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IMPLEMENTING ROAD USER CHARGING IN SATURN

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ABSTRACT

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This working paper details modifications carried out to the congested assignment traffic network model SATURN in order to represent road user charging. The work was undertaken as part of an SERC funded study to investigate the network effects of a series of alternative road user charging systems upon an existing road network.

Four road user charging systems which were tested during the study have been represented in SATURN. These are toll cordons, time-based charging, congestion charging and distance-based charging.

KEY WORDS: SATURN; road pricing.

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IMPLEMENTING ROAD USER CHARGING IN SATURN

1. INTRODUCTION

This working paper details modifications carried out to the congested assignment traffic network model SATURN in order to represent road user charging. The work was undertaken as part of an SERC funded study to investigate the network effects of a series of alternative road user charging systems upon an existing road network. Further details of this study are reported elsewhere (Milne, 1993a; Milne, 1993b; Milne et al, 1993).

Four road user charging systems which were tested during the study have been represented in SATURN. These are toll cordons, time-based charging, congestion charging and distance-based charging. This paper explains the methodology employed to allow the alternative road user charging systems to be represented and also provides a user guide for the extensions developed to the SATURN software.

A DOS batch file procedure, SATTAX, has been added to the SATURN suite to apply charging. Facilities exist to model the network response to charging both with fixed demand, in order to isolate rerouteing issues, and with an elastic demand response, using the SATURN elastic assignment algorithm, SATEASY. The latter allows the network impacts of charging to be viewed in conjunction with possible modifications to demand patterns and should provide more realistic results unless other methods of representing demand response, such as interaction with strategic models, are available. Separate work is currently being carried out by Cambridgeshire County Council and WS Atkins to link the representation of road user charging in SATURN with the mode choice module, SATCHMO. At present, the SATTAX procedure only operates for a single demand "User Class" and should not be applied to networks in conjunction with the *logical parameter* ROSIE.

2. DEFINITIONS OF THE CHARGING SYSTEMS REPRESENTED

The four road user charging systems which have been incorporated into SATURN are described briefly below.

2.1 Toll Cordons

Toll cordons represent the simplest and most conventional form of road user charging. Urban toll systems operate in three Norwegian cities and a pilot study was carried out in Hong Kong. A fixed charge is levied at specific points on the road network in order to permit travel within a specified area, defined by a single or series of boundaries. The charge incurred by the user depends upon the number of boundary crossings made, but does not relate to the amount of travelling within the area accessed or the levels of prevailing congestion.

2.2 Time-based Charging

Time-based charging levies charges based upon the time spent travelling in a specified area. This system was under consideration for Richmond in London employing the TIMEZONE microwave beacon, in-vehicle unit and smart card technology developed by Easams, a subsidiary of GEC (Easams, 1991). Charge rates may be set differentially across a series of separate geographical areas. The amount of money paid by the road

user relates to the amount of travelling within the charge area. Charges would also reflect congestion levels to some degree, as journeys in heavy traffic would be expected to take longer than in free-flow conditions.

2.3 Congestion Charging

The concept of congestion charging involves relating road user charges directly to the prevailing level of congestion on the road network. Its supporters consider it to be fairer than other systems because charges are only levied when congestion occurs. A *congestion metering* system has been under consideration in Cambridge, based upon technology developed during the European DRIVE projects, PAMELA and ADEPT (Oldridge, 1990; Blythe and Hills, 1991 and 1994). This system involves the recording of time taken and distance travelled for each vehicle individually on a rolling basis by in-vehicle technology. Only when a specified congestion threshold is exceeded, expressed in terms of time and distance, is a charge incurred. Defining a tangible congestion threshold would appear to be the only feasible method for designing a practical congestion charging system with current levels of technology. An ideal congestion charging system would be capable of identifying accurately the portion of travel time caused by congestion (ie the excess time over free-flow conditions) and subjecting it to a time-based charge. As no charges are levied unless congestion occurs, a congestion charging system should not require the specification of different charge levels for different areas. The amount of money paid by road users in different parts of the network should be self regulating, unless it is considered that the sensitivity of drivers to charge rates for congestion varies geographically.

2.4 Distance-based Charging

Distance-based charging levies a charge based upon the distance travelled in a specified area. As with time-based charging, charge rates may be varied across a series of separate geographical areas. The charges paid by the user are related to the amount of travelling, but not to congestion levels. Its supporters view it as a more desirable alternative to time and congestion related systems because it avoids uncertainty regarding the financial costs of journeys. Also, there is no obvious incentive within the system to reduce money paid through altering driver behaviour adversely (eg driving faster, disobeying pedestrian crossings and traffic signals etc) which are concerns with the other variable charging systems.

More detailed information on alternative charging methods is available elsewhere (Milne, 1992).

3. METHODOLOGY FOR REPRESENTING ROAD USER CHARGING

Congested assignment traffic network models, such as SATURN, estimate drivers' route choices and subsequent congestion levels in terms of "generalised cost", a combination of time and cost. Under normal operation SATURN calculates generalised cost based on two components, the value of time and the value of distance, distance being the physical financial cost of travelling. These are represented in the SATURN network by the *real parameters* PPM (pence per minute) and PPK (pence per kilometre) respectively. The values of these parameters are used to convert travel costs for all links and turns in the network into a single currency unit, which in SATURN is "generalised time", measured in seconds.

Thus:

$$COST = (PPM*TIME) + (PPK*DIST) \quad (1)$$

and $$GTIME = TIME + (DIST*PPK/PPM) \quad (2)$$

Where:

COST = total travel cost
GTIME = total travel cost in generalised time
TIME = travel time
and DIST = travel distance

Some care is needed within the programs to ensure that the units are correct. Within SATURN times are stored in units of seconds and distance in units of metres. Hence, to convert distances in metres to generalised time in seconds the numerically correct conversion constant must be:

$$(PPK/1000) / (PPM/60)$$

$$= 0.06*PPK/PPM \quad (3)$$

For each link in the network, a fixed travel time equivalent to the distance cost is calculated using the above conversion factor and stored in the array coded 2603. Therefore, the generalised cost within the assignment may be represented by the equation:

$$c = t + c^{2603} \quad (4)$$

Where:

c = total travel cost in seconds
t = travel time in seconds
c^{2603} = fixed travel cost in seconds from array 2603

Road user charging may be added to this equation quite simply as a modification to the generalised cost calculations. The precise form of the modification required depends upon the charging system to be reflected.

This approach is the easiest for modelling the impacts of charging, but relies upon the assumption that road users consider direct charges alongside and in equal weight to the costs of running a car and the value of their time. It may be that future research findings regarding the behavioural effects of charging will not support this and more complex methods for reflecting responses to direct charging in traffic network models will need to be sought.

