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SYSTEMS OPERATION STUDIES FOR AUTOMATED GUIDEWAY TRANSIT SYSTEMS

SYSTEM AVAILABILITY MODEL USER'S MANUAL

GM Transportation Systems Division
General Motors Technical Center
Warren, MI 48090

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FINAL REPORT

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16. Abstract

The System Availability Model (SAM) User's Manual describes the program, its input requirements and operating procedures. The SAM is a system-level model which provides measures of vehicle and passenger availability. Maintenance and standby fleet size required to support the operational fleet are also determined.

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PREFACE

In order to examine specific Automated Guideway Transit (AGT) developments and concepts - and to build a better knowledge base for future decision-making - the Urban Mass Transportation Administration (UMTA) has undertaken a new program of studies and technology investigations called the UMTA Automated Guideway Transit Technology (AGTT) program. The objectives of one segment of the AGTT program, the System Operation Studies (SOS), are to develop models for the analysis of system operations, to evaluate performance and cost, and to establish guidelines for the design and operation of AGT systems. A team headed by GM Transportation Systems Division (GM TSD) has been awarded a contract by the Transportation Systems Center to pursue these objectives. The Technical Monitor for the project at TSC was Arthur Priver, who was assisted by Li Shin Yuan and Thomas Dooley.

This document was prepared under the direction of the SOS Program Manager, James F. Thompson, at GM TSD. The report was authored by Robert Oglesby, GM TSD.

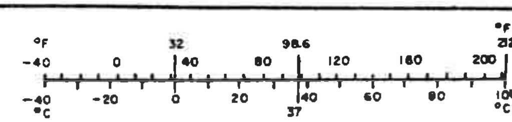
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

1.1 IDENTIFICATION

The System Availability Model (SAM) was designed by Robert Oglesby of General Motors Transportation Systems Division (GM TSD), and James Boldig, GM TSD. It was programmed by Eugene Mauch of Applied Systems Corporation. GM TSD Report No. EP-77056A, System Availability Model Technical Specification, September 1977, specifies the technical requirements for the SAM.

1.2 APPLICABILITY

The SAM operates in conjunction with the AGT-SOS Discrete Event Simulation Model (DESM). The DESM output is the normal source of the delays information portion of SAM's input data set. There is no inherent restriction on the systems applicability of SAM; the range of applicability of the DESM, then, defines the range of applicability for SAM.

1.3 CAPABILITIES

Utilizing the parameters that the user inputs (Section 4.1.1.4.1) and the trip logs generated by DESM (Section 4.3.1), the SAM computes:

- Vehicle Availability (Section 2.1)
- Passenger Availability for various delay thresholds (Section 2.1)
- Fleet maintenance measures for various fleet sizes:
  - Maintenance fleet size
  - Probability of a replacement vehicle being available when needed
  - Minimum service facility required

The full set of system alternatives which the DESM models is acceptable to the SAM.

1.4 LIMITATIONS

Modification of the following limitations requires recompilation of the source code.

Demand intervals	5
Reliability levels	5
Delay thresholds	10
Failure modes	5
Reliability regions	5

2.0 PROGRAM DESCRIPTION

2.1 OVERVIEW

The System Availability Model (SAM) is a system-level model which provides measures of vehicle and passenger availability. Maintenance and standby fleet size required to support the operational fleet are also determined.

The basic parameters required by the model for computation of the availability measures are:

1. Subsystem failure rates
2. Subsystem repair rates
3. Vehicle operating time
4. Vehicle delay time
5. Passenger trip times
6. Passenger trip delay times

For the purpose of determining the availability measures, AGT systems are described by a complement of hardware. The hardware concept is analyzed from a reliability point of view to determine the expected reliability characteristics of the major elements of the system. These are established in the form of a predicted frequency or rate of occurrence of failures of the identified subsystems, e.g., failures per 1000 hours of operation for vehicles, failures per number of operations for stations, failures per 1000 hours of system operation for central management, etc.

Five classes of failures, in terms of the effect on system performance, can be considered. They include those failures which are expected to cause a stoppage of movement on a segment of the guideway or in stations; and failures which do not stop movement but which require some action on the part of the system, such as reduced vehicle velocity, which allows the system to function at a reduced level of performance.

A set of predicted component failure frequencies are developed and contained in the Input and Description File (failures per 1000 hours, etc.) for failures which cause stoppages or degraded levels of operation within a segment of the system.

The expected frequencies of occurrence of failure is used by the model to calculate the number of occurrences of failures of a given type that would be expected to occur during any specified period of operating time of the system. For example, if 10,000 hours of vehicle operating time were accumulated during a specified interval of system operating time and the calculated frequency of vehicle failures (failure rates) which cause stoppages, and which result in degraded operation were 1.0 and 2.0 failures per 1000 hours of operation, respectively, the expected number of stoppages to occur during the 10,000 hours of vehicle operation would be 10 and the expected number of occurrences of degraded operation would be 20.

To determine the vehicle availability, i.e., the ratio of vehicle operating time minus delay time to the vehicle operating time, for the above example, it is necessary to establish the vehicle delay times associated with the occurrences of failure.

Delay time data for the availability model are developed from the Discrete Event Simulation Model, using the two system operating conditions that would be expected as a result of a failure, i.e., the system is either stopped or operating in a degraded mode. All subsystem failure effects which can cause a system delay fall into these two categories. There may be various levels of degradation effects that systems experience depending on the specific failures.

To establish the system-level effects of failures requires a failure management policy for the system. The failure management policy, e.g., how failed vehicles are removed, will determine the period of time during which system level delays would accrue.

Two approaches are used to establish delay consequence data. If failure management strategy analyses have been completed and policies established, expected system downtime and degraded operation requirements will have been determined and the associated operational constraints imposed on the system will be known. These can be input directly into the Discrete Event Simulation Model (DESM) to determine the delay consequences which result. In the absence of specific data, a range of system stoppage times, e.g., 5, 10, 15 minutes, and degraded operational conditions, e.g., maximum vehicle speed of 5, 10, and 15 kilometers per hour, can be entered as operational conditions in the Discrete Event Simulation Model and a range of delay time consequences (increased queueing time) developed.

In both cases, delay as a function of stoppages and degraded operation is obtained by differencing vehicle operating time and passenger trip time data for a nominally operating system from that of the perturbed system.

The delay times (increased queue times) developed within a system as a result of failures are a function of the specified network configuration in the local region where the failure occurs and the demand level on the system at the time the failure occurs.

To determine the regional characteristics that a specific network type exhibits (these may differ for each subsystem), stoppages and degraded operational conditions for each subsystem, i.e., vehicles, stations, guideway, central management are caused to occur at selected locations within the network being analyzed. The user selects a sample of guideway links, stations, etc. for the introduction of failures. Those areas of the network, that is, stations and guideway links which exhibit similar delay or queuing time characteristics in the presence of a failure, are grouped by the analyst into regions for availability analysis purposes.

Thus, the delay time data to be used by the Availability Model are developed in the form of three -dimensional matrices involving failures, regions, and demand levels.

The distribution of failures to regions within a network makes use of the vehicle operating time, system operating time, and/or the number of operations of hardware within each region. The failure frequency or failure rate of each subsystem is contained within SAM and is based on the reliability analyses of the components within the subsystem. The product of regional operating time and the rate of failure occurrence provides a measure of the number of failures per region. Using the demand level data from the DESM, the appropriate delay time matrix can be entered to obtain the delay time per failure. The delay time is summed for all failures in all regions and with the specified demand levels used to obtain the total delay for the scenario being evaluated. Thus, the parameters required for the availability delay time measures are developed.

This approach provides the ability to study the effects of variations of failure management strategies or demand levels by altering the delay time data in the delay time matrices either as user input or through the use of the DESM.

Reliability factors such as redundancies and high quality parts can be evaluated by modifying the failure frequency or failure rate data in SAM either as user-selected inputs or through the development of modified or new hardware descriptions. Failure rate changes vary only the number of occurrences of failure events which occur during a given period of system operation.

Two measures of the number of vehicles required to support the active fleet are developed by SAM. These are maintenance fleet size and standby fleet size. The model utilizes the active fleet failure rate, vehicle repair rate, and the number of maintenance bays to develop these measures.

Vehicle failure rate data exists within SAM and is used along with vehicle operating time to determine the rate at which vehicles are entering the maintenance cycle as a result of failures.

The maintenance and standby fleet measures are derived from queuing theory as it relates to the maintenance facility. Failed vehicles may be thought of as arriving at the maintenance facility at random times. These arrival times are considered to have an exponential distribution with mean given by the active fleet failure rate. It is recognized that failures do not always require the same time to be repaired in a service bay. With this in mind, the time of repair in each service bay is considered to be exponentially distributed with mean given by the vehicle repair rate.

We now have a queuing theory problem with a single queue and multiple servers where service and arrival times are exponentially distributed. Each failed vehicle in maintenance was replaced by a vehicle from the standby fleet (if one was available). Therefore, the probability that no standby vehicle was available to replace a failed vehicle is the probability that the maintenance queue is larger than the original standby fleet. That is, the maintenance facility is thought to be initially empty and the vehicles of the standby fleet are expected to replace the vehicles which enter maintenance for failure repairs. The probability of being in any particular state (maintenance fleet size) is given by Reference 7. The probability of being in some state greater than the standby fleet size can be derived by summing the probabilities of being in each state greater than the standby fleet size. Subtracting this probability from 1, we have the probability that a standby vehicle will be available to take the place of a failed vehicle.

The average failure maintenance fleet is found by summing the states, weighted by the probability of occurrence.

2.2 ORGANIZATION

The SAM is divided into three program modules. The input processor, the model processor, and the output processor. The input processor validates user inputs and computes passenger delays from the DESM trip log. The model processor computes the availability measures. There are three categories: passenger availability, vehicle availability, and fleet maintenance. The output processor prints the results in report format. These are diagrammed in Figures 2-1, 2-2, and 2-3.

2.3 FUNCTIONS

The model structure is shown in Figure 2-4 and the functions are described. Functions requiring further description are expanded below.

2.3.1 Trip Log Processing (AINUMT)

The number of trips delayed is computed by comparing the travel times of individual trips in the trip log. To do this the DESM runs must use identical trips (i.e., start time, origin station, destination station, and trip size). The trip logs read by SAM must be sorted to be in the same order which the DESM produces (i.e., ordered by trip termination time). Given the suitable trip logs, the input processor identifies identical trips and computes travel time (arrival time - start time) for each trip log. If the failure increased the travel time more than a threshold, the trip size is added to the number of passengers delayed. The program provides for several thresholds resulting in a delay time histogram, which is used by the model processor.

2.4 OPTIONS

The SAM has no options which are selected at linkedit or program initialization; the input processor has two modes of operation: create, and update.

2.4.1 Create Mode

This is selected by omitting the UPDATE parameter. (See section 6.4.1.) All the parameters are specified and this creates a new structured data file.

