U.S. Department of Transportation

Decision Tools for Transportation Infrastructure Reinvestment

User Guidelines for Microcomputer Decision Support System (DSS)

July 1988

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Inquiries about the availability of the software described in this report can be directed to the Principal Investigator. The Decision Support System (DSS) software is also available through PC-TRANS, the microcomputer support component to the Kansas University Transportation Center's Technology Transfer Program. For further information on software availability through PC-TRANS, call (913) 864-5655 or write to PC-TRANS, Kansas University Transportation Center, 2011 Learned Hall, Lawrence, Kansas 66045. Their March 1990 catalog indicated a cost of $22.50 for DSS through that source.

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User Guidelines for Microcomputer Decision Support System (DSS)

Final Report
July 1988

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EXECUTIVE SUMMARY
DECISION TOOLS FOR TRANSPORTATION INFRASTRUCTURE REINVESTMENT
USER GUIDELINES
DSS: MICROCOMPUTER DECISION SUPPORT SYSTEM

This report is intended to improve the quality of decisions about reinvestments, and modest new investments, in highway transportation infrastructure. Decisions of this type comprise the majority of planning actions taken in the field of public sector transportation management. Our aging highway system, faced with changing demands which result from demographic trends and market shifts, stresses the limited resources available for reinvestment. Thus, it is particularly important that economically sound reinvestment choices be made.

To improve the quality of such decisions, a microcomputer package has been developed to support the routine use of economic evaluation as a part of the highway reinvestment process. Observation of professional practice, and consultation with a technical advisory panel, suggested that the use of economic evaluation methods is not widespread in the highway transportation field. Among the factors limiting the application of such tools are time pressures on technical professionals, their lack of available data, and in some cases, lack of timely and relevant analysis skills.

To contribute to improving this situation, a user-oriented microcomputer software package was developed which can assist the highway professional in the performance of an economic evaluation of proposed reinvestment projects. The program package is screen oriented, that is, it presents a series of data input forms which invite the user to supply logical and generally available data needed to perform the economic analysis. Where data may not be available, the software supports judgmental estimation by immediately computing and displaying the quantitative implications of judgments, supporting and efficient judgment-results-evaluation-revision cycle.

The software package, known as DSS for Decision Support System, is highly structure to step the user through logical consideration of a broad set of project cost and benefit categories. The overall design philosophy calls for presenting the user with opportunities to consider each category. This is intended to support comprehensiveness in the analysis. Support of judgmental estimation helps break down the barrier presented by absence of objective data. Of course, if objective data are available, they can and should be used in the analysis.

The DSS system comprises five modules. The main program, MAINDSS, supports detailed economic analysis of project provider costs, including annualized and present worth costs by expenditure category, inflation-sensitive future cash flows, fixed percentage "local" share of costs, and costs allocated to vehicle miles of travel by three vehicle types.

Benefits which are offered for consideration are vehicle travel time savings, fuel cost savings, and accident reduction savings. Each of these is estimated based on project descriptions and data on current operations and accident rates supplied by the user. Numerous opportunities are presented to recycle, review, and revise the data input and analysis. A benefit cost analysis, including benefit-cost ratio and net annualized and present worth computations, is performed.

Detailed hard copy reports, including all input data and analytic results, may be printed by a separate program, PRINTDSS. Project data may be saved to and retrieved from disk files.

A supporting program, INSTALL, may be used to install user-specified parameters, such as fleet average fuel consumption, values for travel time, and accident costs, to be used in every analysis.

Another supporting program, VIEW, may be used to review filed data and print brief reports without entering MAINDSS. A final supporting program uses dynamic programming to determine the optimal investment program from a series of proposed projects and a user-supplied budget level.

The package has been tested with a wide variety of technical professionals in training settings. It requires an IBM-PC, XT, or AT or compatible computer, one disk drive (fixed or floppy), DOS 2.10 or higher, and at least 256k bytes of random access memory.

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ACKNOWLEDGEMENTS

Many people provided important support in the development of this report and the software package it supports. We worked with a small technical advisory committee which provided guidance on the overall approach. On this committee were Mr. Ned Becker, Director of Transportation for Naperville, Illinois; Mr. Richard Hansen, Director of Public Works for Wilmette, Illinois; and Mr. David Jennings, Traffic Engineer for Evanston Illinois.

Professor Paul P. Jovanis provided thoughtful advice on the treatment of traffic operations and modeling fuel consumption.

Dr. Koji Tsunokawa developed the fuel consumption models along with Sompong Sirisoponsilp, who also wrote the program VIEW. Yen Jen Hung wrote the original version of the investment programming module, PROG.

This program package has been tested over several years in short courses offered by the Northwestern University Traffic Institute, under the management of Mr. Alex Sorton, who provided encouragement and feedback.

CHAPTER ONE
INTRODUCTION

Purpose of DSS

DSS stands for Decision Support System. The DSS software system was developed to encourage and support the use of more systematic and objective evaluation procedures in the planning and selection of highway improvement projects. Its particular focus is on highway reinvestment or rehabilitation projects of various sizes.

Through the integration of computer software and hardware, the DSS System is intended to make it easy, perhaps even pleasant, for the user to apply methods of economic evaluation, sometimes known as engineering economy, to the evaluation of proposed (not in-place) highway improvement projects. The system allows the user -- working interactively with the computer -- to describe a project, define its costs, specify its past (or existing) performance characteristics, and describe its expected performance when (and if) it is implemented.

Based on this user-provided information, the DSS system estimates benefits from various aspects of the proposed improvement, computes the economic worth of benefits and costs, and compares these to provide an overall economic evaluation. The system is rather highly structured, in that -- unlike a general analysis tool such as a spreadsheet routine -- it defines the structure of the analysis, including the items considered and the order in which they are treated. Some users may find this a bit constraining initially, but there is a reason for this. In the development process, we attempted to balance a number of important issues.

Issues in the Development of DSS

First, the development of the DSS system was guided by a desire to assure the reasonable use of economic evaluation tools in highway reinvestment planning. The nature of these tools imposes a useful structure on the analysis.

Second, we wanted to work with a reasonably comprehensive set of benefit types which would encompass the major economic outcomes of the most typical highway improvement projects. Some users will discover that the DSS system calls for examination of benefits which do not result from a particular project they are considering. DSS asks the user to look for such benefits, but allows each benefit category to be skipped if it is not appropriate. But as a user, you will always be asked to consider each benefit category. Consider this a reminder to be comprehensive.

In other cases, users will find that there is no room in the DSS structure to consider a benefit unique to a given project. Here, the user should (really, must) consider that benefit category outside the framework of the DSS system.

An important (and third) issue in the development of the DSS system was the effort to ensure usefulness of the system by requiring only, or at least primarily, input data which a typical user is likely to have available. As a consequence, in some cases the DSS system uses a simple way to estimate a benefit, rather than a complicated way, in order to make the users' task feasible.

We worked with a small advisory committee of transportation professionals regularly engaged in highway project evaluation to get a better sense of project types, user needs, and typical data availability. Thus, the simplifications made in program development were based on recent and typical experience and professional practice.

Fourth, we have developed a system which does not substitute for other, advanced forecasting models or computer programs. Thus, for example, the DSS system does not perform a capacity analysis, because we did not want to replicate the Highway Capacity Manual. Instead, it asks the user to estimate by whatever means (e.g., judgment, capacity analysis, etc.) certain traffic performance inputs.

In most cases where the user is asked for data which may well be supplied through judgment, the immediate consequences of those judgments or assumptions for the evaluation are displayed on the screen. Then an opportunity is provided for the user to try different values of the input parameters, the computational results of which are again shown. The intent of this style is to allow the user to test the sensitivity of judgments as they are made.

The DSS system which accompanies this manual is the result of compromises among the above, and other, factors. One of those other factors was the computer environment. The system was developed to function on a simply-configured IBM-PC or compatible system. This imposed some constraints, as did the choice of Microsoft Basic and Basic Compiler as software environments. While this form of the Basic language is straightforward and widely supported, in the version used here it is significantly constrained in terms of program length (i.e., < 64K bytes). This necessitated some major structural features of the DSS system. The compiler, the first and until recently the only version of this compiler, suffers from a number of quirks which influenced the structure and style of the DSS system.

These constraints were dealt with in program development; the software is effective and reliable, though some operating features reflecting these constraints remain. They should not, we think, make the system less useful.

Who Should Use the DSS System

The DSS system is intended to be used by professionals engaged in planning and evaluating proposed highway improvement projects. DSS is useless for before-after evaluation of improvements, and it should not be applied for this purpose. It is also suitable for use by technicians working with such professionals. No knowledge of computer programming is necessary, though it will be important for the user to be thoroughly familiar with his or her computer and its operating system.

Professionals routinely engaged in the analysis of highway improvement projects will be the most logical users, since the DSS system can make repeated evaluation efforts efficient and less tedious.

We think it is particularly important that the user have a reasonable knowledge of economic analysis methods. While the DSS system does this analysis for the user, appropriate application of the system requires intelligent application: using the system without fully understanding the methods and assumptions of economic evaluation is risky at best and dangerous at worst. This users' manual will document the procedures used in the DSS system, and it will provide some important warnings. It is not written to be a substitute for a textbook on economic evaluation.

Traveling at Your Own Risk: Some Initial Caveats

No computer program or system can make its users "smart" or protect them from all pitfalls.

The most important warning for users to understand is that, like any computer program, the DSS system is dumb: it will take any input data you give it (as long as it is within some reasonable mathematical range) and process it to produce outputs. It has no way to know if those inputs and outputs are nonsense. It is up to the user to guard against such errors.

The DSS system does not supply data. The user supplies the data. Thus, project attributes, the value of travel time, the costs of accidents, the level of improvement expected from projects, etc., all must come from the user. In some cases this will present a challenge, in that data will not always be readily available. But don't expect the program to supply it for you.

Computer Requirements

The DSS system is written for IBM-PC and compatible computers. Delivered in compiled Basic, it requires no particular run-time support software other than your computer's MS-DOS operating system. That is, with the DSS system alone, the user should be able to accomplish the procedures described in this manual. The operating system will be required to prepare (format) diskettes, to create a working version of the DSS system and to make diskettes ready for file storage.

The operating system must be equivalent to the IBM MS DOS 2.10 (or higher), since the DSS system uses certain features of that operating system, in particular, the use of configuration files (CONFIG.SYS).

The computer itself must have at least 256K bytes of random access memory available when the DSS system is called. It should have at least two disk storage devices, either two floppy disk drives or one floppy drive and one hard disk. When it is run on a dual floppy configuration, the main project evaluation routine, called MAINDSS, requires the use of a ramdisk, a virtual disk drive which the program creates in memory when it is booted (started from scratch), but not when it is called from the operating system. Thus, to use this program with a dual floppy system, you must reboot the machine, either by simultaneously pushing Ctrl-Alt-Del or by turning the machine (off and then) on.

The required ramdisk will be named as either drive C or D, depending upon which designation is available: if you have a hard disk (normally drive C), the DSS Ramdisk will become drive D. If you have no drive C, the DSS ramdisk takes that designation. You may run DSS on a computer with a fixed disk without rebooting as long as there are about 2500 bytes free on the active fixed disk directory. This will be used by MAINDSS in place of the ramdisk.

A dot-matrix printer is also required if you want printed reports of project evaluations. It can be an 80 or 132 column printer. The DSS system does not utilize graphics, and so a simple monochrome monitor is sufficient. It will also display text on a color monitor if that is the only screen output device.

DSS should function on IBM compatibles to the PC, XT, and AT, as well as 80286 and 80386 computers.

CHAPTER TWO
DSS SYSTEM STRUCTURE

DSS System Overview

The DSS system has 4 components, illustrated in Figure 1. The principal component, the project evaluation routine, is divided into two parts because of programming software memory limitations. These are called MAINDSS and PRINTDSS. MAINDSS is highly interactive: the user supplies data describing the project, its costs, and effects. The program computes various measures of the project, including economic worth of costs, cash flows by year, and benefit estimates. Each computation is done and presented to the user for review and recycling for changing inputs. A summary report is presented on the CRT screen.