In many real SATURN network applications the PPM and PPK parameters are set as ratios rather than realistic values. For example, one may find a value of time of 1.0 and a value of distance of 0.5, which are both clearly much lower than would be expected. This is not important, as these values are purely behavioural elasticities for the model and play no role in any economic analysis. What is important is the ratio between them. Thus, 1.0 and 0.5 would produce exactly the same assignment as 10.0 and 5.0, as may be seen from equation (3) above. However, it is important to note that when ratios are used instead of real economic values, the ratios assumed tend to be simple, such as the "time

and half distance" example above. The real values used during the SERC funded study were 7.63 pence per minute and 5.27 pence per kilometre, calculated from Highways Economics Note No. 2 (Department of Transport, 1989), giving a ratio of approximately time and 0.69 distance. As the rerouteing impacts of road user charging may be quite sensitive to the ratio assumed, it is advisable for SATURN users intending to apply charging to a network to think carefully about the values chosen for the PPM and PPK parameters. In addition, reflecting charges in terms of units such as time and distance, as part of generalised cost, requires an assumption to be made regarding their real economic values to regulate the magnitude of the cost modifications made.

In order to modify the SATURN generalised cost calculations to reflect road user charging, the user needs to become familiar with the conversion of all travel costs in the assignment to seconds of generalised time. Thus, for the simplest example of levying a fixed charge for passing a certain point on the network, the charge would be imposed as an addition to the fixed travel cost of traversing the appropriate link or turn in seconds. The magnitude of the additional cost would be calculated from the value of time assumed. The time penalty required to reflect a charge of 50 pence per crossing with an assumed value of time of 7.63 pence per minute would be approximately 393 seconds.

SATURN is already able to do this through link and turn based time penalties, contained under the fourth card of the network data file, where the penalty is assumed to be given in units of seconds and is added directly to the array coded 2603. However, the most convenient method for representing all four charging systems in a similar way and incorporating them into a single batch procedure, for the SATURN Version 8.5 suite of programs, is the use of the SATDB data manipulation program between the network building and assignment-simulation loop stages of the model. Therefore, to represent the example above SATDB is used to add a penalty in seconds of generalised time to the data array 2603 in the SATURN network which represents the fixed costs of travelling (including distance) for the specific locations to be charged.

Distance-based charging may be applied in SATDB to the same array of fixed costs, the difference being that instead of adding a fixed unit of generalised time, a distance related charge requires a factor to be applied to the fixed costs of all links within the charge area. Turns have no distance in SATURN and so are unaffected. This factor is calculated relative to the assumed real economic value of distance and effectively modifies the ratio between time and distance in the charged area of the network. For example, if the assumed economic value of distance is 5.27 pence per kilometre and it is intended to test a charge level of 10 pence per kilometre, the new assumed value of distance within the charge area would be 15.27 pence per kilometre and the required factor would be approximately 2.898.

A similar factoring approach is used to represent time and congestion related charging, with the factor being applied to the appropriate variable components of travel cost relating to total travel time and congested travel time. This cannot be achieved in SATURN quite so simply as with modifications to the fixed costs, because both travel time components vary during the assignment-simulation procedure in response to route choice. Therefore, rather than modifying an existing data array within the model on a single occasion, it has been necessary to amend the assignment procedure to access an additional array of time factors and carry out the calculations internally.

Modifications to the assignment procedure have been implemented solely within the SATEASY program, as this has the ability to assign traffic both with and without elastic demand response. The old SATURN assignment program SATASS can only assign with fixed demand and has not been used to implement road user charging. An array of LINK COST WEIGHTS, with the DA code 2393, has been added to SATEASY and is controlled by a new *logical parameter*, MILNE, which contains options to apply no charging, apply factors to the congested portion of travel times and apply factors to total travel times respectively. Thus equation (4) above becomes:

$$c = F.t + c^{2603} \qquad (5)$$

Where:

F = the factor from array 2393

Therefore, if a value of time of 7.63 pence per minute is assumed and it is desired to test a time-based charge of 10 pence per minute, the modified value of time within the charge area would be 17.63 pence per minute and the appropriate factor would be approximately 2.311. The same values for factors apply to both time and congestion related charges. The difference is the portion of travel time to which the factors are applied. So, if the travel time on a link may be written:

$$t = t_0 + d(v) \qquad (6)$$

Where:

t = total link travel time
t_0 = fixed travel time
and d(v) = extra delay to traffic at flow v

Then, we may define weighted total time cost (c^w) by either:

$$c^w = F.t_0 + F.d(v) + c^{2603} \qquad (7)$$

or

$$c^w = t_0 + F.d(v) + c^{2603} \qquad (8)$$

The former represents time-based charging and the latter may be thought of as delay-based or congestion charging.

This method of representing congestion charging models the ideal system described in Section 2.3, rather than the practical threshold based system developed in Cambridge. The latter would be much more difficult to represent in a flow based equilibrium model. Firstly, it is not possible to calculate charges separately in SATURN for individual vehicles. For any single road user class charges can only be applied equally to all vehicles using a particular link. Therefore, the expected variability in charges experienced by individual users on any link as a result of overall route choice (ie incorporating previous and subsequent link choices) cannot be represented. Secondly, the concept of a congestion threshold implies a stepped approach to charging rather than a time-based congestion charge and may be expected to produce associated "boundary effects". A more complex modelling mechanism, based on the probabilities of charges being levied on a link by link basis, may allow SATURN to address this issue to some extent. However, a faithfull representation of the congestion metering system developed in Cambridge may only be

achieved by employing a fully microscopic simulation modelling approach (Watling and Van Vliet, 1992).

4. USER GUIDE FOR SATTAX BATCH PROCEDURE

The methodology outlined in Section 3 has been incorporated into SATURN using a new DOS batch file procedure, SATTAX. As stated above, this batch procedure includes the standard network building and assignment-simulation loop stages contained in the existing SATURN batch file, plus a data manipulation stage to apply road user charging. It requires access to four of the SATURN programs, SATNET, SATDB, SATEASY and SATSIM. Section 6.1 of the Appendix contains a copy of the batch file, SATTAX.BAT. Figure 1 contains a flow diagram detailing the SATTAX procedure.