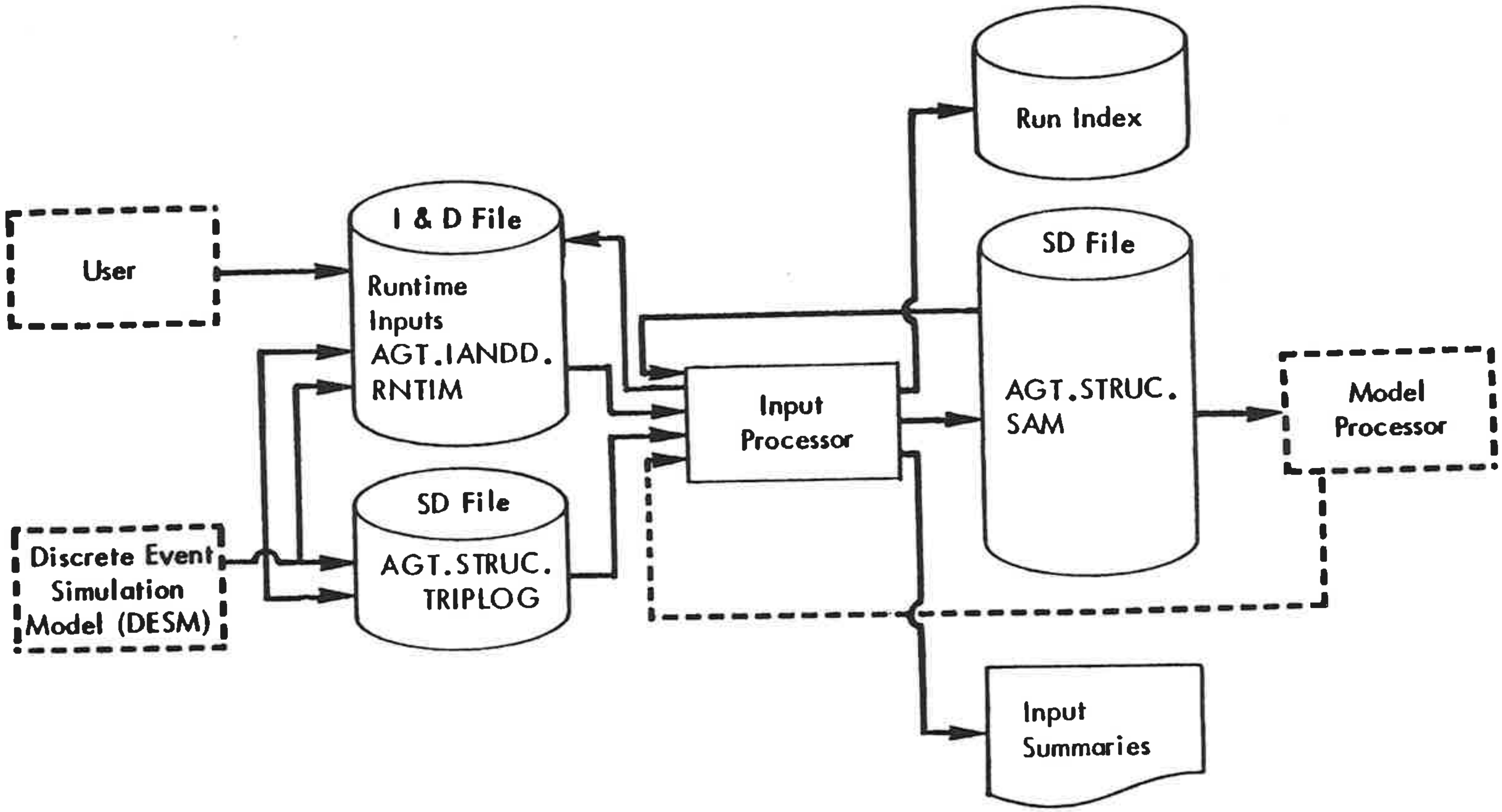

FIGURE 2-1. INPUT PROCESSOR DATA INTERFACE

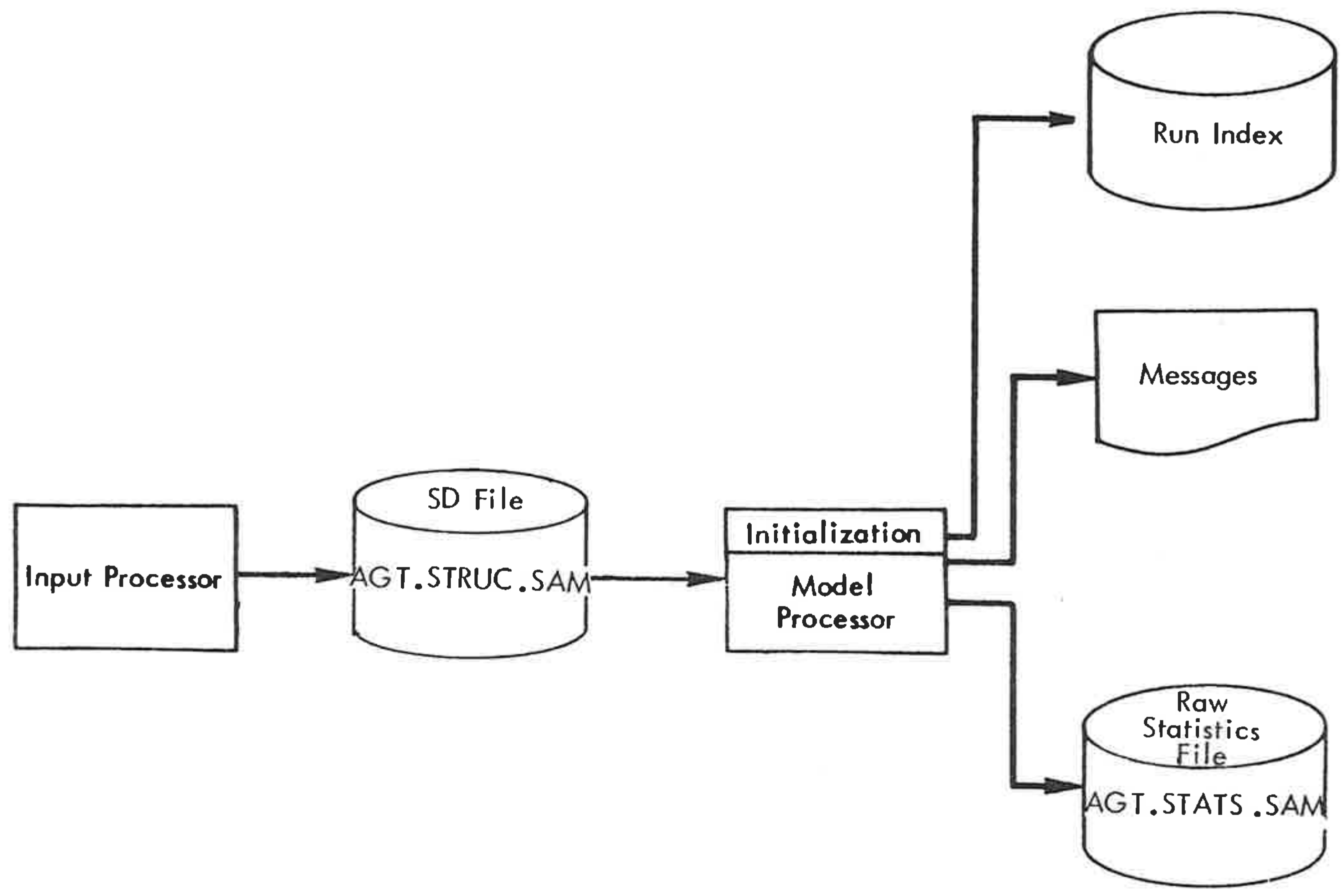

FIGURE 2-2. MODEL PROCESSOR — DATA BASE INTERFACE

OUTPUT PROCESSOR MODEL INTERFACES

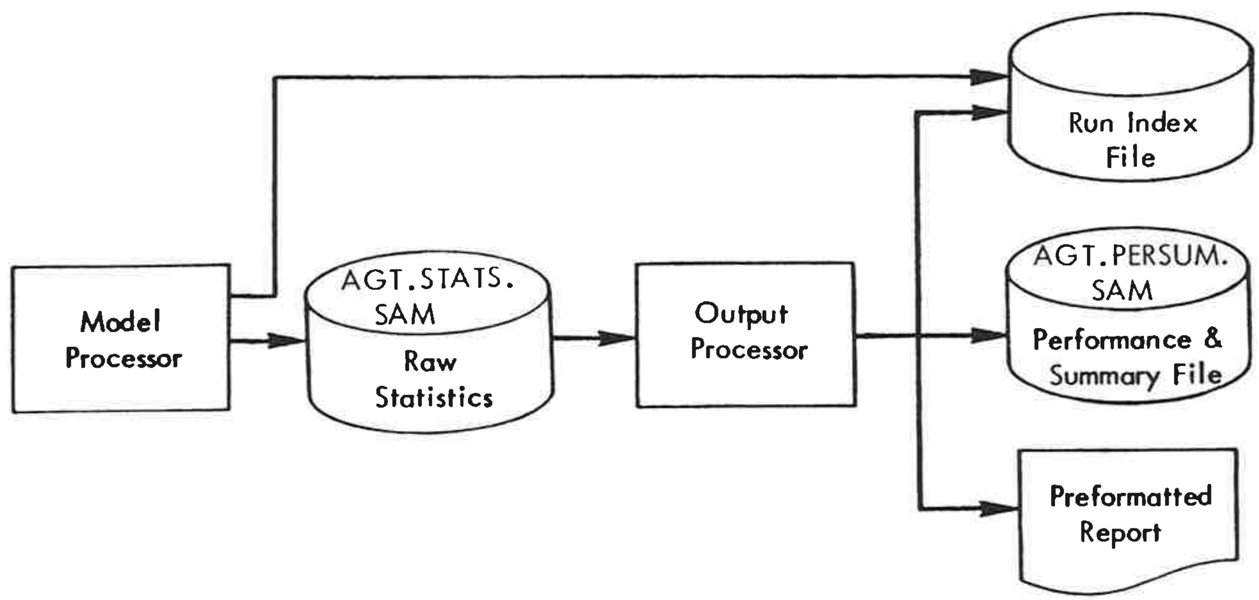

FIGURE 2-3. OUTPUT PROCESSOR MODEL INTERFACES

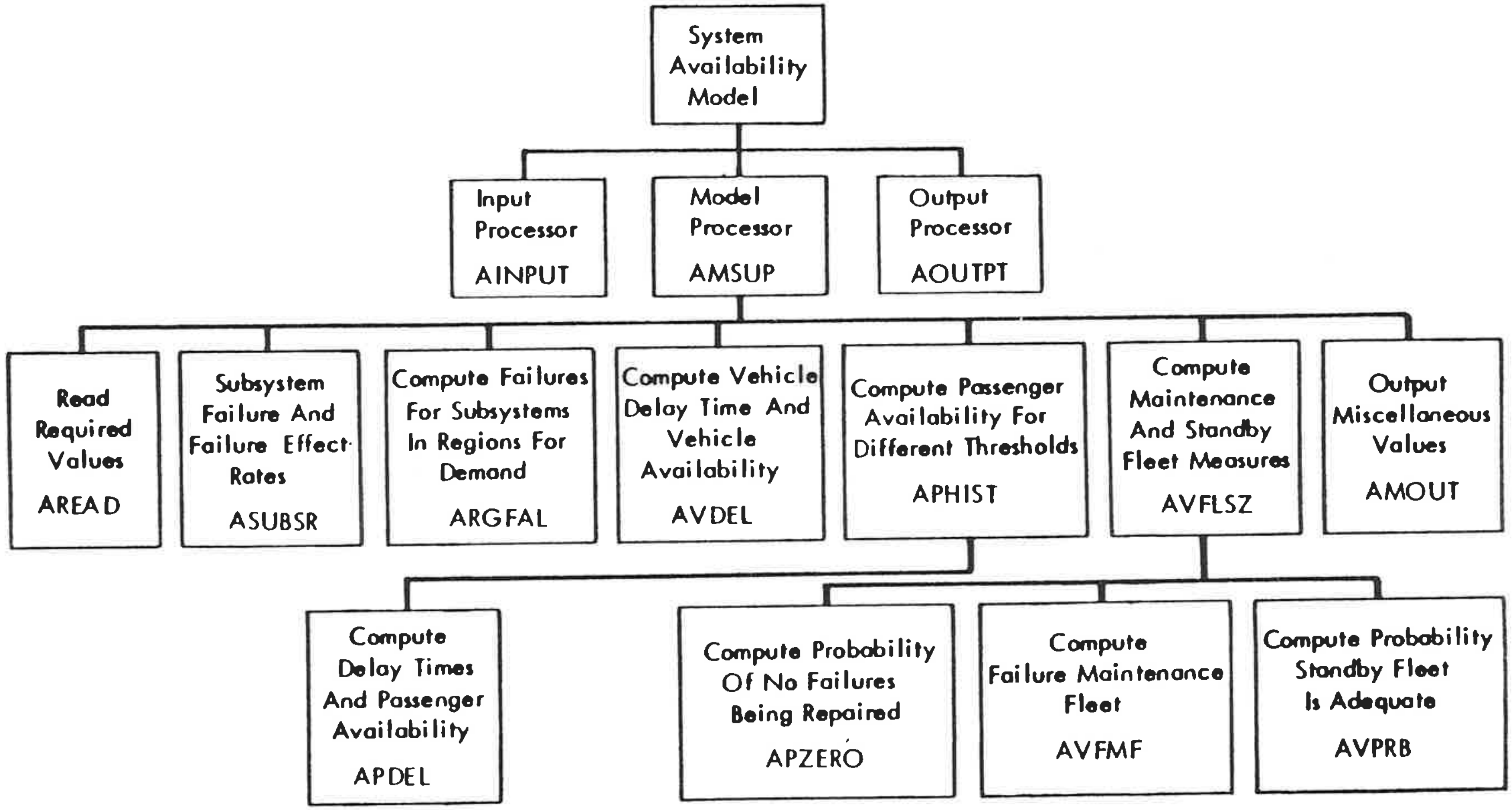

FIGURE 2-4. SAM BLOCK DIAGRAM STRUCTURE

2.4.2 Update Mode

This is selecting by using the UPDATE parameter to specify the structured data file to be updated. It is only necessary to specify the parameters to be modified. This mode is useful when it is desirable to reprocess or add just one trip log without reprocessing all of them.

2.5 FILE STRUCTURE

2.5.1 Input

Dataset name	Type	Source	Content
AGT.STRUC.TRIPLOG	Character	DESM	Completed trip record*
AGT.IANDD.RNTIM	Character	User	Input parameters

2.5.2 Output

Dataset name	Type	Used by	Content
AGT.INDEX.A...	Character	User	Record of run
AGT.PERSUM.SAM	Character	COP	Performance Summary

2.5.3 Internal

Dataset name	Type	Source	Used by	Content
AGT.STRUC.SAM	binary	IP	IP, MP	IP results
AGT.STATS.SAM	binary	MP	OP	MP results

* The items comprising the trip log are described in Section 4.3.1

TABLE 2-1. AVAILABILITY EQUATIONS

VEHICLE AVAILABILITY

$$\frac{\text{VEHICLE OPERATING TIME} - \text{DELAY TIME}}{\text{VEHICLE OPERATING TIME}}$$

PASSENGER AVAILABILITY

$$\frac{\text{SYSTEM DEMAND} - \text{NUMBER OF TRIPS DELAYED ABOVE THRESHHOLD}}{\text{SYSTEM DEMAND}}$$

MAINTENANCE FLEET MEASURES:

SCHEDULED MAINTENANCE FLEET SIZE

FAILURE MAINTENANCE FLEET SIZE

MINIMUM MAINTENANCE BAYS REQUIRED

Failure Maintenance Fleet

$$FMF = \sum_{k=1}^{m-1} P_o \frac{(m\rho)^k}{(k-1)!} + P_o \frac{m^m}{m!}\left[\frac{(1-\rho)\, m\rho^m + \rho^{m+1}}{(1-\rho)^2}\right]$$

FMF = Failure Maintenance Fleet
P_o = Probability that no failures are being repaired
m = Number of maintenance bays
ρ = $\frac{\lambda}{m\mu}$
λ = Failure rate of the active fleet per unit time
μ = Repair rate for a single service bay per unit time

$$P_o = \frac{1}{\sum_{k=o}^{m-1} \frac{(m\rho)^k}{k!} + \frac{(m\rho)^m}{m!}\left(\frac{1}{1-\rho}\right)}$$

Probability of Having a Standby Vehicle Available for Service

$$P_H = \begin{cases} 1 - \left[P_o \frac{m^m}{m!}\left(\frac{\rho^K}{1-\rho}\right)\right] & \text{if } K \geq m \\ 1 - \left[P_o\left(\frac{m^m}{m!}\left(\frac{\rho^m}{1-\rho}\right) + \sum_{k=K}^{m-1} \frac{(m\rho)^k}{k!}\right)\right] & \text{if } K < m \end{cases}$$

P_H = Probability of having a standby vehicle available
$K - 1$ = Standby Fleet Size

3.0 COMPUTER REQUIREMENTS

3.1 CORE MEMORY

Load	Module	Region
IP	85K	112K
MP	78K	108K
OP	87K	104K

The region size will vary with practices at individual facilities, e.g., regarding blocking factors of the files and buffering parameters. There are also differences in dynamically loaded routines (access methods, etc.). The amount of memory used by the program is fixed at compile time.