The second part of the principal component, PRINTDSS, is entered only if the user wants to print a hard copy report on a project. PRINTDSS is hardly interactive at all: it is a printing "engine", and only allows the user to interrupt, restart, or terminate printing. When the print task is completed, control returns to the beginning of MAINDSS. The user will not be affected by this switch between MAINDSS and PRINTDSS, except for a slight time delay while the switch takes place.

Functionally, what happens is as follows: when the user selects the hard copy print option, all of the project data (supplied by the user and computed by the software) are written to a ramdisk file -- a small simulated diskette in the random access computer memory -- or to the active directory on your fixed disk. Then, PRINTDSS is called from the active disk drive

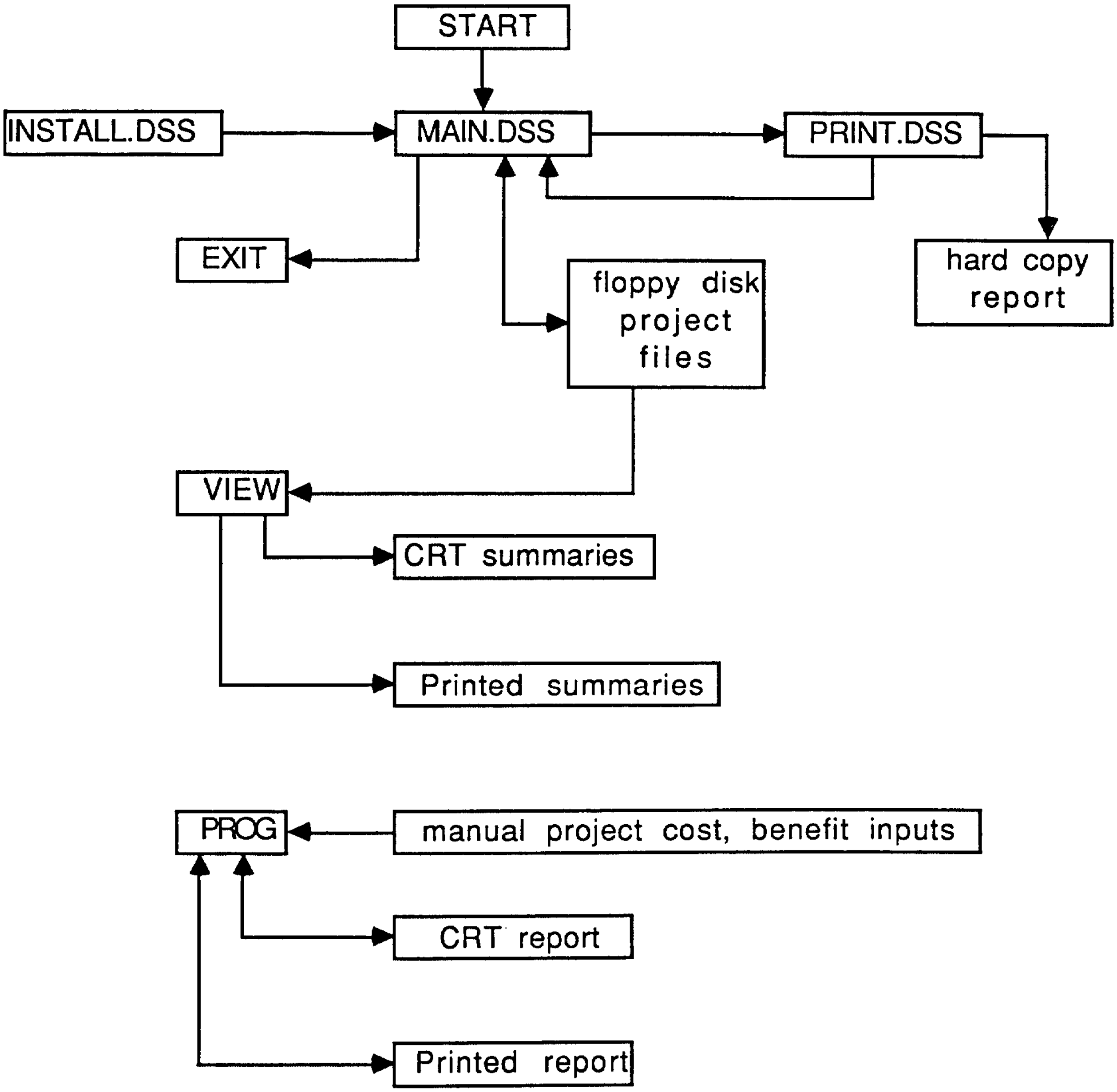

FIGURE 1: DSS SYSTEM COMPONENTS

(and directory), replacing MAINDSS in memory. PRINTDSS takes control, reads the file to be printed from the ramdisk (or fixed disk), and does the print job. Then MAINDSS is called from the active drive, replacing PRINTDSS in memory.

A program called VIEW has been written to allow the user to review project files saved by MAINDSS on floppy diskette (or fixed disk) files. Thus, without running MAIN.DSS, the user can invoke VIEW to look a project files, review a summary of results, and print hard copies of those summaries.

PROG is a program which takes data on a series of non-exclusive projects provided through keyboard input by the user, and finds the optimal investment program for a given budget level. PROG uses dynamic programming to do this, permitting users to select some projects as mandatory: that is, to choose some projects as required to be in the investment program.

PROG can accommodate up to 50 projects. However, the dynamic programming routine at its core is inherently slow, and so even in its machine language form, PROG will run quite slowly when the number of projects gets large.

The final program in the system is INSTALL.DSS, which allows the user to set default values of some key parameters used by the system. These include fuel consumption rates, accidents costs, and values for travel time. INSTALL.DSS is run once -- or occasionally -- by the user to establish default parameter values, which are written to a disk file in the default drive. This file is called STARTUP.DSS. Whenever MAIN.DSS is started, it looks for and tries to read STARTUP.DSS to get these parameter values. If it doesn't find STARTUP.DSS, it lets the user know and proceeds, using some built in default parameter values and starting with zeroes for others. The DSS system is shipped with a valid STARTUP.DSS file, but the user is urged to set his or her own default parameters before using the DSS system on a regular basis.

Program Flexibility

The program accommodates up to three pre-specified benefit types: travel time savings; fuel cost savings; and accident reduction cost savings. One, two, or all three benefit types can be examined for a particular project, although fuel cost savings can only be computed if time savings have been estimated. Benefits can be either positive or negative (disbenefits).

The DSS system analyses either of two improvement site types, intersections ("spot" locations) having zero length, or sections, with lengths greater than zero miles.

Three vehicle types are recognized and carried separately through the analysis. These are predefined as automobiles, light (single unit) trucks, and heavy (combination) trucks. The user may, by varying the data, modify these vehicle definitions, but the data labels may not be changed.

Time and fuel consumption benefits may be treated separately for peak and offpeak periods of the day. Cross street traffic is treated separately from mainline flows (for both intersections and sections) for these two benefits.

Accident reductions are disaggregated by severity class--fatal, injury, and property damage only accidents. They may be further disaggregated into two additional accident type classes (e.g. night and day accidents).

MAINDSS Program Flow

MAINDSS is made up of a series of program or procedure blocks. The program flows smoothly between these without user control, except that the user will have a series of branching options.

Entry routine: When it is started, MAINDSS allows the user to choose (1) to read an existing project file for further processing or modification or (2) to define and evaluate a new project. The user is given the option at this point only to save the new or revised project data on a disk file.

Project Description Entry: In this section of the program, the user enters the project name, description, life, opening year, and traffic data including average daily volumes, vehicle type mix, and projected traffic growth rate.

Project Cost Data Entry: Here the user enters project costs, giving the year incurred, the amount (in total dollars or dollars per mile), and the life of the investment by project component. Thus, costs for design, right-of-way, construction, maintenance and operations can be entered separately. Two "other" cost categories are available for additional items or to reflect, for example, construction costs incurred over several years. The user chooses a discount rate and the program computes present value and annualized costs.

Cash Flow Analysis: At the user's option, the program will compute cost cash flows by year over the project life based on a user-defined inflation rate. A local and nonlocal share cost breakdown may also be computed here.

Cost Allocation: In lieu of, or as a supplement to, a full-blown analysis of project benefits, the project costs may be allocated over the vehicle miles of travel (or entering vehicles for spot locations) to get a cost per vehicle mile by vehicle type. Particularly if the user is unwilling or unable to provide information to estimate benefits, the cost per vehicle mile offers a useful perspective on the worthiness of the proposed projects.

Benefits Analysis: If the user chooses to engage in an evaluation of benefits, the program allows treatment of peak period and nonpeak period traffic differently (because, for example, congestion would probably differ between these periods). At the start of a benefits analysis, the user specifies the fraction of daily traffic in the peak period. Cross street traffic is also entered at this point. Then the program calculates future traffic by time period and vehicle type over the project life, given the traffic growth rate or horizon year volume estimate.

Travel Time Savings: At the user's option, travel time benefits may be evaluated, based either on user-provided before-and-after speeds or before-and-after travel times. Speeds may only be used if the section has a non-zero length (i.e., not for intersections). This may be accomplished by time period (peak/offpeak) and mainline and cross street flows will be treated separately for both intersections and longer sections.

Valuing Time Savings: At three points in the analysis (once for each major benefit type), MAINDSS asks the user to place monetary values on outcomes. In the travel time benefits section, the task is to put a money value on an hour of travel time for each of the three vehicle types. Default values for travel time can be entered in INSTALLDSS and then read from STARTUPDSS. These values can also be entered or modified at this point in the program.

Fuel Cost Savings: Fuel cost savings are strictly based on travel time and speed changes and thus the travel time benefits section must have been completed before proceeding with this section. Values for fleet average fuel economy and idling fuel consumption are required by vehicle type; these may come from INSTALLDSS via the STARTUPDSS file, from internal software defaults, or from user keyboard input at this point. One of the default/inputs is fuel price, so that the money value of fuel consumption changes can be estimated at this point.

Accident Reduction Benefits: Here the software allows the user to define up to two classes of accidents which will receive separate treatment in the benefits analysis. For example, suppose a rehabilitation project involves realignment and new street lighting. Night and day accidents might logically be treated differently -- the street lights might eliminate a share of night accidents but no day accidents. The number of classes and their names must be selected by the user at this point.

Then up to 3 years of accident data, the number of accidents by severity class, may be entered, after which the historical accident rates are computed and presented.

Valuing Accident Reductions: Money values are placed on accident reductions just as they were for travel savings -- from the default values and/or through direct entry. The total money value of accident savings due to the proposed project is then computed.

Summary Evaluation: The next program step computes and displays summary economic evaluation measures, including annualized and present values of costs, benefits by type, total benefits, and net project worths (benefits - costs). A benefit/cost ratio is computed and a simple sensitivity analysis is conducted.

Money values of benefits may be revised at this point, and thus the user can cycle between the summary evaluation and the benefit evaluation to explore the effects of different benefit values. Then the automatic filing routine writes project data to disk file if the user requested disk filing at the start of the run.

After the summary evaluation, the user has several options: (1) print hard copy report; (2) revise analysis of current project; (3) analyse a <u>new</u> project; or (4) quit. Printing causes a data file to be written to ramdisk as stated above, after which a printed report is produced. Revising cycles through the entire program, displaying previously entered data and permitting modifications from the keyboard. Analysing a new project cycles the program to its starting point and wipes out the data in memory describing the previous project.

Figure 2 summarizes this overall program flow and clarifies branch and recycle points.

Numerous, though not unlimited, opportunities are provided for the user to correct data inputs and to modify assumptions throughout the program. Data input correction opportunities are normally presented immediately after data entry, or -- sometimes -- after the associated and primary computational results have been computed and displayed.

Wholesale changes in data may be made by recycling through the analysis process, during which previously entered and/or computed data are displayed and the opportunity to make changes is presented.