4.1 The SATTAX Procedure In Detail

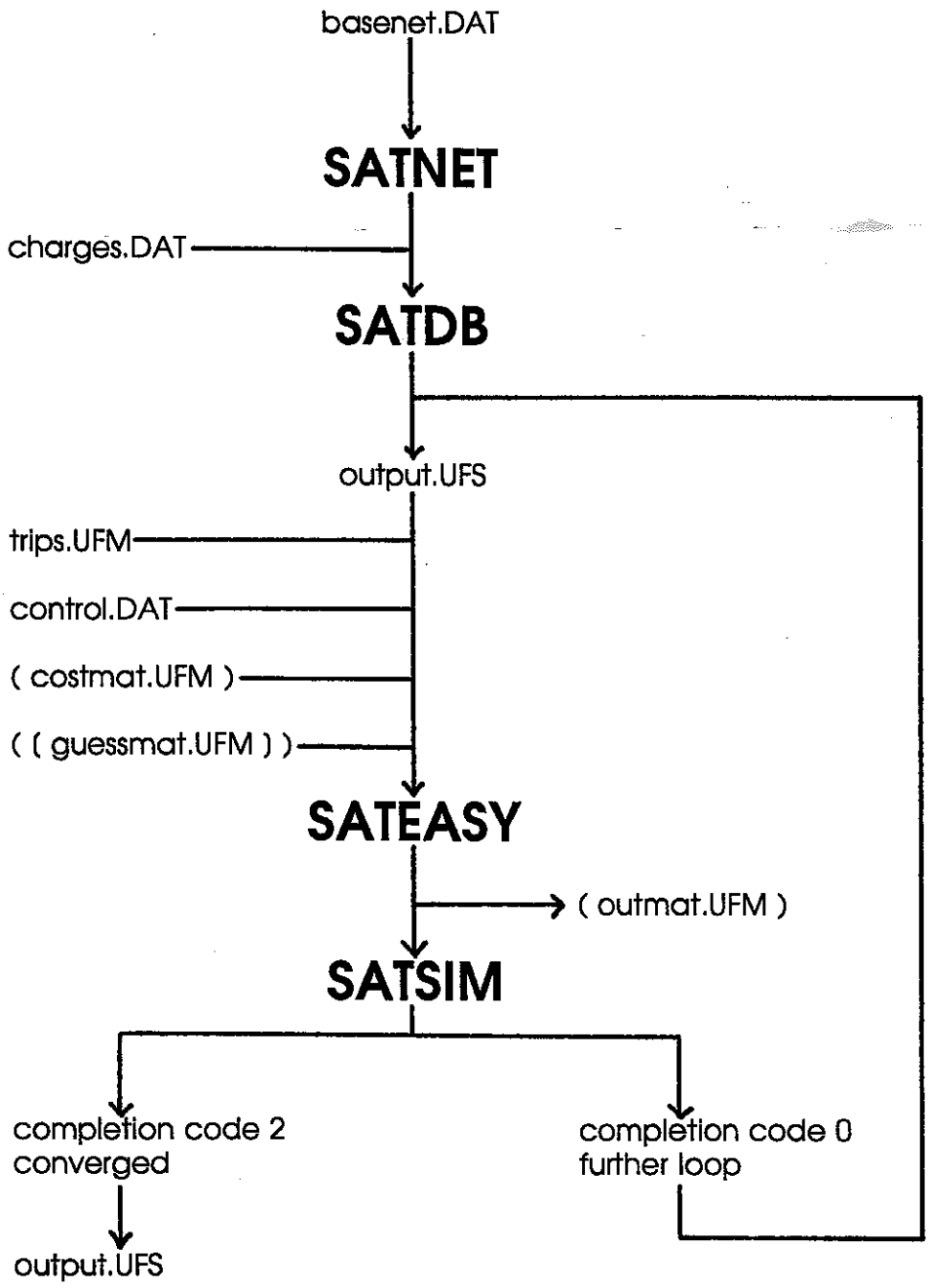
The user is required to provide the basic network and matrix input files for running the assignment-simulation loop, as required by the existing SATURN batch file (basenet.DAT and trips.UFM in Figure 1). If appropriate, files required for elastic assignment, such as a base cost matrix and an estimate of the elastic trip matrix, must also be provided, as for the existing SATEASY batch file (costmat.UFM and guessmat.UFM respectively in Figure 1). One further user specified data file is required to implement road user charging, an ascii data file containing the charge information to be applied (charges.DAT in Figure 1).

The SATTAX procedure can be split into three distinct stages:

Stage One involves building the base network from an ascii data file in SATNET. The network file contains no information relating to charging and the resulting unformatted file (basenet.UFS) is used solely for input to SATDB. Building the unformatted network from a data file for each run of SATTAX ensures that the procedure cannot be undertaken with a network to which charging information has already been applied.

Stage Two uses the SATDB data manipulation program to apply the charge information contained in the user specified file, charges.DAT, to the unformatted network file produced by SATNET. The charge data file is an ascii data file suitable for input to SATDB as "miscellaneous link data". It contains a list of "assignment links" from the base network and appropriate information regarding the factors or fixed cost penalties required to represent charging, as described in Section 3, depending upon the charging system to be applied. The precise format of the charges.DAT file is given in Section 4.3 below. A choice of entries on the command line for the SATTAX batch file control the way in which this data is used in SATDB to apply the correct charging system. Nevertheless, users are encouraged to exercise caution to ensure that the data contained in charges.DAT is compatible with their chosen charging system. SATDB produces an updated unformatted network file, containing a representation of road user charging, for use in the assignment-simulation loop. This file (output.UFS) takes its name from an argument on the command line of the SATTAX batch file, which specifies the name adopted for the run in SATEASY and SATSIM. As road user charging tests typically involve many runs, with different combinations of a number of variable options to be tested (eg charge level, charging system and time period), it is important that sensible names are chosen which help to identify them!

Figure 1: Flow Diagram Detailing SATTAX Procedure



Stage Three incorporates the assignment-simulation loop, with iterative runs of SATEASY and SATSIM. The inputs are those which are required as standard for the existing model programs **plus** a control file for SATEASY which specifies the use of the factor array in the assignment, required for time and congestion related charging, controlled by the parameter MILNE. Therefore, for inelastic assignment, the inputs for this stage are the output network file from SATDB (modified to represent charging) and the unformatted network file trips.UFM: the control file here is one of four preset options called on the command line of the SATTAX batch file.

For elastic assignment, a base cost matrix is also required, containing trip costs from the base assignment without charging. Section 4.4 explains how this file is defined. An estimate of the trip patterns resulting from elastic assignment is required if the SATEASY *logical parameter* REDMEN has been set to TRUE. For elastic assignment, the SATEASY control file contains information regarding both road user charging and the desired elastic response. Therefore, the user must specify this file directly by copying the null control file provided, SATTAX0.DAT and modifying and renaming it to suit the specific needs of the run. The precise format for this file is given in Section 4.5.

As with the existing SATURN batch file, SATTAX continues to iterate between SATEASY and SATSIM until convergence is reached, based upon the convergence parameter ISTOP in the assignment. This parameter specifies a percentage of assigned flows which must be within 5% of their assigned values on the last iteration. Once this figure is reached in SATEASY, a completion code of 2 is prompted and one further simulation run is completed before the procedure terminates. The principal outputs from SATTAX are the unformatted converged network file (output.UFS) and, for elastic assignment, the unformatted elastic trip matrix file after charging (outmat.UFS). Both of these files can be interrogated using the appropriate SATURN analysis programs, SATLOOK, SATDB, P1X and MX.

4.2 Essential Files for SATTAX

In addition to the SATTAX batch file itself, a number of other files are essential for implementing the procedure. These are:

SATTAX.HLP	-	A help file containing documentation for SATTAX.
TOLL.KEY TIME.KEY CONG.KEY DIST.KEY	} } } }	Key files required for modifying generalised cost calculations in SATDB.
TOLL.DAT TIME.DAT CONG.DAT DIST.DAT	} } } }	Control files required for specifying charging system in SATEASY (used for inelastic assignment only).
SATTAX0.DAT	-	A specimen control file for use in SATEASY (modified by the user for applying elastic assignment).

All these files should have been provided, and should be placed in the same directory as the batch file.

4.3 Format Of The Charge Data File

The input charge data file must be formatted as follows, one record per link/turn:

Cols. 1 - 5	The link "A-node"
Cols. 6 - 10	The link "B-node"
Cols. 11 - 15	The "C-node" if referring to a turn (0 or blank otherwise)
Cols. 16 - 20	The charge data

Data is terminated by 99999 in cols. 1 - 5.