3.2 PERIPHERAL EQUIPMENT

The SAM does not need any additional equipment beyond that normally required to support the operating system.

3.3 SYSTEM CONTROL PROGRAM

This model has been developed under OS/VS2, Release 3.7. The following software is necessary for use of the SAM:

1. System Control Program - Use of one of the following will be assumed:

   a. OS/360 (Operating System)
   b. VS1 (Virtual Storage 1)
   c. VS2 (Virtual Storage 2)
   d. VM/370 and CMS (Virtual Machine and Conversational Monitor System).

   For terminal-oriented operation, the use of the Time Sharing Option (TSO) or VM/370 will be assumed.

2. Utilities - Standard Operating System 360/370 utilities will be assumed for development, use, and maintenance of the SPM and will be used for bulk card-to-disk, tape-to tape, tape-to-disk, dataset backup/restore and data base update and editing.

3.4 EXECUTION TIME

3.4.1 Input Processor

The input processor execution time is proportional to the number of records in the failed trip logs. It takes 2 seconds of CPU time for each 1000 records on an IBM 370/168, and 6 seconds of real time per 1000 records.

3.4.2 Model Processor and Output Processor

The model and output processors will normally require less than 10 seconds each of CPU time regardless of problem size.

4.0 INPUT DATA

4.1 DESCRIPTION OF INPUT

4.1.1 Runtime Inputs

The runtime input consists of a sequence of control cards with any required follower cards. The last control card must be an EOD card. Each of the control cards described in the following sections have this format. The control card type must start in Column 7; the remainder of the card is ignored. The control cards are described individually in the following sections:

4.1.1.1 EOD CARD

The EOD card is used to indicate End of Data. The last card of each dataset must be an EOD card. It has no followers.

4.1.1.2 INDEX CARD

The INDEX control card is used to initialize the run index file. It is required for the Input Processor and not recognized by the Model and Output Processors. The first card (after the control card) has the following format:

1-6	Index file name. Same as INDEX= parameter used in JCL.
8-47	Analysis description
49-63	User name
65-72	Date

Additional text describing the run may be optionally included here.

The last card of the run description has END in the first three columns with the rest of the card blank.

4.1.1.3 TEXT CARD

The TEXT control card is used to include comments in the dataset. The cards following the TEXT card are listed and ignored. The comment is followed by a card with the following format:

1-3	END
4-72	blank
73-80	ignored

4.1.1.4 PARAM, DATA, OPTION, and SELECT Control cards

These control cards are used to input data variables. All four cards perform the same action and are interchangable, i.e., any of the variables described below can be input using any of these 4 control cards. The control card is followed by one or more groups of cards, each initializing one variable. The first card of each group has the format:

1-6	Variable name
8-9	Number of items per card
10	Format F for Reals I for Integers L for Logical variables A for Character
11-15	Field width except for F which has the format fieldwidth.0, e.g., F10.0
16-20	Lower bound for first subscript
21-25	Upper bound for first subscript
26-35	Lower & upper bounds for 2nd subscript
36-45	Lower & upper bounds for 3rd subscript
46-55	Lower & upper bounds for 4th subscript

For those familiar with FORTRAN, Columns 8-15 contain an element of a format statement.

The remaining cards of the group have the format:

1-2 Repetition count. It has the effect of including this number of copies of this card. If omitted, 1 is assumed.

3-72 The data fields described in the header in the format specified and of the specified width.

There must be exactly enough data cards to satisfy the header card. The last data group must be followed by a card with the following format:

1-3	END
4-72	blank
73-80	ignored

For example:

```
          PARAM
      KNDM     I5
             2
      END
```

4.1.1.4.1 Input Processor Variables

KNDM Number of demand periods
FORMAT: I

This is the number of passenger demand levels that are being used for a given run. This value is the same number as the number of demands used in building the passenger delay matrix from the DESM trip log data. For example if only one demand level was used, the SAM JCL would contain lines 50000, 51000, and 52000 but not lines 96100, 96200, and 96300. If two demands are used, the latter lines of JCL would be used. If three demands were used, another set of 'update' JCL would be required.

KNDL Number of delay thresholds
FORMAT: I

This parameter defines the number of passenger delay time thresholds to be used when processing the DESM Trip Log and in building the delay time matrix in the input processor. Up to ten (10) increments can be selected. The starting value and the increment are controlled by PTHRDM and THRIND. If it is desired to display all passenger trips with a delay greater than zero (0) minutes, PTHRDM is set to 0. If a five (5.0) minute delay is an acceptable minimum level and it is desired to only look at delay greater than 5.0 minutes, PTHRDM is set to 5.0. THRIND controls the increments; therefore, if it is desired to look at 1.0 minute increments of delay, THRIND would be set to 1.0.

If, for example, it were desired to display 5.0 delay thresholds, starting from zero with an increment of 3.0 minutes, KNDL would be set to 5.0, PTHRDM would be set to zero (0) and THRIND would be set to 3.0. This would generate a delay matrix which would display all passenger trips delayed from 0 to 3 minutes, 3 to 6 minutes, 6 to 9 minutes, 9 to 12 minutes, and the final increment would contain all passenger trips delayed more than 12 minutes.

KNFL Number of failure levels. The user may specify several types of failures, each with its own effect. Typically, this will be two: 1 - stoppage; 2 - degradation
FORMAT: I

This establishes the number of failure modes considered in the run. This parameter has a maximum value of five (5). Generally only two failure modes are considered i.e., stoppages and degraded operation.

For each failure mode that is entered here, a failure rate developed by the analyst through analysis of the subsystem hardware and the related failure modes and effects analysis must be entered in the FRATE matrix.

KNLVL Number of reliability levels
FORMAT: I

This allows the computation of the availability parameters for any number of subsystem reliability levels with a single run of the SAM. The value is one (1) if only one level is input.

For each value entered under KNLVL, there must appear a corresponding set of failure rate values under FRATE. The FRATE values must also reflect the modes of failure, i.e., stoppage, degraded and others, if defined.

KNREG Number of regions
FORMAT: I

This is the number of regions that are required to define, for availability analysis, the network that is being analysed. The value to be entered here is established by analyst or can be determined by entering a given failure condition into a large percentage of the guideway links, station link, etc., and determining the segments (regions) of the network being analyzed wherein a failure yields similar results.

To the extent possible, the number of regions in a network should be minimized since there are other 'IANDD.RNTIM' parameters which the analyst must input which are also defined on a regional basis; DLTIME -- Vehicle Delay Time, GWMILE -- Guideway Length, STATNS -- Number of Stations, UN -- Number of Vehicles, VOPTIM -- Vehicle Operating Time, NUMTRP -- Number of Trips Delayed, PNS -- Passengers thru Stations (not presently used), VENSTA -- Vehicles thru Stations, VM -- Vehicle Miles.

```
FLTSLT Fleet size selection:
       0 - average active fleet
       1 - maximum active fleet
       FORMAT: I
```

The standby fleet size and maintenance fleet parameters are based on the active fleet size. FLTSLT is set to one (1) if it is desired to make the calculations based on the maximum active fleet size or it is set to zero (0) if it is desired to use the average fleet size.

```
PTHRDM Minimum passenger delay threshold (minutes)
       FORMAT: F
```

PTHRDM

Refer to KNDL.

```
RRATE  Average time to repair a vehicle (hours)
       FORMAT: F
```

This is an analyst developed parameter and is based on the expected average vehicle failure repair time. The failure repair rate is used along with the scheduled maintenance rate SMEREQ to determine the maintenance facility requirements. If a failure maintenance analysis has been performed, the resulting average repair time value can be used.

The value which is input is used in the standby and maintenance fleet size computations. Variations of this parameter enable a parametric evaluation of the sensitivity of standby and maintenance fleet size parameters to failure repair rate.

```
SMFREQ Scheduled maintenance frequence in inverse vehicle
       operating hours between maintenance periods;
       i.e., 1/(vehicle-operating-hours)
       FORMAT: F
```

This is the scheduled maintenance frequency for vehicles. This quantity is used along with the unscheduled maintenance rate RRATE to arrive at the total expected rate at which vehicles will be entering the maintenance facility. For systems which are not operated continuously, scheduled maintenance is expected to be performed during non-operating periods and zero (0) would be entered. The value entered is the expected number of scheduled maintenance events per hour of operation, i.e., if one scheduled maintenance action is required per 200 hours of vehicle operation, the value would be 0.005.

SMST Scheduled maintenance service time in hours
FORMAT: F

This is the time required for each scheduled maintenance action. The value entered will depend on the scheduled maintenance required for the type of vehicle considered in the analysis. The rate at which vehicles are expected to be serviced is used to determine the number of service bays a maintenance facility should have. For systems which are not run continuously, it is expected that scheduled maintenance will be performed during non-operating time and zero would be entered for SMST.

THRIND Passenger Delay Threshold increment (minutes)

Refer to KNDL.

DMND System demand for the demand period in passengers
FORMAT: F
SUBSCRIPT: Demand Period

The number of passengers requesting service during each demand interval is entered here. The number of entries must correspond to the number of demand intervals identified under KNDM. If a system was operating for 2 demand periods with an average demand of 1000 passengers per hour for 10 hours and 2000 passengers per hour for 2 hours during a standard day, the quantities entered would be 10,000 and 4000 for example.

The per-hour demand can be obtained from the DESM for each demand profile used by the DESM and can be used to calculate the total demand for each demand interval.

DLTIME Vehicle delay time resulting from failures in hours
FORMAT: F
FIRST SUBSCRIPT: Region containing failure
SECOND SUBSCRIPT: Demand period containing failure
THIRD SUBSCRIPT: Subsystem with failure
FOURTH SUBSCRIPT: Failure level

This is the vehicle delay time that a failure event causes. The delay time is a function of the region where the failure occurs in the network, the demand at the time of the failure, the subsystem that fails, i.e., vehicle, station, guideway in central mangement, and the mode of failure. Thus if a system were defined as having 1 region, 1 demand, 1 subsystem and could only fail in 1 way, there would be 1 entry under DLTIME. However a more likely situation would be 2 regions, 2 demand levels, 4 subsystems, and 2 modes and thus 32 entries would be required (2 x 2 x 4 x 2). The vehicle delay time is determined by differencing the revenue distance traveled for a failed run with the same parameter for the nominal run and dividing by the average vehicle velocity of the nominal run from the DESM.

A large number of DESM runs would be required to obtain a statistical sample if a system is defined in much detail, e.g., many regions, many demand levels, many subsystems, and many failure modes. To the extent possible, each system should be looked at to minimize the number of runs required. This may include using worst case situations by selecting the most complex region and limit it to one, and selecting the highest demand, which would then reduce the above example to eight different conditions. This also applies to the development of the passenger delay data, because a trip log is also required for each condition selected.

```
FRATE  Failure rates
       FORMAT: F
       FIRST SUBSCRIPT:  Subsystem
       SECOND SUBSCRIPT: Failures caused by:
                         1 - Vehicle operating time
                         2 - Passengers through stations
                         3 - System elapsed time
                         4 - Vehicles through stations
                         5 - Vehicle km traveled on the guideway
       THIRD SUBSCRIPT:  Component reliability level
       FOURTH SUBSCRIPT: Failure level
```

The failure rate matrix is developed from the subsystem reliability analysis data. The table makes provisions to include failure rates as a function of causal factors. In general, subsystem failure rates can be defined in terms of vehicle operating time and system operating time; however, if a subsystem failure rate is defined in terms of the number of operations or actuations, the number of passengers guideway length, the 'FRATE' matrix can accommodate this type of input. The matrix can also accommodate multiple entries of subsystem failure rate data and up to five modes of failure can be entered. This matrix, like the DLTIME matrix, is built by the analyst, and the extent of data entry depends on the detail of definition of the system.

```
GWMILE Guideway length (km) in the region
       FORMAT: F
       SUBSCRIPT: Region
```

This is a causal factor parameter for the guideway failure rate and must be set to (1) if the guideway failure rate is defined in terms of system operating time. If the guideway failure rate is defined in terms of the guideway length, the length, in Km, must be entered.

```
STATNS Number of stations in the region
       FORMAT: I
       SUBSCRIPT: Region
```

This parameter contains the number of stations in each region identified under KNREG. This is used in the computation of station failures occurring in each region.

SYSTIM Length of demand period (hours)
FORMAT: F
SUBSCRIPT: Demand period

System time is a causal factor for failures of the stations, guideway and central management subsystems. SYSTIM identifies the length of time the system is operating for each demand level identified under KNDM. The SYSTIM parameter is used to determine the expected number of occurrences of subsystem failures during the SYSTIM time interval. If failure rates for causal factors other than SYSTIM are used for the above subsystem, then the expected number of failures will also be a function of the other causal factors.

PNS Number of passengers
FORMAT: F
FIRST SUBSCRIPT: Region
SECOND SUBSCRIPT: Demand period

This is a causal factor for station failures which are a function of the number of passengers through stations. The value used is zero (0) if station failures are defined in terms of system time. Passenger data is obtained from the DESM. NPAR is the number of passengers arriving at the boarding dock in the DESM.

VINSTA Number of vehicles through the stations
FORMAT: F
FIRST SUBSCRIPT: Region
SECOND SUBSCRIPT: Demand period

This is a causal factor for station failures which are a function of the number of vehicles which pass through stations. The value used is zero (0) if station failures are defined in terms of system time. Vehicles entering stations are obtained from the DESM, VNES.