The DSS system <u>does not benefit from a full screen editor</u>. This means that the user can only cycle back to selected and limited prior points when making corrections or modifications. This inflexibility is the price paid for reducing programming complexity. It has not proved to be a major limitation, for it is easy for the user to learn the limits beyond which corrections to inputs become more difficult. And, it is easy to recycle

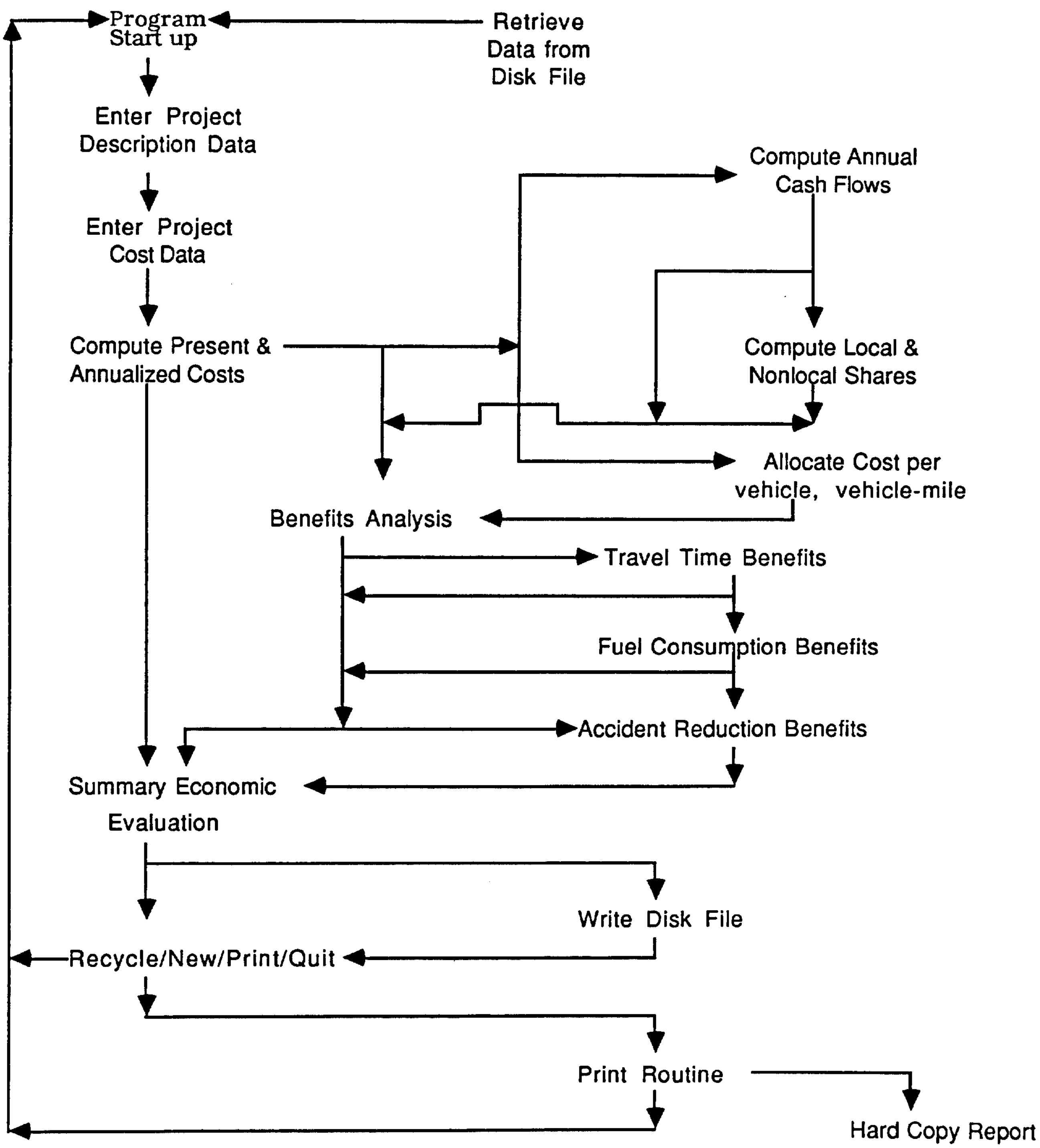

Figure 2: OVERALL FLOW OF MAINDSS

quickly through the entire program after the summary evaluation has been presented on the screen.

CHAPTER THREE
GETTING STARTED WITH DSS

Preparing System Diskettes

Floppy Disk Systems: The first thing the DSS user should do is to prepare two bootable DSS diskettes, each of which contains part of the DOS (2.10 or higher) operating system, one for the main program files and one for the capital budgeting routine, PROG. DSS is not shipped with the operating system on the diskette. Therefore, the user should prepare two appropriately formatted diskettes, as follows:

1. Enter DOS (e.g., by booting the computer with DOS in drive A); respond to the DATE and TIME prompts. You should see the Prompt "A>".
2. Type "FORMAT B:/S" <return>. The prompt should tell you to put a blank diskette in drive B and hit <return>. The blank diskette will be formatted with the bootable segment of the operating system on it.
3. Remove the newly formatted diskette and replace it with a blank one; format the second diskette as in step 2.

Now you must copy the DSS files from the delivery diskette to your formatted diskettes:

4. Put the DSS delivery diskette in drive A; put one of the newly formatted diskettes in drive B.
4. Type "T" <return>. This will copy the main program files on the delivery diskette (in A) onto the newly formatted system diskette (in B). The program will prompt you to remove the first diskette from drive B,

and replace it with the second blank, to which the remaining files will be copied.

Floppy diskette users may now go on to the installation procedure described below.

Fixed Disk Systems: You may install DSS on your fixed disk. First, be sure that you know how to use your fixed disk system. The instructions below are a bit less specific than those for floppy diskette systems, as fixed disk systems may differ.

1. With the computer on and the root directory (e.g., C:\) active, create a subdirectory for DSS: type "MD DSS" <return>. This creates a subdirectory called "DSS". (You may choose any valid directory name you wish).

2. Change the default directory to your new DSS directory: type "CD \DSS" <return>.

3. Put the DSS delivery diskette in the floppy drive (drive A) and type "COPY A:*.*." <return>. This will copy all of the DSS delivery file onto your fixed disk under subdirectory "DSS".

4. DSS is delivered with an autoexecution file, which will start DSS when you reboot your computer. Since you will not want this on your fixed disk, with "DSS" as the default directory, type "ERASE AUTOEXEC.BAT" <return> to delete this file from your fixed disk.

We suggest that you place the DSS delivery diskette in a safe place as your backup. Note that DSS is not copy protected. You may make additional copies using the procedure described above.

Installing DSS

You may now set the default values for key parameters which DSS uses. Each of these parameters will be automatically offered to the user with each pass through DSS. These parameters can be changed at run time, but it is more efficient to set as defaults the values you will most commonly use.

Make sure the DSS files are in the default drive. For a floppy drive installation, this (usually) means drive A. For a fixed disk system, make sure that the DSS subdirectory on the fixed disk is the active directory.

Then type "INSTALL" <return>. This loads and runs the installation program, which will prompt you for default parameter values. Enter each, in sequence, followed by <return>.

The parameters to be specified, along with their default values supplied in the file STARTUP.DSS, are:

- value of travel time for autos, $/hour ($2.50);
- value of travel time for light trucks, $/hour ($5.00);
- value of travel time for heavy trucks, $/hour ($7.50);
- cost per accident for fatal accidents, $/accident ($350,000);
- cost per accident for property damage accidents $/accident ($1,000);
- cost per accident for injury accidents, $/accident ($5,000);
- price of motor fuel, $/gallon ($1.00);

- fleet average running fuel consumption for autos, miles per gallon (16.30);
- fleet average running fuel consumption for light trucks, miles per gallon (12.90);
- fleet average running fuel consumption for heavy trucks, miles per gallon (5.70);
- fleet average idling fuel consumption for autos, gallons per hour (0.5)
- fleet average idling fuel consumption for light trucks, gallons per hour (0.70);
- fleet average idling fuel consumption for heavy trucks, gallons per hour (2.00).

NOTE: The user should provide values for these parameters which reflect local conditions and which are suitable for use over the typical project time frame. This would allow you to introduce projected improvements in fuel economy if you wish.

The vehicle types are merely accounting categories: while you cannot change the names of these types in the program, you can set the values to represent any 3-part classification you wish.

In the development process, we have assumed "autos" to mean all types of automobiles, "heavy trucks" to mean all tractor trailer combination trucks, and "light trucks" to mean all other single unit trucks. Diesel and gasoline powered trucks are lumped together because the fuel price differences for these types are now small.

Note also that the accident costs should be cost per accident, not cost per fatality or injury.

When you have completed entry of these defaults (revising your entries as necessary) confirm the entries in response to the prompt. When you have done this, the installation program will prepare and write to your default directory a file called "STARTUP.DSS."

Each time you load DSS, the program will look for this file and, upon finding it, will load and use your default parameter values. If the STARTUP.DSS file is not present, the program will so notify you, and will proceed with execution with built-in default parameter values.

You may change the default parameter values as often as you like. Before you start the installation procedure, be sure that there is no write protect tab on your DSS system diskette, since INSTALL will try to write to this file.

FLOPPY DISKETTE USERS SHOULD NOW REMOVE THE DSS SYSTEM DISKETTE FROM DRIVE "A" AND PLACE A WRITE PROTECTION TAB ON IT. This will become your standard DSS diskette.

Starting DSS

BEFORE YOU RUN DSS, READ THE DETAILED PROGRAM DESCRIPTION IN CHAPTER 4. Lack of understanding of program operating characteristics may produce misleading results and/or cause program failures.

But, for familiar users anxious to get going with DSS, we present here instructions for starting the program.

With the Computer Off: From a "cold start" on a floppy drive system, put the DSS system diskette in drive A and turn on the machine. The computer should boot, ask for date and time (which you should always provide since floppy files and reports are always date/time stamped), and then load and run DSS.

Floppy diskette users should have a formatted diskette in drive B with sufficient space on which to store project files. These files are small -- around 2,500 bytes or less per project. The AUTOEXEC.BAT file supplied on the DSS system delivery diskette will automatically run DSS.

On a fixed disk system, boot the computer and enter the date and time. Then change to the DSS subdirectory (with "CD\DSS" <return>, and type "DSS" <return>. This will load and run DSS.

You may wish to create a batch file for automatically running DSS on your fixed disk system. Suppose the DSS system is on your fixed disk in a subdirectory called DSS, and you wish to provide quick access to it from the root directory. Make the root directory active (CD\ <return>) and respond to the prompt with:

COPY CON:DSS.BAT <return> {accept batch file DSS.BAT from keyboard}

CD\DSS <return> {change active subdirectory to DSS}

DSS <return> {run DSS}

CD\ <return> {when DSS is finished, return to root directory}

F6 <return> {end batch file and copy to active (root) directory}

To run DSS from the root directory, simply type DSS <return>.

As long as there is sufficient space available on the fixed disk, project files may be stored on this (default) drive. Alternatively, fixed disk users may also store and retrieve project files from the floppy drived; a formatted disk should be provided if this is to be done.

NOTE!!! For floppy disk users starting with the Computer on: To transfer files from the main DSS routine to the hard copy print routine, DSS uses a RAM disk which it creates when the program boots from a "cold start". Thus, floppy drive users who may want to print hard copy must start each session by (re-) booting the computer from the DSS system diskette in order to allow DSS to create the required RAM disk!!

With the computer on, this can be done by simultaneously pressing control, alternate, and delete (Ctrl-Alt-Del) with the DSS system diskette in drive A.

DO NOT START DSS BY TYPING "MAINDSS" <return> FROM A "HOT START" (computer already on) with a floppy system! If you do, the RAM drive will not be available, and the print routine will fail. (The program should not crash in this case. A special file will be written to your floppy drive called "ERROR.FIL" which will have in it all project attributes. You can later retrieve this like any other project file).

On fixed disk system, with the computer already on, simply change to the DSS subdirectory ("CD\DSS" <return> and call DSS

"MAIN.DSS" <return>. In this case, the hard copy print file will be stored temporarily on your fixed disk.

Other programs in the DSS system (i.e., VIEW, PROG) can be run by calling them from DOS. That is, with the operating system "up" (e.g., with an A> or C> prompt), make sure the DSS diskette or subdirectory is the default drive, and then type in the program name (e.g., "VIEW") followed by <return>. To run VIEW, the project files to be viewed should be in an available (Not necessarily default) drive or subdirectory.

Since floppy drive system users were instructed to put PRO on a separate diskette, that diskette must be in the active drive to run PROG.