SATDB requires the miscellaneous data read in from columns 16 - 20 to be in INTEGER format. Therefore, this data should be entered as follows:

TOLLS	Fixed time penalty in seconds
TIME, CONG & DIST	Factor to three decimal places multiplied by 1000

Therefore, to apply a factor of 2, an entry in columns 16 - 20 of 2000 would be required. An entry of 1872 would be interpreted as 1.872. The maximum charges which could be applied in this way would be a fixed toll of 99999 seconds and factors of 99.999. Assuming the generalised costs used during the SERC funded study, these would be equivalent to a toll of approximately £127 per crossing, time and congestion related charges of approximately £7.55 per minute and a distance related charge of approximately £5.22 per kilometre. This should be sufficient to cater for all eventualities. Section 6.2 of the Appendix contains an example charge file.

In the most recent releases of SATURN, SATDB is able to accept miscellaneous data as real numbers and in free format. However, this manual and the related SATURN files have been compiled to work under all releases of version 8.4. It is likely that the SATTAX procedure will be modified in future to take advantage of improvements to the rest of the SATURN suite and, as a result, the precise format of data inputs may change.

4.4 Defining A Base Cost Matrix For Elastic Assignment

A matrix of base costs is required by SATEASY, when implementing elastic assignment, to provide a reference point against which changes in cost produce a demand response. For modelling the effects of road user charging, this matrix may be best defined as the costs from a converged run of the network with the full prevailing trip matrix and no charges.

It is important to note that all work carried out to date to model the impacts of charging in SATURN have been for current year demand levels, beginning with a fixed trip matrix. While there is no reason why SATTAX should not be applied to future year traffic levels, it is not recommended to attempt to use SATEASY to represent both natural capacity restraints to traffic assignment and charging at the same time. For a forecast situation the base cost matrix for modelling charging would need to be the costs from an elastic assignment run to represent future capacity restraint, addressing the two issues separately, in an incremental fashion.

The SATURN analysis program SATLOOK is used to create the cost matrix, using as input the converged UFS file from the base run without charging. The cost matrix need

only be created once for each base year in which road user charging is to be tested and may be created by the user interactively. Alternatively, a batch file (SATCOST.BAT) is available within the SATURN suite to carry out this process automatically. If base.UFS is assumed to be the appropriate file, the following sequence of commands is required to create a cost matrix interactively:

SATLOOK base	- To access SATLOOK
[return]	- To display "master menu"
-2	- To display part 2 of "master menu"
14	- "Minimum zone-to-zone paths or matrices"

The screen then provides a summary of how costs were derived, including the values of the PPM and PPK parameters. These should be checked and the times used should be the "congested times from SATSIM".

[return]	- To access "tree menu"
3	- "Build a cost matrix"
name	- The matrix built will be name.UFM
title	- This will be the title of the matrix
[return]	- Return to "tree menu"
[return]/0	- To return to "master menu"
[return]/0	- To terminate
Y	- To confirm program termination

The file name.UFM should be equivalent to the file costmat.UFM in Figure 1.

4.5 Format Of The SATEASY Control File

A number of options are available for applying road user charging and elastic assignment, specified in the usual *namelist* format for SATURN parameters:

1. START OF PARAMETERS - &PARAM

2. PARAMETER OPTIONS

PARAMETER	TYPE	DEFAULT	INTERPRETATION
MILNE	INTEGER	0	Time factoring option for road user charging. 0 - No factors applied to travel time costs. Choose 0 for cordon tolls and distance-based charging. 1 - Factors from array 2393 applied to variable travel time. Choose 1 for congestion charging. 2 - Factors from array 2393 applied to fixed and variable travel time. Choose 2 for time-based charging.

MCGILL	INTEGER	0	Choice of demand function for elastic assignment. 0 - Inelastic equilibrium. 1 - Logit. 2 - Power law. 3 - Exponential. 4 - Elastic exponential.
BETA	REAL		Elasticity parameter for elastic assignment. Operates for MCGILL = 1 and 3 only. >0 - elasticity parameter.
POWER	REAL		Elasticity parameter for elastic assignment. Operates for MCGILL = 2 and 4 only. >0 - elasticity parameter.
MCOPT	INTEGER	0	Choice of assignment algorithm. 0 - standard Frank-Wolfe applied to extended network. 1 - "double-stage" loading algorithm.
REDMEN	LOGICAL	F	Choice to provide estimate of trips. F - No initial estimate. This option may be preferable for modelling road user charging, as it seems unlikely that the user would be able to predict the impact upon trip distribution. T - Initial estimate provided for SATEASY.
XFFC	REAL	0.0	Choice of cost matrix for elastic assignment. 0.0 - cost parameter matrix provided as separate file for SATEASY. This option is preferable for modelling road user charging, where the cost matrix should be the costs of travel without charging. >0 - cost parameter matrix decided by the formula: C0(I,J) = a * FFC(I,J) where: C0(I,J) = base cost by OD pair. a = value of XFFC. FFC(I,J) = free flow cost for OD pair.

Further explanation of the parameters relating to elastic assignment may be found in the SATEASY documentation (Watling and Van Vliet, 1991a and b). A value of MCGILL = 2 was used during the SERC funded study, with power values in the range of 0 to 1.0. This represents elasticity values within the range 0 to -1, as the signs are reversed for the values of the parameters. It is assumed that the demand response with respect to increases in travel costs will always be negative. Other parameters, relating to standard assignment options in SATURN, may also be added to this file: however, it would be more usual to set values for these in the network data file, basenet.DAT. Section 6.3 of the Appendix contains a copy of the null SATEASY control file provided, SATTAX0.DAT.

4.6 Running SATTAX

In order to view the format of entry requirements for the command line of the SATTAX batch file, type:

SATTAX INFO

This should result in the following screen message:

```
*******SATTAX INFORMATION*****************************************
Call:  SATTAX basenet charges output trips control ( code
       costmat outmat [ guessmat ] )

Files: basenet.DAT        - Input SATURN network data file.
       charges.DAT        - Input charge data file for SATNET/SATDB.
       output.UFS/UFA     - Output run name used in SATEASY & SATSIM.
       trips.UFM          - Input UF matrix file.
       control.DAT        - Input control parameter file for
                            use in SATEASY to invoke charging
                            and elasticity (if required).
                            Without elasticity the options are:
                            TOLL - for cordon toll charging
                            TIME - for time-based charging
                            CONG - for congestion charging
                            DIST - for distance-based charging
       code #             - Type of charging: TOLL,TIME,CONG or DIST.
       costmat.UFM #      - Input UF cost matrix file.
       outmat.UFM  #      - Output UF road trip matrix file.
       guessmat.UFM @     - Input UF 'best guess' road trip matrix.

Key:   # = only required with elastic response.
       @ = only required if parameter REDMEN = T.
*******Latest Update 29.3.94*************************************
```

This message should be reasonably self explanatory. Combining all possible options for road user charging and elastic assignment within a single batch procedure which runs to convergence results in a long and complex set of entries on the command line. The batch procedure has been constructed to provide error messages and warnings to the screen which inform the user of problems before they occur within the programs and prevent logical errors in the combinations of input files provided. However, when elastic assignment is chosen and the user is responsible for providing the SATEASY control file, the potential for mistakes increases and great care should be exercised.