VM Distance traveled by vehicles (km)
FORMAT: F
FIRST SUBSCRIPT: Region
SECOND SUBSCRIPT: Demand period

This is a causal factor for guideway failures which are a function of the number vehicle kilometers traveled. The value used is zero (0) if guideway failures are defined in terms of system time. Vehicle kilometers are obtained from the DESM and are the sum of revenue distance traveled and deadheading distance traveled, i.e., RDST + DDST.

```
VN      Average number of vehicles
        FORMAT: F
        FIRST SUBSCRIPT:  Region
        SECOND SUBSCRIPT: Demand period
```

This identifies the average number of vehicles in each region listed under KNDM. These quantities are used to determine average and maximum fleet size values required for the maintenance and standby fleet size computations.

```
VOPTIM Vehicle operating hours
        FORMAT: F
        FIRST SUBSCRIPT:  Region
        SECOND SUBSCRIPT: Demand period
```

Vehicle operating time VOPTIM is the causal factor for vehicle failures. VOPTIM is defined for each region KNREG and each demand KNDM. The values entered are the product of the average number of vehicles in a region in each demand period and SYSTIM for the demand period. The average number of vehicles in regions for the demand is obtained from the DESM.

NUMTRP

The number of passenger trips delayed matrix NUMTRP is built by the SAM input processor from the trip log data generated by the DESM and is not designed to be user modified. NUMTRP is generated by the FAILURE control and described in Section 4.1.1.5. Failure locations and durations are input into the STRUC.RNTIM file of the DESM. A failure case trip log is created, which is differenced with the trip log for a normally operating system to obtain the passenger delay time data. Each failure case to be included in a given availability analysis run must be identified in terms of the region, demand, subsystem and mode to which it applies. The failure data is entered after the IANDD.RNTIM file data. Failure cases which use a common reference run to obtain the passenger trip delays can be entered as a single data in the IANDD.RNTIM file. If two or more reference runs are required, such as is the case when regions and demands vary, additional IANDD.RNTIM files of failure data must be developed. The NUMTRP matrix is then updated using the SAM control JCL. This provides the capability to develop a complete description of the consequences of failure events for a given system application.

4.1.1.4.2 Output Processor Control Variables

All these variables are unsubscripted and are entered in I format.
A value of zero will omit the corresponding report.

```
FDLTI   Delay time report
FMAIN   Maintenance report
FNTRP   Number of trips delayed report
FPASS   Passenger availability report
FRELY   Reliability report
FSUBSR  Subsystem failure rate report
FVEH    Vehicle availability report
```

4.1.1.5 FAILURE Control Card

The FAILURE control card is used to initiate the processing of a failed trip log to determine the number of trips delayed. It is only used in the Input Processor.

This control card has the following format:

1-5	Trip log number
6	blank
7-13	FAILURE
14-20	blank
21-25	region containing failure
26-30	demand period for triplog
31-35	subsystem failed
36-40	failure level typically 1 - degradation 2 - stoppage
41-80	ignored

There must be one failure control card for each triplog entered. The FAILURE control cards must be ordered by triplog number, and the numbers must be consecutive.

4.2 TERMINAL ENTRY INPUT

This model is designed for batch rather than terminal use; however, all its user inputs can be prepared from a terminal using an appropriate editor. These inputs are described in Section 4.1.

4.3 DATA BASE DEFINITION INPUT

4.3.1 Trip Log

The trip log files are generated by the Discrete Event Simulation Model (DESM). Each record represents one trip with the format:

Trip termination time (minutes)	F10.3
Trip origination time (minutes)	F10.3
(ignored)	30X
Origination station	I3
Termination station	I3
Passengers in trip	I3

The trip log generated by DESM contains additional fields which are ignored by SAM. All trip logs have corresponding records, i.e., each of these fields match except termination time. All trip logs must be then sorted by origination time, origination station, termination station, and trip size using the appropriate DESM catalogued procedure.

5.0 OUTPUT DATA

5.1 DATA SET DESCRIPTION

SAM generates a performance summary file and printed reports.

5.1.1 Performance Summary File

The performance summary file is generated for use by the Comparison Output Processor (COP). The content is:

Active fleet size
Average scheduled maintenance fleet size
Total vehicle delay time (per day)
Fleet size computation selector
Failure effect rates
System operating time per day
Total station demand
Vehicle availability
Operating vehicle-hours per day
Delay threshold
Passenger availability with this delay threshold
Number of trips delayed for this delay threshold
Standby fleet required for a 95% probability of having a replacement
    vehicle when needed (for the minimum number of service bays)
Probability of this fleet size being adequate
Average total maintenance fleet size for the minimum number of service bays
Failure fleet size for the minimum number of service bays
Number of service bays required for a 95% probability of having a replacement
    vehicle when needed (for the minimum standby fleet size)
Probability of this fleet size being adequate

5.2 STANDARD REPORTS

Examples of the standard reports are in Appendix B. Any heading of the reports which is not self-explanatory, is described in the following sections:

5.2.1 Input Listing and Error Messages

This report lists all control card inputs and any error or information messages generated. All the processors generate this report.

5.2.2 Summary of Inputs

This report is generated by the input processor. It is a formatted representation of the inputs.

5.2.3 Failure Rates

This report is generated by the input and output processors. Its content is user input. In the output processor it is controlled by FRELY (See Section 4.1.1.4.2).

5.2.4 Number of Trips Delayed

This report is produced by the input and output processors. In the output processor it is controlled by FNTRP (See Section 4.1.1.4.2). The contents is derived by comparing failure and reference trip logs.

5.2.5 Vehicle Delay Time Resulting from Failures

This report is generated by the input and output processors. In the output processor it is controlled by FDLTI (See Section 4.1.1.4.2). The report is a formatted representation of user inputs.

5.2.6 Reliability Parameters

This report is produced by the output processor and is controlled by FRELY (See Section 4.1.1.4.2). The report contains the subsystem failure rates utilized in the analysis.

5.2.7 Passenger Availability

This report is produced by the output processor and is controlled by FPASS (See Section 4.1.1.4.2). The report displays the percentage of trips not delayed more than the threshhold.

5.2.8 Maintenance Fleet

This report is produced by the output processor and is controlled by FMAIN (See Section 4.1.1.4.2). The report contains maintenance, fleet parameters and measures. The first part contains the scheduled maintenance fleet size, the minimum number of maintenance bays for this fleet, and the active fleet size. The next section of the report contains the probability of the standby fleet and failure fleet being adequate for various standby fleet sizes and service bays.

5.2.9 Vehicle Availability

This report is generated by the output processor and is controlled by FVEH (See Section 4.1.1.4.2). It contains the vehicle availability and the parameters used to derive it.

5.3 GENERAL PARAMETER OUTPUT

There are no provisions for individual variable outputs; all outputs are contained in standard reports.

6.0 OPERATING PROCEDURES

6.1 SYSTEM GENERATION

Normal use of the model will not require system generation. There are no options which are selected by subroutine replacement.

6.2 JOB CONTROL LANGUAGE (JCL)

The use of the model has been simplified by three catalogued procedures that have been written for the SAM. The use of catalogued procedures avoids the necessity of the user preparing the individual JCL statements. The JCL procedure generates the individual statements from the parameters specified by the user. This section elucidates the use of the catalogued procedures; it is not a replacement for the JCL manual (see references). A basic understanding of JCL is assumed.

Basic Format

A job consists of JCL statements combined with data lines which are read by the program. They are distinguished by Columns 1 and 2. If Columns 1 and 2 contain slashes (//), then it is a JCL statement; if Columns 1 and 2 do not contain slashes (//) or slash asterisk (/*), then it is data, and it will be passed to the program. JCL lines with an asterisk in Column 3 are comments (//*) and are ignored by the system. Each JCL statement consists of four fields separated by blanks (embedded blanks are not permitted except in comments). The fields are label, operation, operand, and comment. The operand may be continued by ending the statement with a comma and continuing it on the next line. For continuation lines, Columns 1 and 2 must contain slashes, and the continuation must start in Columns 4-16, inclusive. As many continuations as necessary may be used. The operation field determines the statement type and is described below.

JOB Card

The first card of each job must be a job card. The format will vary between installations. Coding the following parameters is not recommended: ADDRSPC, PERFORM, RD, REGION.

It is advisable to include MSGLEVEL=(2,0) on the JOB statement to reduce the length of system message output.

DD Card

The DD statement is used to define the data sets to be used during a program execution. They are always associated with the preceding EXEC statement. The only DD statement that the availability model user may need to code is SYSIN. It is used when the data are in a data set rather than included in the job. The required parameters are DSNAME= (followed by data set name), and DISP=SHR (for input data sets).

This is an example of a DD statement:

```
    //SYSIN  DD    DSNAME=AGT.IANDD.RNTIM(NULL),DISP=SHR
```

EXEC Statement

The EXEC statements are described in Section 6.4.

Member names

Member names consist of one to eight characters the first of which is a letter and the remaining characters can be either letters or digits. Some parameters further restrict the length.

JCL Example

The following example is not intended to illustrate the use of the model. It only demonstrates the use of JCL statements. Appendix A contains another example which illustrates use of the model.

```
//JTVDHXA JOB  1234,'JOHN DOE',
//            MSGLEVEL=(2,0)
//STEP1  EXEC SAMIP,INDEX=SYSTEM1,STRUC=SYSTEM1
//SYSIN  DD   DSNAME=AGT.IANDD.RNTIM(SYSTEM1),DISP=SHR
```

6.3 TERMINAL MODE

The model is designed for batch mode use only.

6.4 CATALOGUED PROCEDURES

6.4.1 Input Processor

Input Processor execution is requested by including:

```
//stepname EXEC AGTAIP,additional-parameters
```

in the job. It may be followed by the control card input, or the control card inputs may be stored in the run time file (AGT.IANDD.RNTIM). Replace stepname with an identifier which can be referenced from other steps. It also is included in certain system error messages. The additional parameters that may be specified are:

RNTIM=member
Specifies the name of the member containing the control card inputs. This parameter is required unless the control cards are included with the JCL. If any data cards are found in the JCL for this step, this parameter is ignored.

INDEX=
Specifies the run index file name (seven characters maximum). This parameter is required. If the file does not already exist, it will be created.

STRUC=member
Specifies the name under which the structured data will be stored. If it already exists, the old file will be replaced. It is recommended that different names be used for UPDATE= and STRUC. This parameter is required.

UPDATE=member
Specifies that this step updates a previously generated structured data file. Use the same member name that was used in the STRUC= parameter when it was created.

TRPLG00=member
Specifies the reference triplog (containing no failures). Use the same name as used when creating it from DESM. Required if any FAILURE cards are included in the runtime inputs.

TRPLG01=member to TRPLG99=member
Specifies the failed triplogs. The number is the same as the number used on the FAILURE CONTROL card in the run time inputs. Use the same name as used to create it from DESM. Specify the same number of members as there are FAILURE cards in the runtime input.

PROJECT=
Specifies the data library that contains the files to be processed. The default is AGT. Refer to the installation instructions for establishing new data libraries.

STEPLIB=
Specifies the program library that contains the program. Default is AGT.

VERSION=
Specifies the program version to be used. The default is the current version.

SYSOUT=
Specifies the output class for printed output. The default is the same as the MSGCLASS= parameter of the JOB statement.

COND=
Specifies the conditions for bypassing execution of this step. (Bypassed steps have a completion code of 0.) If omitted, it is executed unless a previous step has ABENDed.

TIME=minutes
This parameter is optional. It specifies the maximum amount of CPU time allowed for this step. The default is 30 seconds. It can also be coded as TIME=(minutes,seconds).

ACCT=
Specifies accounting information for this step. This parameter is installation dependent; however, usually it overrides the accounting information specified on the JOB card.

6.4.2 Model Processor

Model Processor execution is requested by including:

```
//stepname EXEC AGTAMP,additional-parameters
```

in the job. It is followed by the control card input. If the control card inputs are in a separate file, include a SYSIN DD statement. Replace stepname with an identifier which can be referenced from other steps. It also is included in certain system error messages. The additional parameters that may be specified are:

INDEX=
This parameter is required. Specify the same name as you did for the Input Processor.

STRUC=member
Specifies the structured data for the Model Processor step. Use the same name as specified for the Input Processor. This parameter is required.

STATS=member
Specifies the name under which the raw statistics will be stored. This parameter is required.

PROJECT=
Specifies the data library that contains the files to be processed The default is AGT. Refer to the installation instructions for establishing new data libraries.

STEPLIB=
Specifies the program library that contains the program. Default is AGT.

VERSION=
Specifies the program version to be used. The default is the current version.

SYSOUT=
Specifies the output class for printed output. The default is the same as the MSGCLASS= parameter of the JOB statement.

COND=
Specifies the conditions for bypassing execution of this step. (Bypassed steps have a completion code of 0.) If omitted, it is executed unless a previous step has ABENDed. If you are running the Input Processor and the Model Processor in the same job, it is recommended that you use:

```
COND=((0,NE,stepname.SAMIP))
```

where stepname is the stepname you used for the Input Processor EXEC statement. This will bypass the Model Processor execution if there were Input Processor errors.

ACCT=
Specifies accounting information for this step. This parameter is installation dependent; however, usually it overrides the accounting information specified on the JOB card.

6.4.3 Output Processor

Output Processor execution is requested by including:

```
//stepname EXEC AGTAOP,additional-parameters
```

in the job. It may be followed by the control card input, or the control card inputs may be stored in the run time file (AGT.IANDD.RNTIM). Replace stepname with an identifier which can be referenced from other steps. It also is included in certain system error messages. The additional parameters that may be specified are:

RNTIM=member
Specifies the name of the member containing the control card inputs. This parameter is optional; if omitted a member containing only an EOD card is used. This parameter should not be specified if control card inputs are included with the JCL.

STATS=member
Specify the same name as used for the Model Processor. This parameter is required.

PERSUM=member
Specify the name under which the performance summary is to be stored. This parameter is required.

INDEX=
This parameter is required. Specify the same name as you did for the Input Processor and Model Processor.

PROJECT=
Specifies the data library that contains the files to be processed The default is AGT. Refer to the installation instructions for establishing new data libraries.

STEPLIB=
Specifies the program library that contains the program. Default is AGT.

VERSION=
Specifies the program version to be used. The default is the current version.

SYSOUT=
Specifies the output class for printed output. The default is the same as the MSGCLASS= parameter of the JOB statement.

COND=
Specifies the conditions for bypassing execution of this step. (Bypassed steps have a completion code of 0.) If omitted, it is executed unless a previous step has ABENDed. If you are running the Input Processor, the Model Processor, and the Output Processor in the same job, it is recommended that you use:

```
COND=((O,NE,stepname.SAMIP),(O,NE,stepname.SAMOP))
```

where the stepnames are the stepnames you used for the Input Processor EXEC statement and the Model Processor EXEC statement. This will bypass the Output Processor execution if there were Input or Model Processor errors.