CHAPTER FOUR
PROGRAM OPERATION AND USE

Entering Data and Commands

DSS has special requirements for data and command entry. Almost all program commands -- which are usually presented in inverse video -- such as branching instructions, call for single key entry. This means that when DSS asks you to select a branching option from a numbered list, for example, you must only enter the number without following it by <return>.

In this case, DSS knows how long the instruction string will be (one character), and so it knows when you have completed entering that string. Where DSS does not look for <return>, an unnecessary <return> will be stored in the keyboard buffer and WILL BE USED AT THE NEXT DATA OR COMMAND ENTRY POINT. Thus, the unnecessary <return> will provide an incorrect input item, and it may cause you to lose a control opportunity at the next branch point.

Use <returns> to follow ONLY data string or numerical entries, or file names. Do not follow branching instructions with <return>!

Character inputs, such as project of file names, should be entered from the keyboard, corrected as necessary using the delete (DEL) and cursor keys or destructive backspace key, and followed by <return>.

Numerical inputs, such as project length, costs, accident history, etc., can be entered using the number keys at the top of the keyboard or the numeric keypad. The latter is faster and easier, and thus we recommend that, when you start DSS, you push "NUM LOCK" to activate the numeric keypad, or use the dedicated numeric key pad if your keyboard has one.

To correct numerical data inputs (in DSS only, not in VIEW or PROG), hit the backslash key (\). This will erase the number you are entering (before you hit <return>) from both the keyboard buffer and the screen display. Then, you can re-enter the correct numerical data. NEITHER THE DELETE KEY (DEL) NOR THE DESTRUCTIVE BACKSPACE WILL WORK IN DSS.

The reason for this is that a numeric data input trap has been written into the program which screens out any non-numeric keyboard inputs (e.g., letters, dollar signs, periods, commas, etc.). If you press any non-numeric key when numeric data is expected, the computer will "beep" and ignore your input. Thus, it also ignores "DELETE" and destructive backspace. it recognizes "\" as a command to erase data and receive corrected values.

While this takes some experience to get used to, it saves an immense amount of grief in routine applications; without this feature, entering non-numeric inputs where numbers are expected would interrupt the program with an error message and destroy the data entry screen format.

At several points in DSS, if you enter incorrect instructions (e.g., branch option 4 when only 3 branches are available; or a file name which cannot be found), the program will cause the computer to "beep", an error message will be displayed in inverse video, and a short time delay will be imposed so you can read the message. Then the program continues by giving you another chance to enter the correct instructions.

The standard procedure in DSS is to provide the user with an on-screen "form" to fill in. Use only the space provided on this "form". Do not go beyond this space or the screen display will be broken up and subsequent data entry will become difficult.

Remember, DSS does not have a full screen editor. This means you should try to correct data entries before hitting <return>. You cannot bounce freely around the screen to change inputs. You will be provided with periodic opportunities to correct the immediately previous collection of entries which have been followed by <return>, but once you pass the inverse video "change inputs (Y,N)" response, the only way to make a change is to recycle the entire analysis of the project you are studying.

Incidently, you should respond to the prompt "change inputs (Y,N)" with single letters, y, Y, n, or N, not followed by <returns>.

The Startup Screen

When DSS is started, you will be presented with three options:

1) Retrieve Data from File

2) Define New Project

3) Quit

Implement the path you wish to follow by pressing the SINGLE NUMBER associated with it on the menu.

Retrieving a File: Retrieving an existing file means pulling back into DSS a project file which has already been written and saved by DSS. If you choose option 1, you will see a new screen which give you an opportunity to view an abbreviated directory of the files in drive A:, B:, or the active directory of drive C:. This is useful if you have forgotten the name of the project file you want to review.

> NOTE: Data describing several projects, or perhaps different versions of the same project, can be stored in a single data file. Thus, when you run DSS, you could define a file called, for example, KNOXCO, containing all current projects in Knox County. If you want to retrieve one of those projects, you do so by retrieving KNOXCO.

If you know the name of the file to be retrieved, you can skip the drive directory option by hitting <return>.

Whether or not you have called for the directory, when retrieving a file DSS will next ask you to name the file to be pulled in.

If that file is in the default drive (and directory), you need only enter the complete file name, including extensions, if any. Thus, you can respond to the file name prompt with something like: KNOXCO, or if there is a filename extension, KNOXCO.DOT.

If the desired file is on a drive other than the default, you must enter that drive name, a colon, and then the complete file name. If you are running DSS from your fixed drive, directory

DSS, and you wish to retrieve a file on drive A:, you might type A:KNOXCO.DOT <return>.

If DSS cannot find the file you name, perhaps because you typed the wrong name, it will recycle the file retrieval screen.

Once the file is found, DSS will show you the project location, proposed action, and date of record creation for each project in that file, in sequence. In each case, you will be asked if this is the file you wish to work on. If it is, type "y" or "Y"; if it is not (and thus you want to continue to flip through the projects in the named file), type "n" or "N".

> NOTE: DSS recognizes responses to prompts which are either lower or upper case characters; you may use either type. DSS accepts <return> as equivalent to "n" or "N" for responses to branching prompts.

If DSS runs out of projects in a file before you find the one you want, it will again recycle the file retrieve screen.

Once you select the file you want, DSS will ask whether you wish to save the changes you will make in it. What it really means is, "do you want to resave this project data set-- whether or not you change anything in it." If you respond to the question with "y" or "Y", the project data record will be appended to the file you have retrieved. Its a good idea to edit the project location identifier when you get to it to indicate "version 2" or something else to remind you that this is different from the original project data record.

Defining a New Project: Select option 2 from the startup screen, if you wish to analyze a project not now on file.

The program will then ask if you want to file the data record from this project, and if so, under what drive and file name. If the file name you select already exists in the active (or selected) directory, the program will warn you and ask if you wish to use a different file name, write over the old file (thus destroying it), or append the record for this new project analysis to the existing file.

IF YOU FAIL TO ASK FOR THE PROJECT DATA TO BE SAVED TO DISK FILE AT THIS POINT, YOU LOSE THE OPPORTUNITY TO DO SO. The data will be written to disk automatically after you have entered all items and DSS has completed its analysis.

Quitting: If you elect to quit DSS at this point, you will return to the operating system and the DSS directory will be active. If you wish to quit anywhere in the middle of a DSS analysis run WITHOUT SAVING YOUR WORK, press ctrl-break (control-break).

Entering Project Description

Now you are ready to enter data about the proposed project. NOTE: If you are reviewing an "old" (filed) project, the procedures described from here on are the same as for a new project, EXCEPT that the old data will be presented on the screen, and you will be given the option of making revisions at each point. You can choose to revise an item by typing "y" or "Y" when given the choice. Or you can skip through parts or all of the project record without making changes. To answer "no" to a branching question you may type "n", "N", or <return>.

In the data entry process, you will see a full-screen form; the cursor will automatically bounce to the first (or next) data entry position. Enter the data item requested, being careful not to go beyond the space on the allotted form. Follow each data item with <return>.

NOTE: Branching instructions should be answered with single key entries, without <return>.

Correct alphanumeric entry errors with the destructive backspace or delete keys; the cursor keys will be functional. Correct numeric data entries by using the backslash (\) key, which will erase the entry and allow you to rekey the item.

Every few lines, you will get a branching opportunity to revise the last <u>series</u> of input items. If you want to make a revision, type "y" or "Y", select the number of the item to be changed, and the old entry will be erased. You may then enter the revised item.

<u>Initial Project Description Panel</u>: In the first panel you will asked to define the PROJECT LOCATION and the PROPOSED ACTION. Use clear descriptions to facilitate retrieving the right file at a later time.

The SECTION LENGTH in miles will be used to evaluate vehicle miles of travel and the costs and benefits related to it. If you enter a zero (or just hit <return>, which is read as a blank, the program assumes you are analyzing a spot location (intersection). The PROJECT LIFE is the time horizon, in years, over which you want to amortize (and thus evaluate) the proposed project.

AADT is the most recent average annual daily traffic on the link or the <u>total entering volume</u> at the intersection. This is used to estimate benefits. Next you are asked for the YEAR of the AADT. This is used to project AADT to the opening year of the project, as well as to future years for benefit estimation.

NOTE: ALL YEARS SHOULD BE ENTERED IN FULL. That is, do not use "88" when you mean 1988. You MUST enter the full label, 1988!!

You will then be asked for the YEAR the project OPENS. This is to accommodate cases where the opening year is different from the AADT year or the year you are doing the analysis. Traffic volume will be projected from the AADT year to the opening and future years using a constant annual percentage growth (or decline) rate. Costs incurred before the opening year will be treated as if they were incurred in the opening year.

In the next panel you must supply the percentage breakdown of traffic at the project site by each of three vehicle types, autos, light (single unit) trucks,and heavy trucks. Travel time and fuel cost savings will be computed separately for each vehicle type. The percentages for each vehicle types must add to 100%; if they do not, DSS will warn you and recycle to allow you to re-enter these percentages.

DSS forecasts traffic growth (or decline) over the project life based on a constant, annual percentage growth rate. You are asked to supply this growth (or decline rate, entered as a negative value), or to hit <return> which signals the program that you have a prediction of design year (end of the project life) traffic from some other source. You will be asked for this prediction.

In either case, DSS computes (either) the end-year volume or the constant annual percentage growth rate to give you the opportunity to review these figures and revise your forecasts at this time. If you have a constant annual percentage growth rate to begin with, you can use the DSS- computed end-year volume as a reasonableness check to be sure that the projected volume does not exceed the capacity of the facility.

From this point on in the operation of DSS, the last line on the left side of the screen will show the proposed action, the project location, the year the project opens, and the life of the investment. This serves as a reminder of what project you are analyzing and its key parameters.

NOTE: The standard printed report provided by DSS will include ALL of your input data as well as ALL computed results. However, if at any point in your use of DSS you see a screen which you wish to preserve, you may press shift-PrtSc (shift-print screen) with a printer online and the screen image will be printed without otherwise affecting the operation of the program.

Provider Cost Data Input

The next screen allows you to enter the provider's costs for the project, that is, the cost to implement, maintain, and operate the improvement. These costs are requested in 7 categories to allow you to account for the fact that the effective lives of these components may be different. The cost categories are:

Design (or engineering) costs;

R-O-W (Right-of-Way) Costs;

Construction Costs;

Maintenance Costs; ⎤ These categories assumed to recur at intervals equal to their service lives.

Operating Costs; ⎦

Other; you may enter any other costs here.

Other; you may enter any other costs here.

The input panel permits you to enter different years of occurrence, and different service lives, for each cost component. Any of these costs may be assigned a zero value by pressing <return> for FIRST YEAR PAID. DSS supports easy analysis of relatively complex patterns of project costs, allowing you flexibility in cost representation, and computing equivalent uniform annualized costs, and the present worth of costs, for each component, as well as for total project costs. This is the first major analysis product of DSS.

For each cost component, you must enter:

The YEAR it is FIRST PAID (a <return> means you have no cost in this category); As before, you must enter all four digits of the year, i.e., "1988," not "88."

LUMP SUM COST value (a <return> here means that you wish to enter unit costs per project mile, which brings you to the next item...

PER MILE COST (entered only if lump sum cost is zero (signified by <return>).

(If you enter per mile costs, DSS computes the lump sum value and writes it to the screen.)

LIFE of the component, which defines the period over which it is amortized.

If the construction cost is incurred in several parts over two or three years, you can indicate this by assigning the first part to CONSTRUCTION COST, and the second and third to the two OTHER cost categories.

All of the costs should be INCREMENTAL, that is, the cost over and above those costs incurred if the project is not implemented. The program accommodates both negative and positive costs, with negative costs signified by entering a "-" sign before the number itself. Negative costs do not make sense for the one-time costs associated with design, right-of-way, and construction; they may be appropriate for recurring costs if the project results in reductions in maintenance and/or operating costs. Such reductions would be represented by negative cost values.

Once you have entered these costs, and have had a chance to modify them, DSS asks for a discount rate, representing the time value of money. This is used in the program to convert all of the cost items to an annualized basis, amortizing each over its unique life. A default discount rate of 10% is built into the software, which you can change at this point.