REMEMBER:

* The value of the MILNE parameter must be compatible with the chosen charging "code" and the values contained in charges.DAT.

* The chosen value of the MCGILL parameter for the elastic function affects whether the elasticity is given by BETA or POWER.

* The factors required in charges.DAT are the same for time and congestion related charges but different for distance-based charging.

* Sensible names should be chosen for files, which reflect the combination of variable options which they represent. Thus:

* The charges.DAT file should have a name which declares the charging system and level to which it applies.

* The control.DAT file should have a name which declares the value of MILNE, MCGILL and the chosen elasticity parameter.

* The output.UFS/UFA and outmat.UFM files should have names which sufficiently identify the run to which they apply, incorporating as many of the variable options as is appropriate given the tests which are to be undertaken.

Due to the complexity of combining road user charging and elastic assignment, the SATTAX batch procedure does not allow all the individual options available within the SATNET and SATEASY programs to be accessed. The options within SATNET to update (UPDATE), preload (PLOD) and pass queues between (PASSQ) networks cannot be invoked; neither can the SATURN batch file option to restart a run (RESTART) or the SATEASY menu option for setting parameters (MENU). At present, it is not possible to model road user charging for multiple user classes, but this option should be incorporated in future with only minimal program changes. In addition, it is not recommended to apply charging in conjunction with the *logical parameter* ROSIE, which addresses the problem of time-flow curves for turns in shared lanes. This results in the generation of additional cost arrays and complicates the procedure of modifying generalised costs to represent charges. Other general parameters which would be likely to cause problems would be:

AMY - If TRUE travel times are fixed at free-flow values.

DUTCH - If TRUE input formats throughout the suite are altered and the use of SATDB to apply charges would need modification.

KNOBS/PPU - If KNOBS >0 extra data fields may be used to affect the assignment by modifying the standard generalised cost calculations based on time and distance to add other parameters. If KNOBS is being used in this way, care should be taken when applying charging.

PPM/PPK=0 - If either of the standard generalised cost parameters has been set to zero, the assignment, with or without charging, will be completely insensitive to changes in the cost of that parameter. Therefore, if a model is operating on time only assignment (PPM=1, PPK=0), distance related charges would be rendered ineffective, as they are applied to the fixed financial costs of travel valued by PPK. This problem is only likely to occur when generalised costs have been valued in terms of ratios rather than real money.

One option which may be helpful is the *logical parameter* DIDDLE, which invokes the use of assigned flows from the previous iteration as a starting point instead of beginning from scratch with an all-or-nothing load. This parameter has been found to improve convergence in networks where elastic assignment has been applied and may be beneficial when charging and elastic assignment are invoked together. The level of convergence of the network may play an important role deciding the reliability of results from modelling

road user charging, especially in conjunction with elastic assignment. The effects on modelled costs from both charging and elastic demand response may result in making convergence more difficult and it is important that changes to both route choices and demand patterns after charging can be distinguished from "noise" and bad convergence. One check which may help identify a problem is the use of SATEASY with elastic assignment, but an elasticity of zero, to attempt to recreate the base trip matrix. In some instances errors of as great as 10% in total trips have been found. During the SERC funded study a SATURN model of Cambridge produced an error of less than 1% from this test.

4.7 Measures Of Performance

Once road user charging has been applied successfully to a network, measures of performance are required to assess the impacts of the option tested. SATURN produces large volumes of calculations and statistics to assess the performance of the network under different conditions. Experience of testing large numbers of possible road user charging alternatives, involving different systems, regimes and charge levels, suggests that it is advisable to use network and area-wide indicators wherever possible and only resort to precise data regarding flows and travel times at specific points for the minimum number of runs.

Possibly the most useful indicators of overall network performance are area-wide statistics for total travel times, total travel distances and the resulting average network speeds. SATURN networks may be divided into different areas by the definition of "link indices" (also sometimes called *capacity indices*) within the third card of the network data file relating to buffer network data. Thus, it is possible to define distinct areas of interest for assessing the impacts of charging, so that aggregate data for times distances and speeds may be subdivided, for example, to distinguish the urban centre, the total charge area and any significant orbital routes which may be expected to carry diverted traffic. When "link indices" are used for an area of network which is defined in the simulation level of detail (under the first card of the network data file), all links to be identified must be duplicated in the third buffer network card. All entries apart from the "A-node", "B-node", "on-way/two-way indicator" and "link index" may be left blank, as any data placed here will be ignored if the link is defined in simulation. However, the *logical parameter* BEAKER must be set to TRUE to allow data for turns in the simulation to be included in the link totals, and therefore the area-wide summaries. Statistics for travel times, travel distances and average network speeds disaggregated by "link indices" are included within the assignment summary statistics printed in the line printer file produced by SATEASY and are accessible directly from the output.UFS file with SATLOOK. "Link indices" are also useful for aggregating other data on an area-wide basis within the SATDB data manipulation program. Further information about this option may be found in the general SATURN documentation.

During the SERC funded study, the following indicators have been considered:

(i) aggregate network performance measures
- area-wide totals for travel time
- area-wide totals for travel distance
- area-wide totals for average network speed
- area-wide totals for queueing delays

(ii) flow based measures
- total flows across important cordons and screenlines
- Total flows on principal diversion routes

(iii) distributional indicators
- matrices of average trip costs
- matrices of average travel times
- matrices of average travel distances

(iv) routeing indicators
- select link matrices travelling through key links
- routes chosen by key movements in the matrix

(v) financial measures
- charging revenue

(vi) demand indicators (for elastic assignment)
- total matrix size by charge level
- matrices of trip changes

(vii) plots
- comparisons of flows with base situation

The majority of indicators are most conveniently produced using the SATDB, SATLOOK and MX programs. The use of KEY files is particularly recommended to automate analysis and calculations which are repeated for each run. In general such KEY files will require network specific information and filenames, so it is not feasible to provide a set of pre-prepared files with the SATTAX software. However, two very simple KEY files are included to produce the most basic summary information common to all SATTAX runs. These files are OUT1.KEY and OUT2.KEY, copies of which may be found in Sections 6.4 and 6.5 of the Appendix respectively.

OUT1.KEY may be used in SATLOOK to produce the assignment summary statistics from SATEASY, which includes area-wide totals for travel time, travel distance and average network speed, both for the whole network and subdivided by *capacity indices*, if applicable. To use this key file the following keyboard entry sequence is required:

SATLOOK output KEY OUT1 VDU SCREEN

This will access the binary file output.UFS and produce assignment summary statistics in the file output.LPL. The terminal will be blank while the program is running, with all usual screen comments being sent to the file SCREEN.VDU. If the procedure fails to produce the desired output the VDU file contains a record of all commands carried out by the KEY file and should help clarify the problem.

OUT2.KEY operates with the MX program to provide row and column totals and a summary of total trips for the output demand matrix resulting from road user charging. This KEY file is only appropriate for situations where elastic assignment has been applied. The keyboard entry sequence required for OUT2.KEY is as follows:

MX output KEY OUT2 VDU SCREEN

Similar to above, MX accesses the binary matrix file produced by SATEASY, output.UFM and produces the summarised information in the file output.LPX. Again SCREEN.VDU contains a record of the screen comments which would be sent to the terminal under normal interactive use of the programs.