ACCT=
Specifies accounting information for this step. This parameter is installation dependent; however, usually it overrides the accounting information specified on the JOB card.

7.0 ERROR MESSAGES

The error messages generated are separated by program (i.e., Input Processor, Model Processor, and Output Processor). Within a section, the messages are ordered by the three-digit error number. Generally, the completion code for the step will be the largest completion code issued by any message.

In addition to the errors generated by the program, FORTRAN and the system also issue messages. They are listed in Fortran IV Compiler and Library messages and OS Message Library (see References).

7.1 INPUT PROCESSOR ERROR MESSAGES

```
*** AIP002I - ### UNMATCHED TRIPS ***
    CAUSE:  This information message displays the number of trips in
            the reference triplog were not found in the failed triplog.
    ACTION TAKEN:  None
    CORRECTION:  If the number of trips is excessive, check:
            1) that the reference triplog and the failed triplog
               were generated from the same triplist
            2) that the failed run is allowed to continue until
               most trips have finished
    SOURCE:  AINPUT                                COMPLETION CODE:  0

*** AIP003I - THRESHOLDS: .......................
    CAUSE:  This message is only generated by the debugging option.
            Refer to Programmer's Manual.
    ACTION TAKEN:  None
    CORRECTION:  Omit DEBUG= parameter on the JCL EXEC card that
                 generated this message
    SOURCE:  AINPUT                                COMPLETION CODE:  0

*** AIP004W - INVALID TRIP LOG IDENTIFIER ***
    CAUSE:  The FAILURE control card contains an invalid parameter.
            It is either an invalid region number, and invalid demand
            period, an invalid subsystem, or an invalid failure level.
    ACTION TAKEN:  FAILURE card is ignored, the remaining inputs are
            checked for validity, and the writing of the STRUC file is
            suppressed.
    CORRECTION:  None
    SOURCE:  AINPUT                                COMPLETION CODE:  4

*** AIP010W - INVALID TRIP LOG IDENTIFIER ***
    CAUSE:  The FAILURE control card contains an invalid parameter.
            It is either an invalid region number, and invalid demand
            period, an invalid subsystem, or an invalid failure level.
    ACTION TAKEN:  FAILURE card is ignored, the remaining inputs are
            checked for validity, and the writing of the STRUC file is
            suppressed.
    CORRECTION:  None
    SOURCE:  AINUMT                                COMPLETION CODE:  4

*** AIP011W - FAIL CARDS OUT OF SEQUENCE ***
    CAUSE:  The FAILURE cards are not in the required sequence.  The
            first must be numbered 1 and each succeeding card must be
            one larger than the preceeding card.  This message may be
            generated when other errors have caused a FAILURE card to
            be ignored.
    ACTION TAKEN:  This failure card is ignored, and output of the
            structured data file is suppressed.
    CORRECTION:  None
    SOURCE:  AINUMT                                COMPLETION CODE:  4

*** AIP098I - PURGED ***
    CAUSE:  A previous error
    ACTION TAKEN:  This card has been ignored.
    CORRECTION:  Correct previous error
    SOURCE:  AIGDIP                                COMPLETION CODE:  0
```

*** AIP099W - UNDEFINED PARAMETER - ???????? ***
CAUSE: This error may be caused by a misspelled parameter name. It may also be generated if the previous variable was incorrectly defined. It will also be generated by a missing END card. Also check that the upper bound of the preceding parameter does not exceed its dimension (in the program).
ACTION TAKEN: Cards are skipped until the next parameter is found. Output of the structured data file is omitted.
CORRECTION: Correct input data.
SOURCE: AIGDIP COMPLETION CODE: 4

*** AIP100W - UNRECOGNIZED CONTROL CARD ***
CAUSE: The control card type may be misspelled or located in the wrong column.
ACTION TAKEN: This card is ignored and output of the structured Data File is omitted.
CORRECTION: Correct the data; check the spelling and the column location of the control card
SOURCE: AACCRD COMPLETION CODE: 4

*** AIP101W - EOD CARD MISSING ***
CAUSE: No EOD card is present in the run time input.
ACTION TAKEN: EOD card is assumed and output of the structured data file is omitted.
CORRECTION: Include an EOD card as the last card of the run time input.
SOURCE: AACCRD COMPLETION CODE: 4

*** AIP102W - INDEX CARD PREVIOUSLY ENCOUNTERED ***
CAUSE: The run time input contained more than one index card.
ACTION TAKEN: Error checking continues, but execution will terminate with an error code.
CORRECTION: Delete the excess INDEX card.
SOURCE: AACCRD COMPLETION CODE: 4

7.2 MODEL PROCESSOR ERROR MESSAGES

*** AFE003S - INCORRECT FORMAT FOR STRUC FILE ***
CAUSE: The structured data file was not generated by the proper version of the input processor.
ACTION TAKEN: Execution terminates.
CORRECTION: Re-run the input processor using the program that corresponds to the model processor.
SOURCE: AFSTRC COMPLETION CODE: 16

*** AFE004S - INSUFFICIENT ARRAY SPACE ***
CAUSE: The structured data file exceeds the internal tables (arrays).
ACTION TAKEN: Execution terminates.
CORRECTION: If a larger version of the input processor exists, re-run the model processor using the larger version. Otherwise, it will be necessary to recompile to process the system.
SOURCE: AFSTRC COMPLETION CODE: 12

7.3 OUTPUT PROCESSOR ERROR MESSAGES

*** AFE001S - INCORRECT FORMAT FOR STATS FILE ***
CAUSE: The raw statistics file was not generated by the proper version of the model processor.
ACTION TAKEN: Execution terminates.
CORRECTION: Re-run the model processor using the version that corresponds to the output processor.
SOURCE: AFSUBS COMPLETION CODE: 16

*** AFE002S - INSUFFICIENT ARRAY SPACE ***
CAUSE: The raw statistics file exceeds the internal tables (arrays).
ACTION TAKEN: Execution terminates.
CORRECTION: If a larger version of the output processor exists, re-run the output processor using the larger version. Otherwise, it will be necessary to recompile to process the system.
SOURCE: AFSUBS COMPLETION CODE: 12

```
*** AOP098I - PURGED ***
    CAUSE:  A previous error.
    ACTION TAKEN:  The indicated card in the control card data is
            ignored.
    CORRECTION:  correct previous error.
    SOURCE:  FIERR                                   COMPLETION CODE:  0

*** AOP099W - UNDEFINED PARAMETER - ???????? ***
    CAUSE:  While reading the control card dataset a unrecognizable
            parameter name was encountered.
    ACTION TAKEN:  The parameter is ignored, and cards are skipped
            until the next parameter is encountered.  Error checking
            continues, however, it will terminate with an error.
    CORRECTION:  correct input data.
    SOURCE:  FIERR                                   COMPLETION CODE:  4

*** AOP100W - UNRECOGNIZED CONTROL CARD ***
    CAUSE:  An invalid control card.
    ACTION TAKEN:  The control card is ignored and error checking
            continues.
    CORRECTION:  Correct the data.  check the spelling and the
            column location of the control card.
    SOURCE:  AACCRD                                  COMPLETION CODE:  4

*** AOP101W - EOD CARD MISSING ***
    CAUSE:  No eod card is present in the run time input.
    ACTION TAKEN:  One is assumed and error checking continues.
    CORRECTION:  Include an EOD card as the last card of the run time
            input.
    SOURCE:  AACCRD                                  COMPLETION CODE:  4
```

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4. OS/MFT and OS/MVT Utilities (GC28-67586), OS/VS Utilities (GC35-0005)

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6. SAM Programmer's Manual

7. Leonard Kleinrock, Queueing Systems, Volume I, J. Wiley & Sons, 1975.

9.0 GLOSSARY

Asynchronous

Operation of vehicles under velocity control or in the vehicle-follower mode with speed changes allowed to prevent potential merge conflicts.

Automated Guideway Transit (AGT)

Computer-controlled transit system operating in demand or scheduled service on a fixed, exclusive guideway.

Automated Rail Transit (ART)

A class of AGT systems which provides multiple-stop service, carries at least 100 passengers in its minimum train consists, operates at speeds equal to or greater than 55 km/h, and generally runs at headways of more than 1 minute.

Availability-Factor Relationships

The sensitivity of the vehicle and passenger availability measures to changes in parameters which affect either system reliability or failure management strategy.

Average Queue Transit Time (TQ)

Average time required to move through a platform boarding queue during a period of congestion such as the peak hour. For a particular station the value is calculated as the difference between the average wait time and one-half the average route headway.

Capital Cost (base year)

The initial cost of deploying a system expressed in base year (1977) dollars. Capital cost is the sum of guideway construction cost, passenger station construction and equipment cost, AGT vehicle cost, central control construction and equipment cost, maintenance facility construction and equipment cost, power distribution system installation cost, and feeder system costs including vehicles, maintenance facilities, and control facilities.

Catalogued Procedure

A pre-coded set of Job Control Language (JCL) statements that is assigned a name, placed in a data set, and may be retrieved and executed by one JCL statement.

Central Business District (CBD)

The downtown retail trade area of a city. As defined by the Census Bureau, the CBD is an area of very high land valuation characterized by a high concentration of retail business offices, theaters, hotels, and service businesses, and by a high traffic flow.

Central City (CC) of an SMSA

The largest city in an SMSA. One or two additional cities may be secondary Central Cities in the SMSA.

Central City (CC) of an Urbanized Area (UA)

A city of at least 50,000 persons within closely settled incorporated and unincorporated areas that meet the criteria for urbanized ring (fringe) areas. A few UA's contain twin cities with a combined population of at least 50,000.

Central City Ring (CCR)

The portion of a Central City not included in the CBD.

Checkpoint File

A file created at a user-specified time by the Model Processor and containing all data necessary to restart the MP from that time.

Closed-Loop Control

Advancement of vehicles under generated control based upon the estimated system state.

Control Block

A specific section of guideway corresponding to a single control segment of a fixed block vehicle regulation and/or headway protection system.

Cruise Speed

The constant velocity at which a vehicle travels after acceleration and prior to braking. This velocity is usually less than the maximum design speed, but can be equal to it.

Crush Load Capacity

The maximum total capacity which a vehicle is designed to accommodate. This limitation is defined by either a vehicle weight limitation or a passenger comfort criterion.

Demand Activated Service Policy

A service policy in which routes, which may include intermediate station stops, are generated in real time on the basis of passenger demand, i.e., point-to-point routing with demand stop.

Demand Responsive Service Policy

A service policy in which non-stop routes are generated in real time on the basis of passenger demand, i.e., point-to-point routing with no intermediate stops.

Demand Stop Service Policy

A service policy in which vehicles travel on predetermined routes but stop at stations along the route only in response to specific passenger demand.

Demand Type

A system deployment parameter which specifies the demand environment on which a detailed demand model will be specified. Three metropolitan area demands and four activity center demand types are identified:

1. Metropolitan area - high CBD, high reverse commutation
2. Metropolitan area - high CBD, low reverse commutation
3. Metropolitan area - low CBD, low reverse commutation

1. Activity Center Line-Haul
2. Activity Center Circulation
3. Activity Center in High Demand CBD
4. Activity Center in Low Demand CBD

Design Load per Vehicle

The nominal passenger capacity of each vehicle.

Deterministic

A strategy by which all merge conflicts are resolved before launch, and barring failures, each vehicle is assured of traversing the network in a predetermined time.

Dial-A-Ride Service

Transit service operated by generating vehicle paths in continual response to demand.

Downtown People Mover (DPM)

An AGT system deployed in a CBD environment, or the UMTA demonstration program to implement such systems.

Empty Vehicle Management (EVM)

A set of strategies which govern the disposition of active, empty vehicles not assigned to a fixed route nor enroute to service a passenger demand. Alternative strategies include:

Circulation

Vehicles are circulated on the network until needed to satisfy a demand. The distribution of circulating vehicles may be based on historical demand or on current demand patterns.

Station storage - historical

Vehicles are routed to stations for storage based on historical demand data.

Station storage - real time

Vehicles are either stored in the station when they become empty or are routed to other stations and stored based on current demand patterns.

Event Model

A representation of an entity (a subsystem or process) in terms of discrete states of the entity and the time required to change from one state to another for use in a discrete event simulation.

Fixed Block

A longitudinal control or headway protection mechanization wherein blocks are hardwired to the guideway and each block transmits velocity or braking commands to the vehicle based on the occupancy of preceding blocks. For longitudinal control, the commands may be altered by central or local control. For headway protection the blocks transmit either braking or velocity limit commands to vehicles which establish upper bounds for any other commands.

Fixed Route Service

Transit service operated on predetermined paths.

Flow Capacity (ρ_c)

A measure of system capacity in terms of passenger spaces per second past a point; the ratio of traveling unit capacity to average route headway.

Fully Connected Grid (FG)

A grid network in which vehicles proceed directly from one station to any other station without retracing any one-or two-directional portion of the guideway.

Global Variables

Variables stored in a common area and known by one name to all segments included in the program.

Grid

Any guideway on which vehicles are presented with a choice of paths during normal operation.

Grid Transit (GT)

A transit system deployed in any demand environment which uses an FG or PG network and has more extensive operational switching capability than on MSLT. Generally shorter headways result than in MSLT. This category includes PRT systems and many systems which are often referred to as Group Rapid Transit (GRT).

Guideway Interface

The vehicle components which contact the guideway for support. Usually the interface is wheels but in some cases it is an air or magnetic levitation force.

Headway

A frequency of service measure: the mean time between vehicles passing a point along a route of known configuration.

Headway Equation

An analytic function which expresses the relationship between minimum headway and system parameters such as traveling unit (vehicle or train) length, cruise speed, acceleration, communication delay, and expected position error.

Intermediate Vehicle Group Rapid Transit (IGRT)

A class of AGT systems which provides multiple-stop service and carries from 25 to 69 passengers in its minimum train consist. Low speed IGRT systems have a maximum operating speed of 13 to 54 km/h and tend to run at 15 to 60 s headways. High speed IGRT systems operate at speeds greater than 54 km/h and at headways which usually fall between 15 and 90 s.