When it has the discount rate, DSS computes the annualized and present values of each cost item, as well as total annualized and present worth costs, and writes them to the screen. You may then revise the discount rate if you wish.

For example, suppose we are evaluating a four mile-long project for which the $125,000 design cost was paid in 1986, prior to the analysis year (1988). Right-of-way cost is $225,000 per mile, and is assumed to have a fifty year life. The Initial construction cost of $850,000 is a lump sum value with a 20 year life. The project results in a <u>savings</u> in biennial maintenance cost of $4,000 per mile, beginning in 1990, the first year maintenance must be applied. Annual operating cost is $1,000 more than for the current facility. The final construction cost increment of $98,000 per mile is applied in 1989. In this case, the provider cost data input screen would be filled in by the user as shown in Figure 3.

If the user selected a discount rate of 8%, DSS would compute the equivalent uniform annualized costs and present worth costs and produce the results shown in Figure 4. Note that the right-of-way life extends beyond the project life, and as a result, DSS

ITEM NAME	(FIRST) YEAR PAID	LUMP SUM	PER MILE	LIFE YEARS
Design	1986	$125,000		20
R-O-W	1988		$225,000	50
Construction	1988	$850,000		20
Maintenance	1990		-$4,000	2
Operation	1989		$1,000	1
Other	1989		$98,000	20
Other				

FIGURE 3
EXAMPLE OF PROVIDER COST INPUT

ITEM NAME	(FIRST) YEAR PAID	LUMP SUM	PER MILE	LIFE YEARS	ANN. COST	PRES. COST
Design	1986	$125,000		20	$12,732	$125,000
R-O-W	1988	$900,000	$225,000	50	$73,569	$722,307
Construction	1988	$850,000		20	$86,574	$850,000
Maintenance	1990	-$16,000	-$4,000	2	-$8,126	-$79,784
Operation	1989	$4,000	$1,000	1	$4,320	$42,414
Other	1989	$392,000	$98,000	20	$39,926	$392,000
Other						
	TOTAL COST				$208,994	$2,051,938

FIGURE 4
EXAMPLE OF PROVIDER COST INPUT AND CALCULATED RESULTS

only charges the project for the share "consumed" during the project life ($722,307 vs. $850,000). The difference is the salvage value, the worth remaining in the right-of-way.

The ability of DSS to manipulate complex cost time streams should be useful to transportation professionals even if they are unable or unwilling to evaluate project benefits.

Financial Analyses

At this point you are presented with several branching options for looking at the financial (i.e., "real money" outlay) implications of the project. This information may be useful for agency financial planning. First, you may examine the implied cash flows associated with the project, that is, the year-by-year outlays associated with the recurring costs (maintenance and operations). DSS simply projects forward, for each year of project life, the annual expenditures. The user may enter a constant INFLATION RATE to see how these recurring costs may be affected by inflation.

DSS applies the inflation rate savings in recurring costs (i.e., negative costs) by reducing the savings as a function of inflation for each year of the project life.

Whether or not you ask for the cash flow analysis, DSS will then offer you the opportunity to see the "local share" of the total cost stream associated with the project. This might be useful in differentiating between, for example, federal and local project costs. The user must specify a single percentage value, which is used to split ALL project costs between the "local" agency and other sources of funds. DSS then produces the time stream of "local" costs over the project life.

The user may cycle between inflation rate and local share calculations, following branching instructions shown on the screen.

NOTE: If you do not elect to evaluate cash flows or local share, this information will NOT be available in the report that DSS prints at the end of the project analysis.

Cost per Vehicle Mile Analysis

One way to assess the worth of a proposed project is to estimate how much it costs for each vehicle mile (or entering vehicle) using the facility over the project life. Even if you cannot estimate the true benefits, getting an idea of the incremental provider costs per user-trip may help decision makers to evaluate whether or not the project is worthwhile.

This analysis is an option presented to the user as a branching opportunity. If it is selected, the cost allocation screen is presented and the user must then choose weights for allocating project costs to vehicle types. These weights represent "passenger car equivalents," reflecting the share of capacity used by each vehicle type and thus the share of project costs to be allocated to each.

Default vehicle type weights are offered to the user, which may be changed at run time to any values you wish to test. Assigning equal weights to all vehicle types will, of course, simply allocate total project life cycle costs equally across all vehicle miles (or entering vehicles for intersection improvements).

User Benefit Analysis

The next portion of DSS supports the evaluation of user benefits, in terms of travel time savings, fuel cost savings, and accident reduction savings. You may skip the benefit analysis entirely, or elect to analyze all or any of the three benefit types by following the branching instructions presented.

DSS has the capability to treat peak period and off-peak traffic operations differently. The first screen in the user benefits analysis asks you to enter the percentage of all-day traffic that travels in all peak periods. This is important if congestion and therefore traffic flow characteristics are significantly different during these two periods.

If you wish to separate peak/off-peak flow characteristics, you must estimate the percentage of traffic moving in the peak periods. For example, if 10% of the ADT moves in the morning peak, and 8 % in the evening peak, you should enter 18% in the peak percentage field. You may treat all time periods equally by setting the peak period percentage to zero (you may simply hit <return> in this field).

DSS provides limited treatment to cross-street flows which may be affected by the improvement. For roadway section improvements, flows on ALL cross streets over the section are aggregated. At this point in the program, you must enter the total cross-street ADT flow in response to the prompt on the screen. For intersections, the cross-street value should be the flow on the minor street, a subset of the total entering volume you supplied earlier. The cross-street volume may be zero.

Now DSS is ready to evaluate each benefit category. You are offered the opportunity to analyze travel time savings, fuel cost savings, and accident cost savings in sequence. You may select each, or skip any of these categories.

Travel Time Savings: To estimate travel time savings, you must estimate and enter the before- and after-improvement per vehicle travel times savings directly or, for roadway section improvements, you may provide the before and after average travel speeds, which DSS will convert to time and time savings.

> NOTE: For spot locations (intersections), be sure that you choose the option to enter travel time savings directly! If you elect to enter speeds, DSS will set all travel time changes to zero no matter what before and after speeds you enter!

For cross-street flows, you must provide an estimate of the before and after per vehicle travel times. These two ways of getting at user travel time savings are provided to give the DSS user more flexibility in application of the analysis system.

In either case, you will be presented with a new screen, on which you must enter the CURRENT or "before improvement" SPEED (or travel time) and the EXPECTED or "after improvement" SPEED (or travel time) on the MAINLINE, defined as the section of interest in your analysis. This must be done for both peak and off-peak flow conditions if you have elected to treat these periods separately.

DSS then computes the difference in speed (or travel time), and, for sections of non-zero length where you have entered speeds, it computes the current, expected, and saved per vehicle travel times. You are then presented with an opportunity to re-estimate before and after speeds or times.

This iterative opportunity is intended to allow users with limited objective information to make reasonable judgments in the benefit estimation process. As should be evident throughout this program, we have tried to make it difficult to ignore cost and benefit categories by making it easy to make good guesses about input data, and to test those guesses by seeing their implications (almost) immediately.

After you have completed data entry for the mainline flow travel time savings, DSS presents you with a similar input screen for data about cross-street flow. Here, you MUST provide before and after cross street per vehicle travel times, since there is no valid measure of the section length on the cross-streets which would support converting speed estimates to time saved. The data entry and iteration opportunity are identical to that used in the mainline analysis.

Valuing Travel Time: One of the more problematic tasks in performing an economic evaluation of travel time savings benefits is assigning monetary values to time saved. DSS supports this process by allowing the user to test different values of travel time, in terms of dollars per vehicle hour by each of the three vehicle types used in its accounting scheme. When you select an hourly rate, the aggregate present worth of travel time savings is immediately displayed on the screen, so you may see the implications, and judgmentally test the reasonableness, of your estimates.

NOTE: You MUST select values for per vehicle travel time using this screen if benefits in this category are to be evaluated. That is, even if you know you want to accept the default per vehicle travel time values, you MUST select each vehicle type and explicitly accept the unit travel time value for each. Otherwise, these time savings will all be valued at zero.

The screen presented for this process is perhaps the most complicated element of DSS, yet the user should find it easy to work with after only a little experience with the program. The initial appearance of this screen is shown in Figure 5. You should focus your attention on the options menu in the lower right corner of the screen. To see, modify, and/or accept the value of auto travel time, press "1"; this will implement the default hourly value of auto travel time (set in the installation process, or at $2.50/hour otherwise). This value will appear as the first entry in the AUTO column. Below it DSS will write the present worth of the total time stream of savings over the project life. To the right, under TOTAL, you will see the

```
      VALUE OF TRAVEL TIME AND TIME SAVING BENEFIT ESTIMATE

                        AUTOS  LIGHT TRUCKS  HEAVY TRUCKS   TOTAL

VALUE OF TIME
$ PER VEHICLE HOUR

TIME SAVING BENEFIT
PRESENT WORTH TOTAL $

    INSTRUCTIONS                         OPTIONS MENU

Push F9 to decrease value        1> change auto time value
Push F10 to increase value       2> change light truck time value
Push <return> to go to MENU =>   3> change heavy truck time value
                                 4> accept all values
                                        SELECT =>
```

FIGURE 5
TRAVEL TIME VALUATION SCREEN

aggregate value of time savings benefits for all vehicle types.

If you wish to change the value of auto travel time, you may:

- Use function keys 9 or 10 to decrease (F9) or increase (F10) the value of auto travel time in decrements or increments of $0.25/hour. The effect of such changes on aggregate time savings benefits will be computed and shown immediately on the screen.
- You may also use the number pad on you keyboard to enter travel time value increments directly, followed by <return> (no dollar signs, please).

When you are ready to look at the value of travel time for light trucks, press <return> to go back to the menu in the lower right corner, and the press "2". The procedure will be identical to that followed for auto travel time value at this point.

Having treated light truck travel time value, press <return> to go back to the menu, and then press "3" to see and explore time savings values for heavy trucks.

If you wish to accept the default values of travel time for each vehicle type, simply cycle through the process by pressing:

1 to select auto

<return> to accept value

2 to select light truck

<return> to accept value

3 to select heavy truck

<return> to accept value

When you have completed the analysis of each vehicle type, (be sure you return to the menu and) press 4 to accept all travel time values. You will be able to get back to this panel at the end of the analysis session if you wish.

The "final" form of the time valuation screen will look something like Figure 6.

Fuel Cost Saving Benefits: The next analysis option allows the user to estimate the savings in fuel costs produced by the proposed improvement. FUEL COST SAVINGS ONLY OCCUR IF THERE IS A CHANGE IN OPERATING SPEED (or travel time). If you showed no speed changes in the previous benefit module, it is not possible to estimate fuel cost savings, and DSS will skip over this component.

The display panel presented if you elect to estimate fuel cost savings asks you to confirm or enter new values for fuel consumption rates. For each of the three vehicle types, DSS requires a fleet average fuel economy figure, in miles traveled for each gallon of fuel. It also requires an estimate of fleet average idling fuel consumption by vehicle type to compute fuel consumption of vehicles waiting to proceed in traffic.

DSS also will need an estimate of the average cost per gallon of fuel. This number should be selected to reflect current and expected prices, and to be a judgmental composite of diesel fuel and gasoline costs.

The underlying fuel consumption model (see appendix A) requires that you decide whether the flow conditions on the

VALUE OF TRAVEL TIME AND TIME SAVING BENEFIT ESTIMATE

	AUTOS	LIGHT TRUCKS	HEAVY TRUCKS	TOTAL
VALUE OF TIME $ PER VEHICLE HOUR	$2.500	$5.000	$7.500	
TIME SAVING BENEFIT PRESENT WORTH TOTAL	$4,689,408	$1,213,729	$662,034	$6,565,171

INSTRUCTIONS

Push F9 to decrease value
Push F10 to increase value
Push <return> to go to MENU =>

OPTIONS MENU

1> change auto time value
2> change light truck time value
3> change heavy truck time value
4> accept all values
SELECT =>

FIGURE 6
TRAVEL TIME VALUATION SCREEN WITH EXAMPLE RESULTS

mainline are classified as "interrupted" or "uninterrupted." Interrupted traffic flow is what we experience when there are relatively frequent stops or acceleration/deceleration cycles. CROSS STREET FLOW IS ALWAYS ASSUMED TO BE INTERRUPTED. You should generally assume that when running speeds are less than 30 miles per hour, the flow condition is interrupted.