Further details of all the SATURN analysis programs and the use of KEY files is contained in the general documentation. However, a few hints are given below:

* The "statistical analysis" option of SATDB may be used to sum column totals.

* SATLOOK may be used to provide matrices of costs.

* MX allows matrices to be compressed to simpler levels (eg 3 by 3).

* SATDB can produce matrices of trips using just a series of selected links.

The rest is up to you! Good Luck.

5. REFERENCES

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6. APPENDIX

6.1 The SATTAX Batch File

```
ECHO OFF
REM:
REM:          SATTAX BATCH FILE - Initiated      14.3.94
REM:                              Latest Update  10.6.94
REM:
IF NOT "%1" == "" GOTO INFO
ECHO .
ECHO .        Welcome to SATTAX - the procedure for running SATURN
ECHO .        with Road User Charging.  Before using this batch file
ECHO .        you are advised to consult the documentation available
ECHO .        in ITS Working Paper 410 (or the SATTAX.HLP file).
ECHO .        To check entry requirements for running SATTAX type:
ECHO .
ECHO .        SATTAX INFO
ECHO .
GOTO EXIT
:INFO
IF "%1" == "INFO" GOTO CALLS
IF "%1" == "info" GOTO CALLS
GOTO START
:CALLS
ECHO .*******SATTAX INFORMATION*****************************************
ECHO .Call:  SATTAX basenet charges output trips control ( code
ECHO .               costmat outmat [ guessmat ] )
ECHO .
ECHO .Files: basenet.DAT      - Input SATURN network data file.
ECHO .       charges.DAT      - Input charge data file for SATNET/SATDB.
ECHO .       output.UFS/UFA   - Output run name used in SATEASY & SATSIM.
ECHO .       trips.UFM        - Input UF matrix file.
ECHO .       control.DAT      - Input control parameter file for
ECHO .                          use in SATEASY to invoke charging
ECHO .                          and elasticity (if required).
ECHO .                          Without elasticity the options are:
ECHO .                            TOLL - for cordon toll charging
ECHO .                            TIME - for time-based charging
ECHO .                            CONG - for congestion charging
ECHO .                            DIST - for distance-based charging
ECHO .       code #           - Type of charging: TOLL,TIME,CONG or DIST.
ECHO .       costmat.UFM #    - Input UF cost matrix file.
ECHO .       outmat.UFM  #    - Output UF road trip matrix file.
ECHO .       guessmat.UFM @   - Input UF 'best guess' road trip matrix.
ECHO .
ECHO .Key: # = only required with elastic response.
ECHO .     @ = only required if parameter REDMEN = T
ECHO .*******Latest Update 10.6.94**************************************
GOTO EXIT
:START
REM .
REM .         Check for HLP file
REM .
IF EXIST SATTAX.HLP GOTO FCHECK
ECHO .        You cannot run SATTAX unless SATTAX.HLP is on your disk!
ECHO .
ECHO .        Have you read the relevant documentation?
GOTO EXIT
:FCHECK
REM .
REM .         Check existence of ALL compulsory files
REM .
IF EXIST TOLL.KEY GOTO OK1A
ECHO .        The essential file TOLL.KEY has not been found
GOTO FILERR
:OK1A
IF EXIST TIME.KEY GOTO OK1
ECHO .        The essential file TIME.KEY has not been found
GOTO FILERR
:OK1
IF EXIST CONG.KEY GOTO OK2
ECHO .        The essential file CONG.KEY has not been found
```

```
GOTO FILERR
:OK2
IF EXIST DIST.KEY GOTO OK3
ECHO .       The essential file DIST.KEY has not been found
GOTO FILERR
:OK3
IF EXIST TOLL.DAT GOTO OK4
ECHO .       The essential file TOLL.DAT has not been found
GOTO FILERR
:OK4
IF EXIST TIME.DAT GOTO OK5
ECHO .       The essential file TIME.DAT has not been found
GOTO FILERR
:OK5
IF EXIST CONG.DAT GOTO OK6
ECHO .       The essentail file CONG.DAT has not been found
GOTO FILERR
:OK6
IF EXIST DIST.DAT GOTO OK7
ECHO .       The essential file DIST.DAT has not been found
GOTO FILERR
:OK7
IF EXIST SATTAX0.DAT GOTO OK8
ECHO .       The essential file SATTAX0.DAT has not been found
GOTO FILERR
:OK8
REM .
REM .        Check existence of user input files and give warnings
REM .
IF "%5" == "" GOTO INPERR
IF EXIST %1.DAT GOTO WARN1
ECHO .      ************************************************************
ECHO .       WARNING! The network file %1.DAT has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:WARN1
IF EXIST %2.DAT GOTO WARN2
ECHO .      ************************************************************
ECHO .       WARNING! The charge file %2.DAT has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:WARN2
IF EXIST %4.UFM GOTO WARN3
ECHO .      ************************************************************
ECHO .       WARNING! The matrix file %3.UFM has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:WARN3
IF NOT "%6" == "" GOTO WARN3A
IF "%5" == "TOLL" GOTO WARN4
IF "%5" == "toll" GOTO WARN4
IF "%5" == "TIME" GOTO WARN4
IF "%5" == "time" GOTO WARN4
IF "%5" == "CONG" GOTO WARN4
IF "%5" == "cong" GOTO WARN4
IF "%5" == "DIST" GOTO WARN4
IF "%5" == "dist" GOTO WARN4
ECHO . ***** TYPE OF CHARGING NOT SPECIFIED *****
ECHO .
ECHO . For inelastic runs your control file must be one of four
ECHO . preset options.  Type: SATTAX INFO for further details.
GOTO EXIT
:WARN3A
IF EXIST %5.DAT GOTO WARN4
ECHO .      ************************************************************
ECHO .       WARNING! The control file %5.DAT has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:WARN4
IF "%6" == "" GOTO SATNET
IF "%6" == "TOLL" GOTO WARN4A
IF "%6" == "toll" GOTO WARN4A
IF "%6" == "TIME" GOTO WARN4A
IF "%6" == "time" GOTO WARN4A
IF "%6" == "CONG" GOTO WARN4A
```

```
IF "%6" == "cong" GOTO WARN4A
IF "%6" == "DIST" GOTO WARN4A
IF "%6" == "dist" GOTO WARN4A
ECHO . ***** UNRECOGNIZED CODE FOR TYPE OF CHARGING *****
ECHO .
ECHO . For elastic runs a code is required to specify the type of
ECHO . charging to be used.  This must be consistent with the
ECHO . parameters set in your control file.  Type: SATTAX INFO for
ECHO . details of the codes which are acceptable.
GOTO EXIT
:WARN4A
IF EXIST %7.UFM GOTO WARN5
ECHO .      ************************************************************
ECHO .       WARNING! The costs file %7.UFM has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:WARN5
IF "%9" == "" GOTO SATNET
IF EXIST %9.UFM GOTO SATNET
ECHO .      ************************************************************
ECHO .       WARNING! The guess file %9.UFM has not been found.
ECHO .       The SATTAX batch procedure will fail.
ECHO .      ************************************************************
:SATNET
REM .
REM .        Start of SATTAX runs with SATNET
REM .
ECHO .
ECHO .       Start of SATTAX runs
ECHO .
ECHO .       Running SATNET...
ECHO .
ECHO .       followed by SATDB
ECHO .       and then by iterative loops of SATEASY & SATSIM
ECHO .
IF EXIST $SATNET.EXE GOTO PROG1
ECHO . ***** $SATNET.EXE FILE NOT FOUND *****
GOTO EXIT
:PROG1
IF EXIST $SAT9.CTL ERASE $SAT9.CTL
CALL SATNET %1
REM :
:NETEND
IF ERRORLEVEL 1 GOTO NETBUG
IF EXIST $SAT9.CTL GOTO NETBUG