Intersection

An X-type merge with 2 input links, 2 output links, 4 ramp links, 4 through paths, and either 2 or 4 queuing areas.

Large Vehicle Group Rapid Transit (LGRT)

A class of AGT systems which provides multiple-stop service, has a minimum train consist capacity of 70 to 109 passengers, operates at a maximum speed of 13 to 54 km/h, and usually runs at headways of 30 to 90 s.

Lateral Control Interface

Vehicle and guideway components that interface to control the vehicle's lateral movement.

Loop

A guideway on which motion is unidirectional during normal operation (except possibly at short station segments or at ends of runs) and which is defined by a closed path.

Loop of Closed Geometry (S)

A simple loop as defined above which encircles no area.

Macro

A standard code segment that is generated in-line at compile time by specification of single statement.

Maximum Operating Speed

The maximum speed at which a vehicle can travel. This limit is imposed by vehicle and propulsion system design constraints.

Merge Strategy

A strategy for resolving merge conflicts. Three strategies are considered:

1. FIFO (first-in, first-out)
2. Prescheduled
3. Priority

Metro Shuttle Loop Transit (MSLT)

A transit system deployed in a metropolitan environment and having high speed capability but no or limited operational switching capability. The network may be of any type. If it is a grid network, however, the switching is of limited capability. This category includes most guideway transit systems currently deployed in metropolitan areas.

Minimum Traveling Unit

The minimum number of vehicles with which a train can operate. For some systems the minimum traveling unit is a single vehicle.

Minimum Traveling Unit Capacity

The nominal capacity (not crush capacity) of a single vehicle times the number of vehicles in a minimum train consist.

Moving Block

A headway protection mechanization wherein an emergency protection zone which moves along with the vehicle is established around each vehicle. Emergency braking commands are issued to the traveling vehicle whenever its emergency protection zone infringes upon that of a leading vehicle.

Multiple Loop (ML)

Any network consisting of two or more loops and requiring that passengers transfer from a vehicle constrained to one loop to a vehicle constrained to another loop if they wish to travel between two points not served by a single loop.

Network Element

Either a link, merge, or an intersection modeled in the DOCM.

Network Type

A system deployment parameter which specifies network configuration. Seven network types are identified:

1. Shuttles (S)
2. Loop of closed geometry (L)
3. Open loop, one-way (L1)
4. Open loop, two-way (L2)
5. Multiple loop (ML)
6. Partially connected grid (PG)
7. Fully connected grid (FG)

Nominal Capacity

Vehicle capacity including seated and standing passengers as specified by the manufacturer according to a passenger comfort criterion. The average area allotted to each standee is generally at least 2.5 square feet.

Non-deterministic

A strategy by which potential conflicts at merges are not considered before launch but are resolved locally in the vicinity of each merge.

Off-Vehicle Feeder Travel Time for Access

The mean time per person enroute to a specific AGT station for delay or non-vehicle travel (including any walking to feeder route or waiting for feeder bus, transferring between vehicles, parking a car, or walking all the way), while going from zone centroids to a specific station.

Off-Vehicle Feeder Travel Time for Egress

The mean time per person enroute from a specific AGT station for delay or non-vehicle travel (including waiting at stations for bus, walking from route to destination, transferring between vehicles, or walking all the way), while going from a specific station to zone centroids.

On-Vehicle Feeder Time for Access

The mean time per person enroute to a specific AGT station spent aboard a feeder vehicle (including feeder bus or private auto), while going from zone centroids to a specific station.

On-Vehicle Feeder Travel Time for Egress

The mean time per person enroute from a specific AGT station spent aboard a feeder vehicle (including the feeder bus or private auto), while going from a specific station to zone centroids.

Open-Loop Control

Advancement of vehicles by user-specified control independent of system state.

Open Loop, One-Way (L1)

A single loop encircling an area and providing one-way circulation.

Open Loop, Two-Way (L2)

Two loops deployed side-by-side encircling an area and providing two-way circulation.

PARAFOR

A superset of FORTRAN utilizing PL/1 macros to add structured programming facilities to standard FORTRAN.

Partially Connected Grid (PG)

A grid network which does not qualify as a Fully Connected Grid (FG).

Partitioned Data Set

A type of file organization in which independent groups of sequentially organized records, called members, are on direct-access storage.

Path

A sequence of guideway links used by a vehicle to travel between two points on a network.

Personal Rapid Transit (PRT)

A class of PRT systems which provides non-stop point-to-point service, has a minimum traveling unit capacity of 3 to 6 passengers, and runs at very short headways, usually 3 s or less. Low speed PRT has a maximum operating speed of 13 to 54 km/h, while high speed PRT has a maximum operating speed exceeding 54 km/h.

Platoon Movement

Simultaneous advancement of a row of vehicles or trains.

Practical Minimum Headway

The minimum headway at which vehicles can operate under normal conditions.

Prescheduled Pathing

A vehicle pathing strategy in which the primary path from origin to destination is predetermined and specified for all station pairs.

Precision Stopping Tolerance

The tolerance within which a vehicle can stop at a given point.

Quasi-deterministic

A strategy by which merge conflicts are not resolved prior to launch, but information about the future state of the network is used to launch vehicles at times that provide a high probability of efficient merging.

Quasi-synchronous

Operation of vehicles under point-follower control but with change of control points allowed to resolve potential merge conflicts by advancing or slipping one or more slots.

Reliability Block Diagram

A diagram that illustrates what equipment or combinations of equipment are required for successful system operation.

Representative System

A collection of values for the following system characteristics and strategies:

1. Vehicle characteristics
2. Guideway characteristics
3. System management strategies
4. Reliability characteristics
5. Cost characteristics

Representative System (continued)

The range of values are chosen to be interrelated in such a way as to represent a general class of state-of-the-art systems for the purpose of conducting system analyses within the SOS program.

Representative System Deployment

A specific combination of a representative system, demand type, and network configuration defined for the purpose of conducting system analyses within the SOS program.

Response Time

A frequency of service measures the mean time between a request for and the arrival of a dial-a-ride service vehicle.

Ripple Movement

Advancement of vehicles and trains one at a time for a row of stationary vehicles/trains.

Route

A designated set of destinations, usually defined by stations, to which a vehicle must travel. The path, or links, to be traversed between any two destinations is not specified.

Routing Strategy

A strategy which identifies routes for vehicles/trains. Two alternatives are fixed routing and real time select routing. Real time routing is used only with demand responsive service and demand activated service, while fixed routing is employed for demand stop and fixed route service policies.

Rural and Scattered Urban (R&SU)

The remaining rural and urban portions of counties not included as part of the urbanized ring of the UA, but still within the boundaries of the SMSA. Thus, with the exception of the New York and Los Angeles SMSA's, the SMSA consists of two components - the UA and the Rural and Scattered Urban. Both New York and Los Angeles Urbanized Areas (UA's) extend into counties outside the boundaries of the SMSA.

Scheduled, Real Time Pathing

A vehicle pathing strategy in which the primary path from origin to destination is selected from among specified alternatives just prior to departure from the origin station on the basis of current traffic conditions on the network.

Sector

An area serviceable by one vehicle in subscription service during a prescribed time interval for a specific demand density.

Service Type

Either non-stop (personal transit) or multiple-stop (group transit) service.

Shuttles (S)

A guideway on which bi-directional motion occurs during normal operation and which is defined by a single curve connecting two distinct end points. Also, any network consisting of two or more simple shuttles, either following the same path or different paths.

Shuttle Loop Transit (SLT)

A low speed AGT system deployment in an activity center demand environment having any non-grid type of network. Thus, SLT system deployments require no operational switching but may require passenger transfers.

Small Vehicle Group Rapid Transit (SGRT)

A class of AGT systems which provides multiple-party service, has a capacity of 7 to 24 passengers in its minimum train consist, and usually operates at headways between 3 and 15 s. Low speed SGRT has a maximum operating speed of 16 to 54 km/h, and high speed SGRT a maximum of over 54 km/h.

Standard Metropolitan Statistical Area (SMSA)

A county or group of counties containing at least one city (or twin cities) with a population of 50,000 or more, plus adjacent counties which are metropolitan in character and integrated economically and socially within the central city.

Switching Mechanism

The mechanism, located either on the vehicle or the guideway, by which vehicles/trains are switched.

Synchronous

Operation of vehicles under point-follower control with no changes allowed in control points during a given guideway trip.

Theoretical Minimum Headway

The minimum headway at which two vehicles can travel, assuming there are no merges or on-line stations.

Total Value Capital Cost

The sum of all capital costs except interest expense over the life cycle period expressed in base-year dollars.

Urbanized Area (UA)

An area containing a central city (or twin cities) of 50,000 or more population, plus the surrounding closely settled incorporated and unincorporated areas which meet certain criteria of population size and density (urbanized ring). UA's differ from SMSA's in that UA's exclude the rural portions of counties composing the SMSA's, as well as places that were separated by rural territory from the densely populated fringe around the central city. The components of the UA's include the central city, as defined above, and the urbanized rings, as defined below.

Urbanized Ring (UR)

Various areas contiguous to a central city or cities, which together constitute its urbanized ring, or "urban fringe," as termed by the Census Bureau.

Variable Cost (base year)

The annual cost of operating and maintaining a system expressed in base year (1977) dollars. Variable costs include maintenance costs, energy costs, and administrative costs for both the AGT and feeder systems.

Vehicle Capacity

When used in correlations of vehicle dimensions and cost to capacity, nominal vehicle capacity is assumed. However, the system simulations interpret vehicle capacity as the maximum number of passengers which can occupy a vehicle at one time.

APPENDIX A

SAMPLE RUN

Figure A-1 shows an example of JCL to run the SAM.

```
//*       THIS RUN GENERATES A STRUCTURED DATA FILE FROM AN INPUT
//*       DATASET.  THEN, IT IS UPDATED BY THE NEXT STEP.  FINALLY,
//*       THE MODEL AND OUTPUT PROCESSORS ARE RUN ON THE RESULTANT
//*       FILE.
//*
//*--------------------------------------------------------------------
//*
//*
//CREATE EXEC   AGTAIP,INDEX=TEST,
//              TRPLG00=TESTREF,TRPLG01=TESTDEL4,STRUC=TEST1,
//              RNTIM=AINPUT01
//UPDATE EXEC   AGTAIP,COND=(0,NE),
//              INDEX=TEST,TRPLG00=TESTREF,TRPLG01=TESTDEL4,STRUC=TEST2,
//              UPDATE=TEST1,TRPLG02=TESTDEL4,TRPLG03=TESTDEL4,
//              TRPLG04=TESTDEL4,RNTIM=AINPUT02
//MP     EXEC   AGTAMP,STRUC=TEST2,COND=(0,NE),
//              STATS=TEST,INDEX=TEST
//OP     EXEC   AGTAOP,STATS=TEST,COND=(0,NE),
//              PERSUM=TEST,INDEX=TEST
//
```

FIGURE A-1. RUN JCL

The runtime inputs (contained in AGT.IANDD.RNTIM) are shown in Figure A-2.

```
         INDEX
  INDEX  TEST OF SAM                                           EUGENE O. MAUCH 8/11/77
  END
         DATA
 KNDM     1I1
  5
 KNREG    1I1
  2
 KNLVL    1I1
  2
 KNDL     1I1
  3
 KNFL     1I1
  2
 KNCMP    1I1
  2
 FLTSLT   1I1
  1
 RRATE    1F10.0
    1.5
 SMFREQ   1F10.0
    0.005
 SMST     1F10.0
    0.5
 PTHRDM   1F10.0
    2.0
 THRIND   1F10.0
    2.0
 DMND     1F10.0      1    5
  5 1000.
 DLTIME   5F10.0      1    5    1    5    1    4    1    5
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 FRATE    5F10.0      1    4    1    5    1    5    1    5
 99 0.001     0.001     0.001     0.001     0.001
    0.001     0.001     0.001     0.001     0.001
 GWMILE   1F10.0      1    2
  2 50.0
 NUMTRP   5F10.0      1    5    1    5    1   40    1    5
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0

    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 99 5.0       5.0       5.0       5.0       5.0
    5.0       5.0       5.0       5.0       5.0
 STATNS   1I2         1    2
  2 3
 SYSTIM   1F10.0      1    5
  5 2.0
 PNS      1F10.0      1    5    1    5
 25 1000.
 VINSTA   1F10.0      1    5    1    5
 25 180.
 VN       1F10.0      1    5    1    5
 25 50.
 VM       1F10.0      1    5    1    5
 25 3000.
 VOPTIM   1F10.0      1    5    1    5
 25 100.
 END
     1 FAILURE             1    1    1    1
       EOD
```