Default values for these parameters are built into DSS based on fleet average figures for the early 1980s. Using the INSTALL program, the user may define new default values which are entered each time DSS is started. Alternatively, the user may modify each of these values at run time using the fuel consumption cost screen.

> NOTE: In selecting values for fuel consumption and price, as well as for user travel time in the previous DSS element, you must select single parameter values to reflect these factors over the life of the project. Therefore, you should think ahead to make a reasonable, judgmental estimate of what these values may be over the project life.

You may accept all fuel consumption parameter values DSS presents by pressing <return>; pressing any other key will allow you to enter new values FOR EACH parameter. These new values will be written to the right of the old ones. Actual fuel cost savings will not be calculated until you respond to the CHANGE VALUES? prompt with either "n" or <return>.

Accident Cost Reduction Benefits: The last optional benefit category treated within the DSS system is the savings due to reductions in accident rates. If you elect not to evaluate accident reduction benefits, DSS skips directly to a benefit-cost summary.

DSS disaggregates accidents in two dimensions. First, it AUTOMATICALLY treats fatal, injury, and property damage only (PDO) accidents separately, since the economic costs of these accident types are radically different. Second, DSS gives you the OPTION to separate all accidents into one or two MUTUALLY EXCLUSIVE subcategories defined by the user. This will give you some added control over the benefit estimation process, allowing you to represent the effect of an improvement which has a differential impact on two classes of accidents. By MUTUALLY EXCLUSIVE we mean that the sum of the accidents in these one or two categories must be less than or equal to the total number of accidents.

For example, the two categories might be day and night accidents, which would be useful where the improvement is expected to affect daytime and nighttime accidents differently (e.g., reflectorized markings, lighting enhancements, etc.). If the improvement included larger clear zones and/or break-away sign posts, it would be important to separate run-off-the-road accidents from all other categories.

DSS begins the accident reduction analysis by asking you to specify the number of years of accident history you wish to enter; this information is used to establish a before-improvement accident rate by severity class (fatal, injury, and PDO accidents). You may enter no more than three year's worth of accident histories. It is advisable to gather a full three year history to be confident that the computed accident rates are representative of conditions on the roadway.

Next you will be asked to define the number of MUTUALLY EXCLUSIVE classes into which you want to further disaggregate the accident experience at the project location. If you do not wish to implement this disaggregation, you must respond to the prompt with <return>. If you wish to disaggregate to two classes, enter "1" or "2" as desired. Working with 1 subcategory will allow you to name the single accident class to which unique reduction factors are to be applied. Of course you must have accident history data for this subcategory.

The next screen presented by DSS asks you to enter the accident history one year at a time, for the number of years you selected. These should be entered starting with the earliest year. DSS sends the cursor in sequence to the fatal, injury, and PDO accident categories. In each, enter the number of accidents in that severity class for that year, followed by <return>. Then enter the historical average daily traffic (ADT), which is necessary for computing the accident rates. For spot (intersection) locations, enter the ENTERING VOLUME.

DSS will accept data for one year at a time and allow you to modify the inputs for each year before proceeding to the next year. If you disaggregated the accident history further, DSS will ask for the accident history breakdown in these categories, using the names you just supplied.

NOTE: Since the special accident categories are defined to be mutually exclusive and a subset of total accidents, the sum of the accidents across all special categories must be less than or equal to the total accidents you entered for each severity class. If not, DSS will recycle this input step.

DSS then computes the accident rates from the entered data history by finding the average number of accidents per year for each class and dividing that number by the average ADT (times the section length to get vehicle miles for non-intersection cases). Rates for fatal accidents are in terms of accidents per hundred million vehicle miles of travel (VMT) or (for intersections) per hundred million entering vehicles. Rates for injury and PDO accidents are per million VMT (or entering vehicles).

These rates are presented to you at this point for your review; you may proceed to the next screen by pressing <return>. DSS assumes these rates will remain constant into the future in computing the no-project (null alternative) accident costs; these rates will be reduced by application of the user-supplied constant reduction factors to project with-project accident costs. If there were no accidents of a particular class in the accident history provided, the rate for that class will be assigned a zero value for projecting future accidents.

At this point you are asked to supply accident reduction factors, the percent of accidents by severity classes and types which you expect to eliminate through the proposed project. These values may be available from your agency, or you may extract them from the published literature.

If in doubt, DSS will support intelligent guessing by showing you the "after" accident rates which result from your assumed reduction factors. It is wise to check these "after" rates against typical or average rates for similar locations in your area. If the resulting "after" rates are below the typical or average rates for your area, they are probably too low.

If you wish to assign the same percentage accident reduction for all severity classes, this single value should be entered under the TOTAL column. If you enter zero or <return> here, the cursor will bounce to FATALS, INJURIES, and PDOs in sequence to allow you to enter different reduction factors for each severity class. DSS asks you to supply reduction factors for the 1 or 2 special categories of accidents, using the same procedure as described for total accidents.

When you have entered the required reduction factors, DSS will compute projected after (with project built) accident rates and show them to you below the measured before rates from the previous screen. Then you are presented with the opportunity to revise the accident rates.

NOTE: As the prompt indicates, you must hit <return>

after modifying reduction factors to signal DSS to recompute the new projected accident rates.

If you elected to disaggregate accidents by one or two additional classes, DSS will separate the accidents in these classes from the total accidents in this historical data, compute class-specific accident rates, and apply the special reduction factors for these classes FIRST; the reduction factors you entered in the row labeled TOTAL (applicable to all accident types) will then be applied to the accident rates based on accidents REMAINING after the accidents from the special classes have been eliminated. This precludes double-counting accident reduction benefits.

Valuing Accident Costs: The next DSS screen asks you to assign unit monetary costs to each accident severity class, fatals, injuries and PDOs. This is necessary for the economic evaluation procedure. While some users may not be comfortable in assigning money costs to injury and fatal accidents, it is clear that there are real, economic costs associated with these accident types. Assigning money values to these accidents is a way to account for the safety benefits associated with the proposed project.

Technical professionals and policy makers who chose to avoid placing money values on accident outcomes set implicit values on such accidents when they make decisions about safety project implementation. For example, if a project costing $500,000 is expected to eliminate 10 fatal accidents over its life, and a decision is made against its implementation, an implicit value of <u>less than</u> or equal to \$50,000 per fatal accident is being set; a decision NOT to implement the project implies that the resulting benefits are less than or equal to the costs:

$$\text{BENEFITS} \leq \text{COSTS}$$

$$10 \cdot V \leq \$500,000$$

where V = economic cost of a fatal accident.

Therefore:

$$V \leq \$50,000.$$

On the other hand, if a decision is made to implement the project, then the implicit value of a fatal accident is <u>greater than</u> or equal to \$50,000:

$$\text{BENEFITS} \geq \text{COSTS}$$

$$10 \cdot V \geq \$500,000$$

$$V \geq \$50,000.$$

We argue that it is more sensible to make the values behind these decision explicit. DSS allows the user to see the implications of choices for accident costs immediately in terms of the resulting aggregate monetary benefits. This supports rapid testing of different accident cost values.

Both the National Safety Council and the National Highway Traffic Safety Administration periodically publish updated estimates of accident costs be severity class (Ref).

NOTE: DSS assumes that the entered accident cost values are on a per accident basis. Thus, for example, DSS expects to get the cost PER FATAL ACCIDENT, not the cost per fatality.

The accident cost valuation screen looks and functions much like the travel time value screen. The user should select options from the menu in the lower right part of the screen to review and modify costs for fatal (option"1"), injury (option "2") and PDO (option "3") accidents.

Initially assumed accident costs are built into the default parameter file which can be modified by the user with the INSTALL program. At run time, accident costs can be changed by selecting the severity class, then either typing in new costs from the keyboard or decrementing (F9) or incrementing (F10) the values in $500 steps with the function keys.

NOTE: As in the case of travel time savings, the user must select each of the severity classes on this screen to assign a non-zero value to the cost of accidents in each.

When you are satisfied with the accident cost values, return to the options menu and press "4" to accept all values and proceed to the next screen.

Economic Evaluation Summary

Now DSS has all the information it needs to develop a summary economic evaluation, which is presented on the next screen. All of the input data you have provided has been used to:

- Compute the annualized and present worth of the time streams of provider costs;

• Project the future traffic using the project section based on the initial average daily traffic and the constant annual growth rate of demand;

• Compute the annualized and present worths of the time streams of user travel time savings, based on future traffic and the travel time or speed changes provided, valued at the rates specified for each vehicle type;

• Compute the annualized and present worths of the time streams of fuel cost savings for each vehicle type, based on future traffic and the travel speed changes provided, using the fuel consumption and price data supplied for each vehicle type;

• Compute the annualized and present worths of accident cost savings, based on traffic growth, historical accident rates, and expected accident reduction factors, valued at the accident cost rates supplied for each severity class;

• Compute the total benefits, the sum of the savings of user travel time, fuel costs, and accident costs, as well as the percentage of benefits in each of these categories (useful for judging if the order of magnitude of benefits from each source is reasonable);

• Compute the net annualized and present worth of the proposed project, the benefits less the costs;

• compute the benefit cost ratio for the proposed project, the benefits divided by the costs.

DSS also performs and reports the results of a simple sensitivity analysis for the project. It shows:

- By what percent the benefits must change, assuming that the costs are accurate as indicated, to bring the project to the breakeven point (benefits = costs);
- By what percent the costs must change, assuming that the benefits are accurate as indicated, to bring the project to the breakeven point (benefits = costs).

This information gives a measure of how "solid" the project is, given the inherent uncertainties in estimates of both benefits and costs. It tells us how close the project is to the breakeven point, net worth = 0 or B/C = 1.0.

For example, if the project has a positive net worth (B/C > 1.0), if the benefits need fall by only a small percentage (e.g., 10-15%) to bring the project back to the breakeven point, the margin of error in benefit estimation is such that the project may not be very attractive. On the other hand, if the benefits must drop, for example, by 40% to bring the benefit/cost ratio back to 1.0, the confidence we have in the worthiness of the project should be greater. This interpretation presumes that the costs are estimated correctly.

Similarly, if the costs must decrease by only a small percent to bring an apparently worthy project down to the breakeven point, uncertainties in estimation might suggest that the project is "shaky." If costs must go up by a large amount for the project to become unworthy (B/C < 1.0), our confidence in the worthiness of the proposal should be greater. This interpretation presumes that the benefit estimates are accurate.

DSS does the same analysis, with analogous interpretations, if the initial analysis shows the project to be unworthy (negative net worth, B/C < 1.0).

The net worth measure of project value is generally more useful and meaningful than the benefit/cost ratio because it shows in absolute terms what the societal "profit" or "loss" is expected to be as a result of the proposed project. While the magnitude of the net worth has meaning, the only useful piece of information in the benefit/cost ratio is whether it is greater than or less than 1.0.

The net worth criterion can also be used in investment programming analysis, where decisions are to be made about selecting groups of worthy projects to be implemented within a given program budget. A simple program for performing this kind of analysis is described in the next chapter of this manual.

Recycling the Analysis, Printing Reports, and Quitting

After the economic analysis summary is presented, DSS offers you an opportunity to modify the values assigned to any of the benefits. This might be useful if, upon review of the results, you felt that the unit values for travel time, fuel consumption rates or costs, and/or accident costs were inappropriately specified. If you choose to re-value any benefits, you will be presented with a menu from which to select which benefits you want to re-value. Selecting one of these recycles the program back to the appropriate benefit valuation screen.

When you have completed this phase, another menu appears, giving you the opportunity to print a hard copy report, to review and revise the project analysis you are now working on, to analyze a new project (which takes you back to the "top" of the program), or to quit.

If you elect to review the current project, DSS recycles to its starting input screen, this time showing you all of the values which you entered, and giving you an opportunity to revise some or all data input items. This offers a chance to correct any input errors which were not caught on the last pass through the program at the "change inputs?" branches.