ECHO .
ECHO .       SUCCESSFUL COMPLETION OF SATNET
ECHO .
:SATDB
ECHO .
ECHO .       And now for SATDB...
ECHO .
IF EXIST $SATDB.EXE GOTO PROG2
ECHO . ***** $SATDB.EXE FILE NOT FOUND *****
GOTO EXIT
:PROG2
IF EXIST $SAT9.CTL ERASE $SAT9.CTL
REM .
REM .        Choose charging method for SATDB
REM .
IF "%6" == "" GOTO FIXDB
IF "%6" == "TOLL" GOTO TOLLDB
IF "%6" == "toll" GOTO TOLLDB
IF "%6" == "TIME" GOTO TIMEDB
IF "%6" == "time" GOTO TIMEDB
IF "%6" == "CONG" GOTO CONGDB
IF "%6" == "cong" GOTO CONGDB
IF "%6" == "DIST" GOTO DISTDB
IF "%6" == "dist" GOTO DISTDB
:FIXDB
IF "%5" == "TOLL" GOTO TOLLDB
IF "%5" == "toll" GOTO TOLLDB
IF "%5" == "TIME" GOTO TIMEDB
IF "%5" == "time" GOTO TIMEDB
IF "%5" == "CONG" GOTO CONGDB
```

```
IF "%5" == "cong" GOTO CONGDB
IF "%5" == "DIST" GOTO DISTDB
IF "%5" == "dist" GOTO DISTDB
:TOLLDB
ECHO .
ECHO . ****************************************
ECHO . * YOUR CHOSEN CHARGING OPTION IS....    *
ECHO . *                                       *
ECHO . *       TTTTT  OOOO  L     L            *
ECHO . *         T    O  O  L     L            *
ECHO . *         T    O  O  L     L            *
ECHO . *         T    O  O  L     L            *
ECHO . *         T    OOOO  LLLL  LLLL         *
ECHO . *                                       *
ECHO . ****************************************
ECHO .
IF EXIST TOLLSPEC.DAT ERASE TOLLSPEC.DAT
IF EXIST TOLTRICK.UFS ERASE TOLTRICK.UFS
IF EXIST TOLLOUT.UFS ERASE TOLLOUT.UFS
IF EXIST TOLL.VDU ERASE TOLL.VDU
IF NOT EXIST %2.DAT GOTO CHARGERR
COPY %2.DAT TOLLSPEC.DAT
CALL SATDB %1 KEY TOLL VDU TOLL
IF EXIST $SAT9.CTL GOTO DBBUG
IF NOT EXIST TOLLOUT.UFS GOTO DBOUTERR
COPY TOLLOUT.UFS %3.UFS
IF EXIST %3.UFS ERASE TOLLOUT.UFS
IF EXIST %3.UFS ERASE TOLTRICK.UFS
IF EXIST %3.UFS ERASE TOLLSPEC.DAT
GOTO ENDDB
:TIMEDB
ECHO .
ECHO . ****************************************
ECHO . * YOUR CHOSEN CHARGING OPTION IS....    *
ECHO . *                                       *
ECHO . *       TTTTT  III  M   M  EEEE         *
ECHO . *         T     I   MM MM  E            *
ECHO . *         T     I   M M M  EEE          *
ECHO . *         T     I   M   M  E            *
ECHO . *         T    III  M   M  EEEE         *
ECHO . *                                       *
ECHO . ****************************************
ECHO .
IF EXIST TIMESPEC.DAT ERASE TIMESPEC.DAT
IF EXIST TIMEOUT.UFS ERASE TIMEOUT.UFS
IF EXIST TIME.VDU ERASE TIME.VDU
IF NOT EXIST %2.DAT GOTO CHARGERR
COPY %2.DAT TIMESPEC.DAT
CALL SATDB %1 KEY TIME VDU TIME
IF EXIST $SAT9.CTL GOTO DBBUG
IF NOT EXIST TIMEOUT.UFS GOTO DBOUTERR
COPY TIMEOUT.UFS %3.UFS
IF EXIST %3.UFS ERASE TIMEOUT.UFS
IF EXIST %3.UFS ERASE TIMESPEC.DAT
GOTO ENDDB
:CONGDB
ECHO .
ECHO . ****************************************
ECHO . * YOUR CHOSEN CHARGING OPTION IS....    *
ECHO . *                                       *
ECHO . *       CCCC  OOOO  N   N  GGGG         *
ECHO . *       C     O  O  NN  N  G            *
ECHO . *       C     O  O  N N N  G GG         *
ECHO . *       C     O  O  N  NN  G  G         *
ECHO . *       CCCC  OOOO  N   N  GGGG         *
ECHO . *                                       *
ECHO . ****************************************
ECHO .
IF EXIST CONGSPEC.DAT ERASE CONGSPEC.DAT
IF EXIST CONGOUT.UFS ERASE CONGOUT.UFS
IF EXIST CONG.VDU ERASE CONG.VDU
IF NOT EXIST %2.DAT GOTO CHARGERR
COPY %2.DAT CONGSPEC.DAT
CALL SATDB %1 KEY CONG VDU CONG
IF EXIST $SAT9.CTL GOTO DBBUG
```

```
IF NOT EXIST CONGOUT.UFS GOTO DBOUTERR
COPY CONGOUT.UFS %3.UFS
IF EXIST %3.UFS ERASE CONGOUT.UFS
IF EXIST %3.UFS ERASE CONGSPEC.DAT
GOTO ENDDB
:DISTDB
ECHO .
ECHO . ****************************************
ECHO . * YOUR CHOSEN CHARGING OPTION IS....    *
ECHO . *                                       *
ECHO . *       DDD   III   SSSS  TTTTT         *
ECHO . *       D  D   I   S        T           *
ECHO . *       D  D   I    SSS     T           *
ECHO . *       D  D   I       S    T           *
ECHO . *       DDD   III  SSSS     T           *
ECHO . *                                       *
ECHO . ****************************************
ECHO .
IF EXIST DISTSPEC.DAT ERASE DISTSPEC.DAT
IF EXIST DISTRICK.UFS ERASE DISTRICK.UFS
IF EXIST DISTOUT.UFS ERASE DISTOUT.UFS
IF EXIST DIST.VDU ERASE DIST.VDU
IF NOT EXIST %2.DAT GOTO CHARGERR
COPY %2.DAT DISTSPEC.DAT
CALL SATDB %1 KEY DIST VDU DIST
IF EXIST $SAT9.CTL GOTO DBBUG
IF NOT EXIST DISTOUT.UFS GOTO DBOUTERR
COPY DISTOUT.UFS %3.UFS
IF EXIST %3.UFS ERASE DISTOUT.UFS
IF EXIST %3.UFS ERASE DISTRICK.UFS
IF EXIST %3.UFS ERASE DISTSPEC.DAT
:ENDDB
ECHO .
ECHO .        SUCCESSFUL COMPLETION OF SATDB
ECHO .
:SATEASY
ECHO .
ECHO .        Running SATEASY...
ECHO .
IF EXIST $SATEASY.EXE GOTO PROG3
ECHO . ***** $SATEASY.EXE FILE NOT FOUND *****
GOTO EXIT
:PROG3
IF EXIST $SAT9.CTL ERASE $SAT9.CTL
IF EXIST $SAT2.CTL ERASE $SAT2.CTL
REM .
REM .         Choose correct number of entry files for SATEASY
REM .
IF "%9" == "" GOTO EASY1
CALL SATEASY %3 %4 KR %5 M 21 %7 M 22 %9 M 23 %8
GOTO EASYEND
:EASY1
IF "%6" == "" GOTO EASY2
CALL SATEASY %3 %4 KR %5 M 21 %7 M 23 %8
GOTO EASYEND
:EASY2
CALL SATEASY %3 %4 KR %5
:EASYEND
REM :
REM :  Branch on error level but, since it doesn't seem to work
REM :  under MS-DOS, double check on the existence or not of special
REM :  control files.
REM :
IF ERRORLEVEL 3 GOTO ASSBUG
IF ERRORLEVEL 2 GOTO ENDOK
IF EXIST $SAT9.CTL GOTO ASSBUG
IF EXIST $SAT2.CTL GOTO ENDOK
ECHO .
ECHO .        SUCCESSFUL COMPLETION OF SATEASY
ECHO .
:ASSEND
ECHO .
ECHO .        ....followed by SATSIM and test for continuity
ECHO .
IF EXIST $SATSIM.EXE GOTO PROG4
```

```
ECHO . ***** $SATSIM.EXE FILE NOT FOUND *****
GOTO EXIT
:PROG4
IF EXIST $SAT9.CTL ERASE $SAT9.CTL
IF EXIST $SAT2.CTL ERASE $SAT2.CTL
REM :
CALL SATSIM %3
REM :
IF ERRORLEVEL 3 GOTO SIMBUG
IF ERRORLEVEL 2 GOTO ENDOK
IF EXIST $SAT9.CTL GOTO SIMBUG
IF EXIST $SAT2.CTL GOTO ENDOK
REM :
REM :         SUCCESSFUL COMPLETION OF SATSIM
REM :
GOTO SATEASY
REM :
:ENDOK
ECHO .
ECHO . ***** The SATEASY/SATSIM Iterative Loops have Converged *****
ECHO .
ECHO .        YOUR ROAD USER CHARGING RESULTS ARE READY!
ECHO .
GOTO EXIT
REM :
:FILERR
ECHO . ***** SATTAX CANNOT CONTINUE WITHOUT AN ESSENTIAL FILE *****
GOTO EXIT
REM .
:INPERR
ECHO . ***** INPUT ERROR *****
ECHO .
ECHO . Type: SATTAX INFO to see the correct input format
GOTO EXIT
REM .
:NETBUG
ECHO . ***** FATAL ERROR DETECTED IN SATNET *****
GOTO EXIT
REM :
:DBBUG
ECHO . ***** FATAL ERROR DETECTED IN SATDB *****
GOTO EXIT
:ASSBUG
ECHO . ***** FATAL ERROR DETECTED IN SATEASY *****
GOTO EXIT
REM :
:SIMBUG
ECHO . ***** FATAL ERROR DETECTED IN SATSIM *****
REM :
:CHARGERR
ECHO . ***** YOUR CHARGE DATA FILE HAS NOT BEEN FOUND
ECHO .        THE SATTAX PROCEDURE HAS FAILED *****
GOTO EXIT
REM :
:DBOUTERR
ECHO . ***** SATDB HAS NOT PRODUCED AN UPDATED .UFS FILE
ECHO .        THE SATTAX PROCEDURE HAS FAILED *****
:EXIT
IF EXIST $SAT9.CTL ERASE $SAT9.CTL
IF EXIST $SAT2.CTL ERASE $SAT2.CTL
```