FIGURE A-2. RUNTIME INPUT

APPENDIX B

SAMPLE OUTPUT

Examples of all the reports generated by the SAM are included here; some duplicate reports have been eliminated.

```
          INDEX
 GRT-2  INITIAL SAM VEHICLE AVAIL RUN FOR GRT-2  JAMES D. BOLDIG 10/  /7800020021
 END                                                                  00010000
          DATA                                                        00030000
                                                                      00040000
 KNDM     1I1          0     0     0     0     0     0     0     0
  04                                                                  00060014
 KNREG    1I1          0     0     0     0     0     0     0     0
  05                                                                  00080014
 KNLVL    1I1          0     0     0     0     0     0     0     0
  01                                                                  00100021
 PTHRDM   1F10.0       0     0     0     0     0     0     0     0
  00.0                                                                00120007
 THRIND   1F10.0       0     0     0     0     0     0     0     0
  01.0                                                                00140014
 KNDL     1I2          0     0     0     0     0     0     0     0
  010                                                                 00160014
 KNFL     1I1          0     0     0     0     0     0     0     0
  02                                                                  00180000
 FLTSLT   1I1          0     0     0     0     0     0     0     0
  01                                                                  00200000
 RRATE    1F10.0       0     0     0     0     0     0     0     0
  08.0                                                                00220002
 SMFREQ   1F10.0       0     0     0     0     0     0     0     0
  00.005                                                              00240009
 SMST     1F10.0       0     0     0     0     0     0     0     0
  02.0                                                                00260009
 DMND     4F10.0       1     4     0     0     0     0     0     0
  1    24270.     33366.     31716.     21288.                        00280027
 DLTIME   5F10.0       1     5     1     4     1     4     1     2
  1 2.12       0.94       0.52       0.74       0.57                  00300024
  1 2.20       0.82       0.31       0.51       0.36                  00310024
  2 0.66       0.33       0.11       0.12       0.19                  00320024
  1 2.12       0.94       0.52       0.74       0.57                  00330024
  1 2.20       0.82       0.31       0.51       0.36                  00340024
  2 0.66       0.33       0.11       0.12       0.19                  00350024
  1 2.12       0.94       0.52       0.74       0.57                  00360024
  1 2.20       0.82       0.31       0.51       0.36                  00370024
  2 0.66       0.33       0.11       0.12       0.19                  00380024
  1 7.21       0.0        0.0        0.0        0.0                   00390024
  1 6.29       0.0        0.0        0.0        0.0                   00400024
  2 2.92       0.0        0.0        0.0        0.0                   00410024
 16 0.0        0.0        0.0        0.0        0.0                   00420024
 FRATE    4F10.0       1     4     1     5     1     1     1     2
  1 0.002971   0.0        0.0        0.0                              00440022
  1 0.0        0.0        0.0        0.0                              00450000
  1 0.0        0.000414   0.002465   0.000957                         00460022
  1 0.0        0.0        0.0        0.0                              00470000
  1 0.0        0.0        0.0        0.0                              00480000
  1 0.001657   0.0        0.0        0.0                              00490022
  1 0.0        0.0        0.0        0.0                              00500000
  1 0.0        0.000881   0.000959   0.000302                         00510022
  1 0.0        0.0        0.0        0.0                              00520000
  1 0.0        0.0        0.0        0.0                              00530000
 GWMILE   1F10.0       1     5     0     0     0     0     0     0
  5 1.0                                                               00550014
 NUMTRP   5F10.0       1     1     1     1     1     1     1     1
  1 0.0        0.0        0.0        0.0        0.0                   00570000
```

FIGURE B-1 (1 of 12). SAMPLE OUTPUT

```
STATNS  5I3            1      5      0      0      0      0      0      0          00590025
 1 14 16  5  5 11
SYSTIM  4F10.0         1      4      0      0      0      0      0      0          00610014
 1 3.0       3.0        6.0        12.0
VN       5F10.0        1      5      1      4      0      0      0      0          00630024
 1 32.78     28.52      8.28      15.48      13.94                                  00640024
 1 29.46     28.94      7.31      11.35      13.94                                  00650024
 2 16.12     14.54      5.36       5.68       7.30
VOPTIM  5F10.0         1      5      1      4      0      0      0      0          00670024
 1 98.34     85.56     24.84      46.44      41.82                                  00680024
 1 88.38     86.82     21.93      34.05      41.82                                  00690024
 1 96.72     87.24     32.16      34.08      43.80                                  00700024
 1 193.44   174.48     64.32      68.16      87.60
END                    0      0      0      0      0      0      0      0          00720004
    1 FAILURE               1    1    1    1                                      00730014
    2 FAILURE               1    1    1    1                                      00740024
    3 FAILURE               1    1    1    1                                      00750024
    4 FAILURE               1    1    1    1                                      00760024
    5 FAILURE               2    1    1    1                                      00770024
    6 FAILURE               2    1    1    1                                      00780024
    7 FAILURE               2    1    1    1                                      00790024
    8 FAILURE               2    1    1    1                                      00800024
    9 FAILURE               3    1    1    1                                      00810024
   10 FAILURE               3    1    1    1                                      00820024
   11 FAILURE               4    1    1    1                                      00830024
   12 FAILURE               4    1    1    1                                      00840024
   13 FAILURE               5    1    1    1                                      00850024
   14 FAILURE               5    1    1    1                                      00860024
   15 FAILURE               1    1    2    1                                      00870024
   16 FAILURE               1    1    2    1                                      00880024
   17 FAILURE               1    1    2    1                                      00890024
   18 FAILURE               1    1    2    1                                      00900024
   19 FAILURE               2    1    2    1                                      00910024
   20 FAILURE               2    1    2    1                                      00920024
   21 FAILURE               2    1    2    1                                      00930024
   22 FAILURE               2    1    2    1                                      00940024
   23 FAILURE               3    1    2    1                                      00950024
   24 FAILURE               3    1    2    1                                      00960024
   25 FAILURE               4    1    2    1                                      00970024
   26 FAILURE               4    1    2    1                                      00980024
   27 FAILURE               5    1    2    1                                      00990024
   28 FAILURE               5    1    2    1                                      01000024
   29 FAILURE               1    1    3    1                                      01010024
   30 FAILURE               1    1    3    1                                      01020024
   31 FAILURE               1    1    3    1                                      01030024
   32 FAILURE               1    1    3    1                                      01040024
   33 FAILURE               2    1    3    1                                      01050024
   34 FAILURE               2    1    3    1                                      01060024
   35 FAILURE               2    1    3    1                                      01070024
   36 FAILURE               2    1    3    1                                      01080024
   37 FAILURE               3    1    3    1                                      01090024
   38 FAILURE               3    1    3    1                                      01100024
   39 FAILURE               4    1    3    1                                      01110024
   40 FAILURE               4    1    3    1                                      01120024
   41 FAILURE               5    1    3    1                                      01130024
   42 FAILURE               5    1    3    1                                      01140024
   43 FAILURE               1    1    4    1                                      01150017
      EOD
 *** AIP002I -  93 UNMATCHED TRIPS ***
 *** AIP002I - 118 UNMATCHED TRIPS ***
```

FIGURE B-1 (2 of 12). SAMPLE OUTPUT

```
*** AIP002I -  58 UNMATCHED TRIPS ***
*** AIP002I -  93 UNMATCHED TRIPS ***
*** AIP002I -  47 UNMATCHED TRIPS ***
*** AIP002I -  29 UNMATCHED TRIPS ***
*** AIP002I -  80 UNMATCHED TRIPS ***
*** AIP002I -  61 UNMATCHED TRIPS ***
*** AIP002I -  17 UNMATCHED TRIPS ***
*** AIP002I -  13 UNMATCHED TRIPS ***
*** AIP002I -  69 UNMATCHED TRIPS ***
*** AIP002I -  46 UNMATCHED TRIPS ***
*** AIP002I -  23 UNMATCHED TRIPS ***
*** AIP002I -  22 UNMATCHED TRIPS ***
*** AIP002I -  93 UNMATCHED TRIPS ***
*** AIP002I - 118 UNMATCHED TRIPS ***
*** AIP002I -  58 UNMATCHED TRIPS ***
*** AIP002I -  93 UNMATCHED TRIPS ***
*** AIP002I -  47 UNMATCHED TRIPS ***
*** AIP002I -  29 UNMATCHED TRIPS ***
*** AIP002I -  80 UNMATCHED TRIPS ***
*** AIP002I -  61 UNMATCHED TRIPS ***
*** AIP002I -  17 UNMATCHED TRIPS ***
*** AIP002I -  13 UNMATCHED TRIPS ***
*** AIP002I -  69 UNMATCHED TRIPS ***
*** AIP002I -  46 UNMATCHED TRIPS ***
*** AIP002I -  23 UNMATCHED TRIPS ***
*** AIP002I -  22 UNMATCHED TRIPS ***
*** AIP002I -  93 UNMATCHED TRIPS ***
*** AIP002I - 118 UNMATCHED TRIPS ***
*** AIP002I -  58 UNMATCHED TRIPS ***
*** AIP002I -  93 UNMATCHED TRIPS ***
*** AIP002I -  47 UNMATCHED TRIPS ***
*** AIP002I -  29 UNMATCHED TRIPS ***
*** AIP002I -  80 UNMATCHED TRIPS ***
*** AIP002I -  61 UNMATCHED TRIPS ***
*** AIP002I -  17 UNMATCHED TRIPS ***
*** AIP002I -  13 UNMATCHED TRIPS ***
*** AIP002I -  69 UNMATCHED TRIPS ***
*** AIP002I -  46 UNMATCHED TRIPS ***
*** AIP002I -  23 UNMATCHED TRIPS ***
*** AIP002I -  22 UNMATCHED TRIPS ***
*** AIP002I - 117 UNMATCHED TRIPS ***

DATE AND TIME  FILES REFERENCED
10/13/78 18:57 AGT.AGT.LOAD(AINPUT03)
               AGT.STRUC.SAM(AGRT2A)
```

FIGURE B-1 (3 of 12). SAMPLE OUTPUT

SUMMARY OF INPUTS

SCHEDULED MAINTENANCE FREQUENCY (1/HOURS) 0.0050
SCHEDULED MAINTENANCE TIME (HOURS) 2.00
AVERAGE VEHICLE REPAIR TIME (HOURS) 8.00
MAXIMUM ACTIVE FLEET SIZE WILL BE USED

DEMAND PERIOD	REGION	GUIDEWAY KILOMETERS	PASSENGERS	STATIONS	DEMAND	OPERATING HOURS VEHICLE	OPERATING HOURS SYSTEM	VEHICLES THROUGH STATIONS	VEHICLE KILOMETERS	NUMBER OF VEHICLES
1	1	1.00	0.	14	24270.	98.34	3.00	0.	0.	33.
	2	1.00	0.	16		85.56		0.	0.	29.
	3	1.00	0.	5		24.84		0.	0.	8.
	4	1.00	0.	5		46.44		0.	0.	15.
	5	1.00	0.	11		41.82		0.	0.	14.
2	1	1.00	0.	14	33366.	88.38	3.00	0.	0.	29.
	2	1.00	0.	16		86.82		0.	0.	29.
	3	1.00	0.	5		21.93		0.	0.	7.
	4	1.00	0.	5		34.05		0.	0.	11.
	5	1.00	0.	11		41.82		0.	0.	14.
3	1	1.00	0.	14	31716.	96.72	6.00	0.	0.	16.
	2	1.00	0.	16		87.24		0.	0.	15.
	3	1.00	0.	5		32.16		0.	0.	5.
	4	1.00	0.	5		34.08		0.	0.	6.
	5	1.00	0.	11		43.80		0.	0.	7.
4	1	1.00	0.	14	21288.	193.44	12.00	0.	0.	16.
	2	1.00	0.	16		174.48		0.	0.	15.
	3	1.00	0.	5		64.32		0.	0.	5.
	4	1.00	0.	5		68.16		0.	0.	6.
	5	1.00	0.	11		87.60		0.	0.	7.

FIGURE B-1 (4 of 12). SAMPLE OUTPUT

FAILURE RATES

10-13-78

RELIABILITY LEVEL	SUBSYSTEM	FAILURE LEVEL	CAUSAL FACTORS: VEHICLE TIME	PASSENGERS	ELAPSED TIME	VEHICLES THRU STATION	VEHICLE MILES
1	VEHICLES	1	0.002971	0.0	0.0	0.0	0.0
		2	0.001657	0.0	0.0	0.0	0.0
	STATIONS	1	0.0	0.0	0.000414	0.0	0.0
		2	0.0	0.0	0.000881	0.0	0.0
	GUIDEWAY	1	0.0	0.0	0.002465	0.0	0.0
		2	0.0	0.0	0.000959	0.0	0.0
	CENTRAL	1	0.0	0.0	0.000957	0.0	0.0
		2	0.0	0.0	0.000302	0.0	0.0

FIGURE B-1 (5 of 12). SAMPLE OUTPUT

RELIABILITY PARAMETERS (FOR RELIABILITY LEVEL 1)

DEMAND PERIOD	REGION	FAILURE LEVEL	GUIDEWAY KILOMETERS	PASSENGERS	STATIONS	OPERATING HOURS VEHICLE	OPERATING HOURS SYSTEM	VEHICLES THROUGH STATIONS	VEHICLE KM	SUBCOMPONENT FAILURE RATES VEHICLES	STATIONS	GUIDEWAYS	MANAGEMENT
1	1	1	1.00	0.	14	98.34	3.00	0.	0.	0.292168	0.017388	0.007395	0.002871
		2								0.162949	0.037002	0.002877	0.000906
	2	1	1.00	0.	16	85.56		0.	0.	0.254199	0.019872	0.007395	0.002871
		2								0.141773	0.042288	0.002877	0.000906
	3	1	1.00	0.	5	24.84		0.	0.	0.073800	0.006210	0.007395	0.002871
		2								0.041160	0.013215	0.002877	0.000906
	4	1	1.00	0.	5	46.44		0.	0.	0.137973	0.006210	0.007395	0.002871
		2								0.076951	0.013215	0.002877	0.000906
	5	1	1.00	0.	11	41.82		0.	0.	0.124247	0.013662	0.007395	0.002871
		2								0.069296	0.029073	0.002877	0.000906
2	1	1	1.00	0.	14	88.38	3.00	0.	0.	0.262577	0.017388	0.007395	0.002871
		2								0.146446	0.037002	0.002877	0.000906
	2	1	1.00	0.	16	86.82		0.	0.	0.257942	0.019872	0.007395	0.002871
		2								0.143861	0.042288	0.002877	0.000906
	3	1	1.00	0.	5	21.93		0.	0.	0.065154	0.006210	0.007395	0.002871
		2								0.036338	0.013215	0.002877	0.000906
	4	1	1.00	0.	5	34.05		0.	0.	0.101163	0.006210	0.007395	0.002871
		2								0.056421	0.013215	0.002877	0.000906
	5	1	1.00	0.	11	41.82		0.	0.	0.124247	0.013662	0.007395	0.002871
		2								0.069296	0.029073	0.002877	0.000906
3	1	1	1.00	0.	14	96.72	6.00	0.	0.	0.287355	0.034776	0.014790	0.005742
		2								0.160265	0.074004	0.005754	0.001812
	2	1	1.00	0.	16	87.24		0.	0.	0.259190	0.039744	0.014790	0.005742
		2								0.144557	0.084576	0.005754	0.001812
	3	1	1.00	0.	5	32.16		0.	0.	0.095547	0.012420	0.014790	0.005742
		2								0.053289	0.026430	0.005754	0.001812
	4	1	1.00	0.	5	34.08		0.	0.	0.101252	0.012420	0.014790	0.005742
		2								0.056471	0.026430	0.005754	0.001812
	5	1	1.00	0.	11	43.80		0.	0.	0.130130	0.027324	0.014790	0.005742
		2								0.072577	0.058146	0.005754	0.001812
4	1	1	1.00	0.	14	193.44	12.00	0.	0.	0.574710	0.069552	0.029580	0.011484
		2								0.320530	0.148008	0.011508	0.003624
	2	1	1.00	0.	16	174.48		0.	0.	0.518380	0.079488	0.029580	0.011484
		2								0.289113	0.169152	0.011508	0.003624
	3	1	1.00	0.	5	64.32		0.	0.	0.191095	0.024840	0.029580	0.011484
		2								0.106578	0.052860	0.011508	0.003624
	4	1	1.00	0.	5	68.16		0.	0.	0.202503	0.024840	0.029580	0.011484
		2								0.112941	0.052860	0.011508	0.003624
	5	1	1.00	0.	11	87.60		0.	0.	0.260260	0.054648	0.029580	0.011484
		2								0.145153	0.116292	0.011508	0.003624