If you decide to print a hard copy report at this point, selecting the appropriate command will write your project data into a temporary file in a ramdisk (for floppy operations) or onto the active directory of your hard disk. Then the program PRINTDSS will be called to replace MAINDSS in your computer memory.

A prompt will ask you to prepare the printer. Position the paper so that the print is at the very top (don't leave a top margin), and press any key when you are ready to print. The DSS system will ask you to signal it to return to MAINDSS after printing by entering the letter "r".

NOTE: DON'T RETURN TO MAINDSS UNTIL THE PRINTING PROCESS

HAS BEEN COMPLETED, EVEN IF YOUR COMPUTER SYSTEM HAS A PRINT BUFFER.

When you return to MAINDSS, you will see the initial menu, which will permit you to define a new project or retrieve an old one, as before. If you filed the current project to disk, you may review and revise it at this time. This supports analyzing different versions of the same project, printing hard copy reports on each before proceeding to the revision.

DSS prints a four-page report, after which control is returned to MAINDSS. An example of the DSS report is shown in Figure 7.

PROJECT EVALUATION REPORT

DATE: 07-29-1986 **TIME:** 12:02:54

PROJECT LOCATION: Wilmette Avenue, Greenbay to Ridge

PROPOSED ACTION: resurface and modernize lighting

==

PROJECT CHARACTERISTICS AND COSTS

LENGTH, MILES: 2.00 **PROJECT LIFE, YRS:** 15 1985 **AADT:** 18,500

OPENS IN: 1987 **ANNUAL TRAFFIC GROWTH:** 1.50% **END YEAR VOLUME:** 23,828

DISCOUNT RATE: 10.0%

COST ITEM	FIRST YEAR PAID	ITEM LIFE	ACTUAL AMOUNT	ANNUALIZED WORTH	PRESENT WORTH
DESIGN	1985	15	$85,000	$11,175	$85,000
R-O-W	0	0	$0	$0	$0
CONSTRUCTION	1986	15	$650,000	$85,458	$650,000
MAINTENANCE	1987	1	-$3,000	-$3,300	-$25,100
OPERATION	1987	1	-$4,000	-$4,400	-$33,467
OTHER	0	0	$0	$0	$0
OTHER	0	0	$0	$0	$0
TOTAL				$88,933	$676,433

CASH FLOW ANALYSIS

INFLATION RATE: 3.5% **'LOCAL' SHARE:** 10.0%

YEAR	INFLATED COST	'LOCAL' SHARE	OTHER SHARE
1985	$85,000	$8,500	$76,500
1986	$650,000	$65,000	$585,000
1987	-$7,000	-$700	-$6,300
1988	-$7,000	-$700	-$6,300
1989	-$6,755	-$676	-$6,080
1990	-$6,501	-$650	-$5,851
1991	-$6,239	-$624	-$5,615
1992	-$5,967	-$597	-$5,371
1993	-$5,686	-$569	-$5,118
1994	-$5,395	-$540	-$4,856
1995	-$5,094	-$509	-$4,585
1996	-$4,782	-$478	-$4,304
1997	-$4,460	-$446	-$4,014
1998	-$4,126	-$413	-$3,713
1999	-$3,780	-$378	-$3,402
2000	-$3,423	-$342	-$3,080
2001	-$3,052	-$305	-$2,747
2002	-$2,669	-$267	-$2,402
TOTAL	$653,070	$65,307	$587,763

FIGURE 7: EXAMPLE DSS PRINTED REPORT

Wilmette Avenue, Greenbay to Ridge
resurface and modernize lighting

ECONOMIC COST ALLOCATION

VEHICLE TYPE	PERCENT OF TRAFFIC	COST WEIGHT (E.G., PCE'S)	WTD. COST PER VEHICLE-MILE
AUTOS	90.0%	1.0	$0.0026
LIGHT TRUCKS	8.0%	2.0	$0.0052
HEAVY TRUCKS	2.0%	3.5	$0.0090

BENEFIT ANALYSIS

PEAK PERIOD PERCENTAGE: 25.0%

CROSS STREET TRAFFIC: 4,000

TIME SAVINGS BENEFITS
MAINLINE TRAFFIC

	CURRENT TRAVEL TIMES	EXPECTED TRAVEL TIMES	TRAVEL TIME SAVINGS
PEAK	6.0	5.5	0.5
SPEED	20.0	22.0	
OFF PEAK	5.0	4.8	0.2
SPEED	24.0	25.0	
OVERALL	5.3	5.0	0.3

TIME SAVINGS BENEFITS
CROSS STREET TRAFFIC

	CURRENT TRAVEL TIMES	EXPECTED TRAVEL TIMES	TRAVEL TIME SAVINGS
PEAK	0.5	0.5	0.0
OFF PEAK	0.5	0.5	0.0
OVERALL	0.5	0.5	0.0

	AUTOS	LIGHT TRUCKS	HEAVY TRUCKS
VALUE OF TIME	$2.50	$5.00	$7.50
PRESENT WORTH OF TIME SAVING	$636,157	$113,095	$42,410

Wilmette Avenue, Greenbay to Ridge
resurface and modernize lighting

FUEL COST SAVINGS

	AUTOS	LIGHT TRUCKS	HEAVY TRUCKS
FLEET AVERAGE MILES/GALLON:	16.30	12.90	5.70
FLEET AVG IDLE CONSUMPTION,GAL/HR	0.50	0.70	2.00

FUEL PRICE: $1.30 FLOW CONDITIONS: UNINTERRUPTED, >30 MPH

PRESENT WORTH FUEL COST SAVINGS

AUTOS	LIGHT TRUCKS	HEAVY TRUCKS	TOTAL
$53,133	$13,085	$11,439	$77,658

ACCIDENT COST SAVINGS
ACCIDENT HISTORY

YEAR		FATAL ACCIDENTS	INJURY ACCIDENTS	PDO ACCIDENTS	AADT
1	TOTAL	0	4	8	18,000
	day	0	1	3	
	night	0	3	5	
2	TOTAL	0	6	7	18,500
	day	0	2	4	
	night	0	4	3	
3	TOTAL	0	9	11	18,500
	day	0	3	6	
	night	0	6	5	

PERCENT OF ACCIDENTS ELIMINATED

ACCIDENT TYPE	TOTAL	FATALS	INJURIES	PDOs
TOTAL	10.0	0.0	0.0	0.0
day	0.0	0.0	0.0	0.0
night	40.0	0.0	0.0	0.0

ACCIDENT RATES

	FATALS	INJURIES	PDOs
PRESENT RATE	0.000	1.420	1.943
PROJECTED RATE	0.000	0.928	1.399

[PER MILLION VEHICLE MILES. FATALS, PER 100 MILLION]

	FATALS	INJURIES	PDOs
COST/ACCIDENT	$350,000	$5,000	$1,000
PRESENT WORTH OF ACCIDENT SAVING	$0	$291,257	$64,448

Wilmette Avenue, Greenbay to Ridge
resurface and modernize lighting

ECONOMIC EVALUATION SUMMARY

ITEM	ANNUALIZED WORTH	PRESENT WORTH	% TOTAL BENEFIT
COST	$88,933	$676,433	
TIME SAVINGS	$104,083	$791,662	64.6%
FUEL COST SAVINGS	$10,210	$77,658	6.3%
ACC. COST SAVINGS	$46,766	$355,706	29.0%
TOTAL BENEFIT	$161,059	$1,225,025	100.0%
NET WORTH	$72,125	$548,592	
BENEFIT/COST RATIO	1.81		

With costs as shown, benefits MAY DECREASE -44.78% to bring B/C down to 1.0.

With benefits as shown, costs MAY INCREASE 81.10% to bring B/C down to 1.0.

CHAPTER FIVE
SUPPORTING PROGRAMS

Introduction

Two supporting programs are supplied as a part of the DSS system. VIEW allows the user to examine computer files of projects already analyzed to review the results and print a short report describing each. PROG supports investment programming decisions by finding the optimal package of projects for a given budget. These programs are described in this chapter.

Suporting Program "View"

VIEW is intended to support search and review of project data files. It may useful for finding a particular project file and/or for examining the benefit-cost summary quickly, without entering and moving through the MAINDSS program. VIEW will also print a short report containing (only) the benefit-cost summary for a project.

To activate VIEW, with that program in the active directory, simply type VIEW <return>. A screen will be presented allowing you to see a shortened directory of drive A:, B:, or the active directory in Drive C:. You select which directory you wish by typing A, B, or C. If you do not wish to see a directory, type <return>.

To retrieve a file for viewing, type the correct and complete file name, including the drive name, e.g.:

A:KNOXCO.DOT <return>

If the file you want to view is in the active directory, you should not include the drive identifier, e.g.:

KNOXCO.DOT <return>

If the file you name is not found, a message will be printed on the screen and VIEW will recycle. When VIEW finds the file, a listing of all projects in it will be displayed, and VIEW will ask you to verify that this is the correct file. If it is not, enter "n" <return> and VIEW will again recycle.

When the desired file is found, view will ask you to select which project on that file you wish to review. Select that project by entering its sequence number, followed by <return>.

VIEW will then show you a one screen project summary, with its location, action, project opening year, project life, the average daily traffic "now" and at the end of the project life, the discount rate, and the present worth and annualized costs, benefits by source, benefit-cost ratio and net worths. NOTE: VIEW has no computational capability; it only permits you to examine and print out results of prior DSS analyses.

At the bottom of the project summary screen, you will also be presented with a menu offering the following options, to be chosen by their single number identifiers shown to the left of each option:

1 see next project (in this file)

2 see previous project (in this file)

3 print short project report

4 return to list (of all projects in this file)

5 quit VIEW

If you want to examine other files, chose option 4 and, when the list of projects in the current file reappears on the screen, respond to the prompt "is this the correct file" with "n", which will recycle VIEW to its starting point.

Figure 8 shows an example of the printed report from VIEW.

Supporting Program "PROG"

Background and Concept: PROG is the final component of the DSS system. It is a simple package which supports investment programming, the selection of a subset of proposed projects which produce the maximum net worth (benefits - costs) and are within a user-specified budget.

PROG uses dynamic programming, an operations research method which can be used to formulate and solve investment programming problems. The general problem structure used in PROG is as follows:

MAXIMIZE: {total net worth of the package of chosen projects}

SUBJECT TO:

1) Requirement that the total cost of the package of chosen projects cannot exceed a specified budget level; and

2) Requirements (if any) that certain projects on the candidate list must be included in the final program.

Maximizing total net worth of the chosen package is the objective function, a mathematical statement of what we should be trying to achieve in the investment programming process. The next two statements in the formulation are constraints or requirements that must be met by the best or optimal solution to this problem.

PROJECT EVALUATION
SUMMARY REPORT

DATE : 06-24-1988

PROJECT LOCATION : Wilmette Avenue at Greenbay Road

PROPOSED ACTION : Channelization, signals, improved lighting

LENGTH, MILES : 1.00

OPENING YEAR : 1989 **PROJECT LIFE, YRS :** 25

AADT : 27500 **FUTURE AADT :** 35976

DISCOUNT RATE : 8.0 %

	PRESENT VALUE	ANNUALIZED VALUE
COSTS		
DESIGN	$45,000	$4,216
R-O-W	$196,332	$18,392
CONSTRUCTION	$125,000	$11,710
MAINTENANCE	-$8,979	-$841
OPERATION	$13,835	$1,296
OTHER	$375,000	$35,130
OTHER	$0	$0
TOTAL	$746,188	$69,902
BENEFITS		
TIME SAVINGS	$865,235	$81,054
FUEL SAVINGS	$212,952	$19,949
ACCIDENT REDUCTION	$1,057,528	$99,068
TOTAL	$2,135,715	$200,071
NET WORTH	$1,389,528	$130,169
BENEFIT/COST RATIO	2.86	

FIGURE 8: Example VIEW Printed Report

The first constraint is called the budget constraint, and it demands that the chosen package of projects be affordable, i.e., that in total their cost cannot exceed the available funds. The second constraint demands that certain, user-specified projects be included in the optimal collection of projects.

This might be used, for example, where a firm commitment has already been made to include a particular project. It might also be helpful in testing the impact on the overall program of including a specific project. This constraint is optional, that is, the user need not require that any particular project(s) be in the final solution.