6.2 Example Charge Data File

```
9901   11   12 1655
9901   11      1655
  12   11 9901 1655
  12   11      1655
  13   11 9901 1655
  13   11   12 1655
  13   11      1655
 782   12   14 1655
 782   12   13 1655
 782   12   11 1655
 782   12      1655
  14   12   13 1655
  14   12   11 1655
  14   12  782 1655
  14   12      1655
  13   12   11 1655
  13   12  782 1655
  13   12   14 1655
  13   12      1655
  11   12      1655
  11   12  782 1655
  11   12   14 1655
  11   12   13 1655
  12   13      1655
  12   13   21 1655
  21   13   11 1655
  21   13   12 1655
  21   13      1655
  12   14      1655
  12   14  791 1655
  12   14   31 1655
 791   14   31 1655
 791   14   12 1655
 791   14      1655
  31   14   12 1655
  31   14  791 1655
  31   14      1655
  13   21      1655
  13   21 9902 1655
  13   21 9903 1655
9902   21 9903 1655
9902   21   13 1655
9902   21      1655
9903   21   13 1655
9903   21 9902 1655
9903   21      1655
9902   31   14 1655
9902   31   41 1655
9902   31      1655
  14   31      1655
  14   31   41 1655
  14   31 9902 1655
  41   31 9902 1655
  41   31   14 1655
  41   31      1655
  42   41   31 1655
  42   41  831 1655
  42   41      1655
  31   41      1655
  31   41  831 1655
  31   41   42 1655
 831   41   42 1655
 831   41   31 1655
 831   41      1655
  43   42   41 1655
  43   42   51 1655
  43   42      1655
  41   42      1655
  41   42   51 1655
  41   42   43 1655
```

6.3 The Null SATEASY Control File, SATTAX0.DAT

```
 &PARAM
  MILNE  = 0
  MCGILL = 0
  POWER  = 0
  BETA   = 0
  MCOPT  = 0
  REDMEN = F
  XFFC   = 0.0
 &END
```

6.4 SATLOOK Output Analysis KEY File, OUT1.KEY

```
           5  - ASSIGNMENT SUMMARY STATISTICS
           0  - SUMMARY STATISTICS BY CAPACITY INDEX
           0  - TERMINATE
Y             - CONFIRM PROGRAM TERMINATION
```

6.5 MX Output Analysis KEY File, OUT2.KEY

```
          12  - PRINT/DUMP ROW AND COLUMN TOTALS
           1  - PRINT AN EXTERNAL MATRIX ROW AND COLUMN TOTALS TO THE LP FILE
           0  - RETURN
           0  - EXIT
Y             - CONFIRM PROGRAM TERMINATION
```