FIGURE B-1 (6 of 12). SAMPLE OUTPUT

FAILURE RATES (FOR RELIABILITY LEVEL 1)

10-13-78

SUBSYSTEM	FAILURE LEVEL	CAUSAL FACTORS: VEHICLE TIME	PASSENGERS	ELAPSED TIME	VEHICLES THRU STATION	VEHICLE MILES
VEHICLES	1	0.002971(64.2%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
	2	0.001657(35.8%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
	TOTAL	0.004628	0.0	0.0	0.0	0.0
STATIONS	1	0.0 (0.0%)	0.0 (0.0%)	0.000414(32.0%)	0.0 (0.0%)	0.0 (0.0%)
	2	0.0 (0.0%)	0.0 (0.0%)	0.000881(68.0%)	0.0 (0.0%)	0.0 (0.0%)
	TOTAL	0.0	0.0	0.001295	0.0	0.0
GUIDEWAY	1	0.0 (0.0%)	0.0 (0.0%)	0.002465(72.0%)	0.0 (0.0%)	0.0 (0.0%)
	2	0.0 (0.0%)	0.0 (0.0%)	0.000959(28.0%)	0.0 (0.0%)	0.0 (0.0%)
	TOTAL	0.0	0.0	0.003424	0.0	0.0
CENTRAL	1	0.0 (0.0%)	0.0 (0.0%)	0.000957(76.0%)	0.0 (0.0%)	0.0 (0.0%)
	2	0.0 (0.0%)	0.0 (0.0%)	0.000302(24.0%)	0.0 (0.0%)	0.0 (0.0%)
	TOTAL	0.0	0.0	0.001259	0.0	0.0

FIGURE B-1 (7 of 12). SAMPLE OUTPUT

PASSENGER AVAILABILITY 10-13-78

TRIPS DELAYED BY FAILURES (FOR RELIABILITY LEVEL 1)

DEMAND PERIOD	STATION DEMAND	THRESHOLD (MIN.) 1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
1	24270.	1369.	788.	621.	511.	426.	367.	299.	227.	168.	108.
2	33366.	1889.	1219.	940.	772.	656.	575.	459.	368.	290.	208.
3	31716.	893.	477.	378.	328.	245.	206.	166.	131.	89.	47.
4	21288.	603.	318.	249.	232.	169.	139.	109.	91.	66.	35.
TOTAL	110640.	4755.	2803.	2188.	1842.	1496.	1287.	1034.	816.	613.	397.
AVAILABILITY		95.7%	97.5%	98.0%	98.3%	98.6%	98.8%	99.1%	99.3%	99.4%	99.6%

FIGURE B-1 (8 of 12). SAMPLE OUTPUT

MAINTENANCE FLEET (RELIABILITY LEVEL 1) 10-13-78

VEHICLE OPERATING TIME (HOURS)	1452.00
SCHEDULED MAINTENANCE FREQUENCY	0.0050
SCHEDULED MAINTENANCE TIME (HOURS)	2.00
AVERAGE SCHEDULED MAINTENANCE FLEET SIZE	1.
VEHICLE FAILURE FREQUENCY	0.28
VEHICLE REPAIR TIME (HOURS)	8.00
MINIMUM MAINTENANCE BAYS	3
MAXIMUM ACTIVE FLEET SIZE	99.

PROBABILITY OF FLEET SIZE BEING ADEQUATE

SERVICE BAYS	MAINTENANCE FLEET SIZE TOTAL	MAINTENANCE FLEET SIZE FAILURE	FLEET SIZE 0	1	3	5	7	9	19	29	39	49
3	5.	4.	7.6%	24.7%	58.0%	76.6%	86.9%	92.7%	99.6%	100.0%	100.0%	100.0%
3	5.	4.	7.6%	24.7%	58.0%	76.6%	86.9%	92.7%	99.6%	100.0%	100.0%	100.0%
4	3.	3.	10.0%	32.4%	76.2%	92.5%	97.7%	99.3%	100.0%	100.0%	100.0%	100.0%
4	3.	3.	10.0%	32.4%	76.2%	92.5%	97.7%	99.3%	100.0%	100.0%	100.0%	100.0%
5	3.	2.	10.5%	34.0%	80.0%	96.0%	99.2%	99.8%	100.0%	100.0%	100.0%	100.0%
5	3.	2.	10.5%	34.0%	80.0%	96.0%	99.2%	99.8%	100.0%	100.0%	100.0%	100.0%
6	3.	2.	10.6%	34.4%	80.9%	97.0%	99.6%	99.9%	100.0%	100.0%	100.0%	100.0%
7	3.	2.	10.6%	34.5%	81.1%	97.3%	99.7%	100.0%	100.0%	100.0%	100.0%	100.0%
7	3.	2.	10.6%	34.5%	81.1%	97.3%	99.7%	100.0%	100.0%	100.0%	100.0%	100.0%
8	3.	2.	10.6%	34.5%	81.1%	97.3%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%

AVERAGE NUMBER OF VEHICLES

DEMAND PERIOD	DEMAND PERIOD (MINUTES)	REGION 1	2	3	4	5
1	3.0	33.	29.	8.	15.	14.
2	3.0	29.	29.	7.	11.	14.
3	6.0	16.	15.	5.	6.	7.
4	12.0	16.	15.	5.	6.	7.

FIGURE B-1 (9 of 12). SAMPLE OUTPUT

VEHICLE AVAILABILITY 10-13-78

VEHICLE DELAY(HOURS)/VEHICLE OPERATING TIME(HOURS) (FOR RELIABILITY LEVEL 1)

DEMAND PERIOD	TOTAL		REGION 1		2		3		4		5	
1	1.20/	297.	0.69/	98.	0.26/	86.	0.05/	25.	0.11/	46.	0.08/	42.
2	1.02/	273.	0.65/	88.	0.23/	87.	0.02/	22.	0.06/	34.	0.05/	42.
3	0.40/	294.	0.24/	97.	0.10/	87.	0.01/	32.	0.02/	34.	0.03/	44.
4	0.81/	588.	0.48/	193.	0.21/	174.	0.03/	64.	0.03/	68.	0.07/	88.
TOTAL	3./	1452.										

AVAILABILITY 99.8%

FIGURE B-1 (10 of 12). SAMPLE OUTPUT

VEHICLE DELAY TIME RESULTING FROM FAILURES (IN HOURS)

DEMAND PERIOD	REGION	FAILURE LEVEL	SUBSYSTEMS VEHICLES	STATIONS	GUIDEWAYS	MANAGEMENT
1	1	1	2.12	2.12	2.12	7.21
		2	0.0	0.0	0.0	0.0
	2	1	0.94	0.94	0.94	0.0
		2	0.0	0.0	0.0	0.0
	3	1	0.52	0.52	0.52	0.0
		2	0.0	0.0	0.0	0.0
	4	1	0.74	0.74	0.74	0.0
		2	0.0	0.0	0.0	0.0
	5	1	0.57	0.57	0.57	0.0
		2	0.0	0.0	0.0	0.0
2	1	1	2.20	2.20	2.20	6.29
		2	0.0	0.0	0.0	0.0
	2	1	0.82	0.82	0.82	0.0
		2	0.0	0.0	0.0	0.0
	3	1	0.31	0.31	0.31	0.0
		2	0.0	0.0	0.0	0.0
	4	1	0.51	0.51	0.51	0.0
		2	0.0	0.0	0.0	0.0
	5	1	0.36	0.36	0.36	0.0
		2	0.0	0.0	0.0	0.0
3	1	1	0.66	0.66	0.66	2.92
		2	0.0	0.0	0.0	0.0
	2	1	0.33	0.33	0.33	0.0
		2	0.0	0.0	0.0	0.0
	3	1	0.11	0.11	0.11	0.0
		2	0.0	0.0	0.0	0.0
	4	1	0.12	0.12	0.12	0.0
		2	0.0	0.0	0.0	0.0
	5	1	0.19	0.19	0.19	0.0
		2	0.0	0.0	0.0	0.0
4	1	1	0.66	0.66	0.66	2.92
		2	0.0	0.0	0.0	0.0
	2	1	0.33	0.33	0.33	0.0
		2	0.0	0.0	0.0	0.0
	3	1	0.11	0.11	0.11	0.0
		2	0.0	0.0	0.0	0.0
	4	1	0.12	0.12	0.12	0.0
		2	0.0	0.0	0.0	0.0
	5	1	0.19	0.19	0.19	0.0
		2	0.0	0.0	0.0	0.0

FIGURE B-1 (11 of 12). SAMPLE OUTPUT

DEMAND PERIOD 1

		FAILURE LEVEL 1				FAILURE LEVEL 2			
REGION	DELAY (MIN.)	VEH	STATN	GUIDE	CNTRL	VEH	STATN	GUIDE	CNTRL
1	1.0	562.	562.	562.	584.	0.	0.	0.	0.
	2.0	244.	244.	244.	522.	0.	0.	0.	0.
	3.0	158.	158.	158.	606.	0.	0.	0.	0.
	4.0	150.	150.	150.	382.	0.	0.	0.	0.
	5.0	78.	78.	78.	320.	0.	0.	0.	0.
	6.0	91.	91.	91.	514.	0.	0.	0.	0.
	7.0	141.	141.	141.	340.	0.	0.	0.	0.
	8.0	106.	106.	106.	290.	0.	0.	0.	0.
	9.0	97.	97.	97.	280.	0.	0.	0.	0.
	10.0	191.	191.	191.	622.	0.	0.	0.	0.
2	1.0	746.	746.	746.	0.	0.	0.	0.	0.
	2.0	162.	162.	162.	0.	0.	0.	0.	0.
	3.0	122.	122.	122.	0.	0.	0.	0.	0.
	4.0	73.	73.	73.	0.	0.	0.	0.	0.
	5.0	48.	48.	48.	0.	0.	0.	0.	0.
	6.0	78.	78.	78.	0.	0.	0.	0.	0.
	7.0	61.	61.	61.	0.	0.	0.	0.	0.
	8.0	43.	43.	43.	0.	0.	0.	0.	0.
	9.0	66.	66.	66.	0.	0.	0.	0.	0.
	10.0	127.	127.	127.	0.	0.	0.	0.	0.
3	1.0	659.	659.	659.	0.	0.	0.	0.	0.
	2.0	191.	191.	191.	0.	0.	0.	0.	0.
	3.0	40.	40.	40.	0.	0.	0.	0.	0.
	4.0	36.	36.	36.	0.	0.	0.	0.	0.
	5.0	32.	32.	32.	0.	0.	0.	0.	0.
	6.0	23.	23.	23.	0.	0.	0.	0.	0.
	7.0	26.	26.	26.	0.	0.	0.	0.	0.
	8.0	39.	39.	39.	0.	0.	0.	0.	0.
	9.0	21.	21.	21.	0.	0.	0.	0.	0.
	10.0	41.	41.	41.	0.	0.	0.	0.	0.
4	1.0	592.	592.	592.	0.	0.	0.	0.	0.
	2.0	99.	99.	99.	0.	0.	0.	0.	0.
	3.0	50.	50.	50.	0.	0.	0.	0.	0.
	4.0	26.	26.	26.	0.	0.	0.	0.	0.
	5.0	37.	37.	37.	0.	0.	0.	0.	0.
	6.0	40.	40.	40.	0.	0.	0.	0.	0.
	7.0	33.	33.	33.	0.	0.	0.	0.	0.
	8.0	39.	39.	39.	0.	0.	0.	0.	0.
	9.0	48.	48.	48.	0.	0.	0.	0.	0.
	10.0	0.	0.	0.	0.	0.	0.	0.	0.
5	1.0	304.	304.	304.	0.	0.	0.	0.	0.
	2.0	73.	73.	73.	0.	0.	0.	0.	0.
	3.0	92.	92.	92.	0.	0.	0.	0.	0.
	4.0	55.	55.	55.	0.	0.	0.	0.	0.
	5.0	80.	80.	80.	0.	0.	0.	0.	0.
	6.0	53.	53.	53.	0.	0.	0.	0.	0.
	7.0	18.	18.	18.	0.	0.	0.	0.	0.
	8.0	20.	20.	20.	0.	0.	0.	0.	0.
	9.0	11.	11.	11.	0.	0.	0.	0.	0.
	10.0	42.	42.	42.	0.	0.	0.	0.	0.

FIGURE B-1 (12 of 12). SAMPLE OUTPUT

APPENDIX C

REPORT OF NEW TECHNOLOGY

The System Availability Model (SAM) provides two system-level availability measures and fleet size data for Automated Guideway Transit (AGT) systems. The first availability measure is the percentage of vehicle operational time. The second availability measure is the percentage of passengers whose wait is below a specified threshold.

The fleet sizing data establishes the number of maintenance and stand-by vehicles.

The SAM operates in conjunction with the Discrete Event Simulation Model (DESM). The DESM output provides the delay information for the SAM analysis.