
Average Arterial	45.98	13.73	17.73	24.71
Mill Intersection	119.54	34.70	76.80	78.62
College Intersection	78.62	39.20	145.50	157.60
Rural Intersection	99.53	28.20	37.70	27.10
Terrace Intersection	8.10	5.90	3.90	6.20
Dorsey Intersection	49.32	5.90	6.20	10.39
McClintock Intersection	117.10	28.50	38.70	29.96
Overall Network	89.54	27.00	58.10	57.17

Computer Execution Times:

In this section, a comparative assessment was carried out on seven programs to estimate the execution times on three types of computers. An IBM 4341 mainframe, a VAX 11/780 super-mini, and an IBM-PC/XT microcomputer were the three machines used. The microcomputer was equipped with the 8087 math co-processor which proved to be a powerful piece of hardware needed to execute a large number of mathematical calculations within a reasonable time frame. The seven software assessed were:

PASSER III

TRANSYT 7F

PASSER II-84

SIGOP III

SOAP-84

MAXBAND

NETSIM

The Broadway network data were inputted into the seven programs using the same assumptions for all to provide a time comparative assessment. The execution times obtained from the mainframe computer and the super-mini were obtained in Central Processing Unit times in seconds. The problem with obtaining accurate execution times on mainframe and super-mini computers is that they execute several jobs simultaneously (time sharing mode of operation). In this assessment, an attempt was made to perform the analysis during the low demand period of the day when the machines are least utilized. This is not the case with microcomputers because the user can only run one job at a time on a single unit running under the MS-DOS operating system.

The execution times are listed in Table 13. As expected, the mainframe execution time was found to be the lowest and the microcomputer time was the highest. Using the mainframe time as a bench mark, ratios between micro and mainframe times, and super-mini and mainframe times were determined. It was observed that the highest ratio between micro and mainframe was 166 and the lowest ratio was 18.9, and the highest and lowest ratios for the supermini were 5.87 and 0.82, respectively. The 0.82 ratio indicates that the supermini has lower execution time of the TRANSYT-7F program than the mainframe. Experience has shown that, in general, the VAX machine can execute repeated mathematical calculations faster than mainframes, and since TRANSYT-7F requires a repeated searching process for an optimum solution, VAX proved to be a powerful machine in this respect.

MAXBAND and NETSIM execution times could not be obtained for the VAX because a large number of the functions used in these programs are system dependent and to adjust these programs is a major task that goes beyond the scope of this study.

As Table 13 shows, for the same computer type, SOAP-84 has the lowest execution time and NETSIM has the highest execution time. This is as expected because SOAP-84 is a macroscopic model used for timing an isolated intersection (Broadway and Mill) while NETSIM is a complicated microscopic computer simulation model used to simulate traffic flow through the Broadway network. It is also interesting to compare TRANSYT-7F and SIGOP III execution times. TRANSYT-7F took almost 40 percent less time than SIGOP III.

Table 13 Comparison of Computer Execution Times For Mainframe, Supermini and Microcomputer

Computer Type	PASSER III	TRANSYT-7F	PASSER II-84	SIGOP III	SOAP-84	MAXBAND	NETSIM
Mainframe (IBM 4341)	1.54 seconds	2 min. + 46.6 sec.	1.76 seconds	7 min. + 2.3 sec.	0.49 sec.	13.9 sec.	10min.+ 3 sec.
Supermini (VAX 11/780)	7.77 seconds	2 min. + 17.8 sec.	3.89 seconds	9 min. + 22.37 sec.	2.88 sec.	N.A.	N.A.
Microcomputer (IBM-PC/XT + Math Copro- processor 8087)	4 min. + 15 sec.	1 hr. + 20 min.	1 min. + 40 sec.	2 hr. + 13. min. + 32 sec.	28 sec.	7 min. + 5 sec.	3 hr. + 27 min. + 15 sec.

N.A.: Not Available

SUMMARY AND CONCLUSIONS

This study attempted to identify all available computer software that are pertinent to traffic signal timing and to conduct a comparative assessment of a selected group of programs with the ultimate goal of recommending the best programs to traffic engineers.

An inventory of currently available software was conducted, and 18 isolated intersection programs, 13 arterial street programs, and 12 grid network programs were recorded. Information related to the developer, program application, and operating system environment, as published in the software resources, were provided.

Thirty-five programs were adopted for the comparative assessment, out of which 16 were for isolated intersection programs, 10 arterial street programs, 1 diamond interchange program, and 8 grid network programs. Six-intersection arterial data were inputted to the 35 programs, and a detailed comparative assessment was conducted. The following conclusions were made:

1. For isolated intersection software assessment:

   a) Using the optimization option, significant differences were observed between results obtained from software that use the 1985 HCM procedures and the remaining programs.

   b) Using the design option, significant differences were observed among the delay figures attained from the three capacity manual procedures, namely, 1965 HCM, Circular 212, and 1985 HCM.

   c) The majority of the software do not explicitly provide timing for pedestrian signals.

   d) In general, signal settings and the measures of effectiveness are sensitive to variations in the delay expressions embedded in the software and more calibrations of these models are needed.

e) Six software are recommended for use and they are:

CAPCALC 85

CAPCALC

EZ-POSIT

SIGNAL

SIAP & FREESIAP

SOAP 84

2. For preprocessor software, EDBAND, EZ-TRANSYT, and PASSETUP are recommended.

3. For network software assessment:

a) Five software are recommended for use and they are:

PASSER II-84

TW-BANDWIDTH

NETSIM

TRANSYT-7F

TW-SIGOP

b) Using the Broadway network data, TRANSYT-7F produced results very close to NETSIM results. In addition, PASSER II-84 was observed to underestimate delay while SIGOP III tends to overestimate delay.

c) None of the network software explicitly include signal timing plans for pedestrian activities.

RECOMMENDATIONS FOR FURTHER RESEARCH

The study revealed some shortcomings that can be addressed in further research work and they are:

1. Well defined statistical procedures are needed to assist in validating and calibrating delay and optimization logics of signal timing software.
2. Pedestrian activities should be included in signal system software.

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