In general, one should expect that requiring the inclusion of a particular project will reduce the value of the objective function, that is, it will give a poorer solution in terms of net worth. This follows the principle that the more one constrains an optimization problem, the more one restricts the value of the objective function at optimality.

Of course if a required project would have been in the optimal package found for the unconstrained problem anyway, requiring that project will not result in a lower (inferior) objective function.

Dynamic programming is a systematic, iterative approach to finding the optimal solution to problems of this type. Over a (potentially long) series of steps, the procedure adds candidate projects to the chosen set until it is no longer possible to add or substitute projects and improve the level of the objective function while meeting (both of) the constraints.

This is a many-step process which can take even the computer a long time. For a large set of candidate projects (i.e., more than 20) the solution times can be very long, measured in 10s of minutes. PROG is intended to support the development of relatively small investment programs.

NOTE: PROG IS LIMITED TO ANALYZING 50 OR FEWER PROJECTS! It should not be used for developing a statewide program that may have hundreds of candidate projects. This is a task which should be done on a mainframe computer, or with more specialized microcomputer software that takes advantage of math co-processor chips and uses a more efficient solution algorithm.

Using Prog: PROG requires that you enter project data from the keyboard; it does not extract data directly from files created in DSS. It does create and read its on files.

The program is run [from floppy diskette by inserting the diskette with PROG on it - the second bootable diskette you made -], making the drive or directory in which PROG resides the active directory, and typing PROG <return>. You will quickly see a menu of options: retrieve from disk file (created by PROG), define a new set of candidate projects, and quit. Choose your desired action by typing its number.

File retrieval works as it does in VIEW. You may call for a file directory of one of the floppy drives or the active fixed disk directory by typing the drive letter. Hitting <return>

skips the directory and asks you to enter the complete file name (including drive identifier if it is not on the active drive/directory and extension), followed by <return>. When the file is found, PROG shows you its contents and asks if you want to change them. It then proceeds through its routine analysis process.

PROG will not store multiple project lists under the same file name; you must pick a new name for each file you want to save.

When you retrieve data from a file, PROG will step you through the analysis, showing you the filed data and presenting you with opportunities to revise the inputs at each step.

When entering a new programming problem, PROG will first ask how many candidate projects are to be considered. This is the total number of projects on the list, from which a subset will be selected for the optimal program.

> NOTE: Once entered, you cannot change the number of candidate projects unless you define a new set of projects. If you think you might want to add a few projects to your initial list, enter them with zero costs and benefits. You can change these later.

Then, PROG will ask for the following data on each project in sequence: project name, costs, and benefits.

Costs and benefits may either be in terms of equivalent, uniform, annualized amounts or present worths, BUT BOTH MUST BE IN THE SAME TERMS. Furthermore, the total budget, which PROG asks for after all of the project data have been entered, MUST BE IN THE SAME TERMS AS PROJECT COSTS. Thus, if project costs (and benefits) are in terms of present worth, then the present worth (actual current dollar amount) of the budget must be used. If project costs (and benefits) are annualized values, then you must use an equivalent uniform annualized budget.

You can annualized a current dollar budget with the following formula:

$$\text{Annualized Budget} = \text{Present Worth Budget} \cdot \left[\frac{i\,(1+i)^n}{(1+i)^n - 1} \right]$$

After you enter the budget, PROG asks how many of the projects are required (must be included in the final program). You may select zero (or hit <return>) if none are required. If some must be included, you must first type how many, and then enter their numbers, followed by <return>.

You can cycle through PROG repeatedly testing the affect of requiring different projects. However, each type you revise the current set of inputs, you must tell PROG how many and which projects are required. It does not store this information, nor does it record required projects to disk files.

When data for all projects and the budget have been entered, PROG will display all of these inputs and give you an opportunity to revise any or all of them. It will ask if you want to change project data or the budget. If you choose to modify projects, it will ask which number, and then permit you to re-enter all data for that project. Then, after the modified input data have been echoed to the screen, you will be presented with another opportunity for revisions.

When you choose not to make any (more) revisions (by responding with "n", "N", or <return>, the solution process will begin. PROG will print to the screen some aspects of the intermediate solutions it considers while proceeding toward the optimal package. This will be done "on the fly," and with a small number of candidate projects, you will not be able to read the intermediate results because they will scroll by too quickly. As the number of candidate projects gets larger, the solution process gets more cumbersome and slows down. You will be able to read intermediate results, and for larger problems they will stay on the screen for quite a while. This display serves to confirm that the program is working toward the solution.

When it has found the optimal solution, PROG "beeps" and displays a table containing the chosen candidate projects (alternatives), the remaining alternatives, the costs, benefits, net worths, for each project, for the chosen package, and the remaining package.

At this point you can print a hard copy report using the current data. Whether or not you print this report, PROG will offer you the opportunity to revise the inputs. When you decline this opportunity, PROG asks if you want to file the CURRENT INPUT DATA to disk. If you say no, the program cycles back to its beginning point, at which you may quit, retrieve data from a file, or define a new program.

If you elect to file your data, you will be asked for a complete file name specification, e.g., A:KNOXCO.DOT <return>. If the data are to be filed in the active directory, you need not enter the drive identifier. As stated, each data set must be stored in a file with a unique name, one data set to each file.

While PROG is not fast enough to solve large problems, it should be very handy for finding optimal investment packages from smaller lists of candidates. Such cases would be quite burdensome to analyze by hand.

Its major advantage lies in its ability to cycle through optimization, revision, and testing the effects of "requiring" inclusion of different groups of projects.

Example Investment Programming Problem: Suppose we have the following set of projects, from which we wish to select the optimal investment program:

Project #	Project Name	PW Cost	PW Benefit
1	First Ave.	$125,000	$152,000
2	55th St.	$132,500	$195,000
3	Jones Bridge	$495,000	$758,000
4	Dann Ramp	$335,000	$405,000
5	Carr Road	$129,500	$151,000
6	Wesley St.	$225,000	$325,000

Suppose we have a budget of $950,000. Using PROG to solve this problem in its current form, we get the results shown in Figure 9. On a 4.77 mHz IBM XT, this solution required about 6 seconds.

INVESTMENT PROGRAM
BUDGET = $950,000

I. ALTERNATIVES CHOSEN

Project Name	Cost	Benefit	Net Worth
55th Stree	$132,500	$195,000	$62,500
Jones Brid	$495,000	$758,000	$263,000
Wesley St.	$225,000	$325,000	$100,000
Total	$852,500	$1,278,000	$425,500

II. OTHER ALTERNATIVES

Project Name	Cost	Benefit	Net Worth
First Ave.	$125,000	$152,000	$27,000
Dann Ramp	$335,000	$405,000	$70,000
Carr Road	$129,500	$151,000	$21,500
Total	$589,500	$708,000	$118,500

Figure 9: Example PROG Printed Report

INVESTMENT PROGRAM
BUDGET = $950,000

I. ALTERNATIVES CHOSEN

Project Name	Cost	Benefit	Net Worth
Jones Brid	$495,000	$758,000	$263,000
Wesley St.	$225,000	$325,000	$100,000
First Ave.	$125,000	$152,000	$27,000
Total	$845,000	$1,235,000	$390,000

II. OTHER ALTERNATIVES

Project Name	Cost	Benefit	Net Worth
55th Stree	$132,500	$195,000	$62,500
Dann Ramp	$335,000	$405,000	$70,000
Carr Road	$129,500	$151,000	$21,500
Total	$597,000	$751,000	$154,000

FIGURE 10: Example PROG Printed Report, Modified Problem

If we require that project 1 (First Avenue) be in the solution, we get the results shown in Figure 10. The net worth of the optimal package has declined by $35,500 because project 1 was required. This solution required approximately 3 seconds.

APPENDIX A
COMPUTATION OF FUEL CONSUMPTION SAVINGS

Fuel consumption savings are computed separately for (1) spot locations (intersections) and cross street traffic and (2) sections of non-zero length. Computations are further separated by each of three vehicle types and by peak and off-peak flows.

In all cases, the difference in the rate of fuel consumption (without project - with project) is multiplied by the total traffic (by time period and vehicle type) expected over the project during its life, and then by the fuel price. In actual computations, the discounted present worth of this money value is found by projecting year-by-year traffic, and discounting the traffic volume back by multiplying the traffic in each year by:

$$\frac{1}{(1+i)^n}$$

where

i = discount rate

n = project life in years.

This has the same effect as computing the savings in each year and discounting it back to present worth.

The effect of the peak/off-peak splits and percentage of traffic by vehicle type are handled by separating traffic flows into time periods and vehicle classes using simple percentage multipliers.

Spot locations and cross traffic are treated by assuming that changes in fuel consumption come from changes in the amount of engine idling time. If a vehicle spends 0.5 minutes less going through an intersection, it is assumed to consume fuel at the idling rate for 0.5 minutes less.

For non-zero length sections on the mainline portion of a project, fuel consumption models by vehicle type were derived from work done at Texas A & M University and General Motors Corporation. Models were estimated separately for interrupted (<30 m.p.h.) and uninterrupted flows. Uninterrupted flow fuel savings models are shown in Table 1; interrupted flow fuel savings models are shown in Table 2.

The models shown in these tables are the results of regressing data points reported in the sources cited above in order to develop the simplest, combined models possible.

TABLE 1
UNINTERRUPTED FUEL COST SAVINGS MODELS

Automobile Model

$$\delta \text{ Fuel Cost} = \frac{16.3}{MPG(A)} \left[497 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] + 0.0139 \cdot \left[VO(J)^2 - VN(J)^2 \right] \right] \cdot$$

$$PCT(Auto) \cdot PPCT(J) \cdot PWTFC \cdot GASPRICE \cdot LENGTH$$

Light Truck Model

$$\delta \text{ Fuel Cost} = \frac{12.9}{MPG(LT)} \left[832.19 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] + 0.016 \cdot \left[VO(J)^2 - VN(J)^2 \right] \right] \cdot$$

$$PCT(LT) \cdot PPCT(J) \cdot PWTFC(LT) \cdot GASPRICE \cdot LENGTH$$

Heavy Truck Model

$$\delta \text{ Fuel Cost} = \frac{5.7}{MPG(HT)} \left[1986.88 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] + 0.0178 \cdot \left[VO(J)^2 - VN(J)^2 \right] \right] \cdot$$

$$PCT(HT) \cdot PPCT(J) \cdot PWTFC \cdot GASPRICE \cdot LENGTH$$

Where:

MPG (A,LT,HT)	= projected fuel consumption by vehicle type
VO(J), VN(J)	= old and new vehicle speed for time period J (1= peak, 2 = off-peak)
PCT(A,LT,HT)	= fraction of given vehicle type in traffic volume
PPCT(J)	= fraction of flow in peak (J=1) and off-peak (J=2)
PWTFC	= discounted present worth of traffic over project life
GASPRICE	= price of fuel, $ per gallon
LENGTH	= section length in miles

TABLE 2
INTERRUPTED FUEL COST SAVING MODELS

Automobile Model

$$\delta \text{ Fuel Cost} = \frac{16.3}{MPG(A)} \cdot 601.69 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] \cdot PCT(A) \cdot PPCT(J) \cdot PWTFC \cdot GASPRICE \cdot LENGTH$$

Light Truck Model

$$\delta \text{ Fuel Cost} = \frac{12.9}{MPG(LT)} \cdot 1006.95 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] \cdot PCT(LT) \cdot PPCT(J) \cdot PWTFC \cdot GASPRICE \cdot LENGTH$$

Heavy Truck Model

$$\delta \text{ Fuel Cost} = \frac{5.7}{MPG(HT)} \left[2000689 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right]^2 + 14 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] \cdot \left[VO(J)^2 - VN(J)^2 \right] \right] \cdot$$

$$PCT(HT) \cdot PPCT(J) \cdot PWTFC \cdot GASPRICE \cdot LENGTH \cdot$$

$$\left[\left[832.9 \cdot \left[\frac{1}{VO(J)} - \frac{1}{VN(J)} \right] + 0.16 \cdot \left[VO(J)^2 - VN(J)^2 \right] \right] \right]^{-1}$$

Where all terms are as defined in Table 1.

NOTICE

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TECHNOLOGY SHARING

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