



1. Introduction

1.1 The Function of SATURN

SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is a suite of flexible network analysis programs developed at the Institute for Transport Studies, University of Leeds and distributed by Atkins Limited since 1981. It has six basic functions:

- i) as a combined traffic simulation and assignment model for the analysis of road-investment schemes ranging from traffic management schemes over relatively localised networks (typically of the order of 100 to 200 nodes) through to major infrastructure improvements where models with over 1000 junctions are not infrequent;
- (ii) as a “conventional” traffic assignment model for the analysis of much larger networks (e.g., up to 6000 links in the standard PC version, 37500 in the largest)
- (iii) as a simulation model of individual junctions;
- (iv) as a network editor, data base and analysis system;
- (v) as a matrix manipulation package for the production of, e.g., trip matrices.
- (vi) as a trip matrix demand model covering the basic elements of trip distribution, modal split etc.

As a combined simulation and assignment model - its original function - **SATURN** is most suitable for the analysis of relatively minor network changes such as the introduction of one-way streets, changes to junction controls, bus-only streets, etc. (which can be loosely categorised as “traffic management measures”) and whose evaluation requires a detailed analysis of traffic behaviour at junctions.

However from its starting point as a combined simulation and assignment model, **SATURN** has been extended in both directions so that it can function both as a conventional traffic assignment model and as a pure junction simulation model. As a “conventional” traffic assignment model (with or without simulation) **SATURN** can deal with large conurbation, regional or even national models.

These may then interface with smaller localised models using the greater precision of the junction simulation models or indeed using the **DRACULA** micro-simulation with routes generated by **SATURN**.

With both simulation and conventional network representations **SATURN** provides a wide range of assignment options such as generalised cost, all-or-nothing, Wardrop equilibrium, Burrell multiple-route assignment (SUE) and, more recently, demand-responsive (elastic) assignment to deal with induced traffic. All these are founded on theoretically consistent modelling frameworks and convergent algorithms reflecting the academic background of **SATURN**'s development.

The previous version of **SATURN**, 10.9, also includes options to carry out Origin-based Assignment (OBA) as developed by Dr. Hillel BarGera while a PhD student



at the University of Illinois at Chicago in the late 1990's. His work revolutionised traffic assignment in that his methods solve for Wardrop Equilibrium solutions to an accuracy limited only by the numerical accuracy of the computer and within comparable CPU times to existing algorithms such as Frank-Wolfe. See Section 21. More recently, Dr Yanling Xiang of Atkins extended the theoretical framework for use in Multiple User Class assignments.

SATURN 10.9 also includes further features facilities to undertake “warm starts” to speed up one run of **SATURN** using data extracted – in several different ways – from previous runs. See Section 22.

At the other extreme **SATURN** allows for the interactive simulation and editing of individual junctions, so that the user is able to vary parameters such as flows, saturation flows, signal settings, etc and to analyse one node in isolation.

SATURN, through module **P1X**, also possesses powerful graphical display capabilities for network, junction and matrix-based data. Junction details including link and turn data may be shown at both individual junction and network wide levels. The wide range of options available also allows for on-screen cordoning, select link reassignments, GIS-style background displays, animated queues, data editing and tree building.

The interactive and graphical facilities of **PIX** may also be used to “edit” existing networks on screen and/or to build networks from scratch on the screen. The latter function may use an existing bitmap file (e.g. a normal road map which has been scanned) as the background and to “trace” the **SATURN** network on top of it.

In a related fashion **SATURN** may be applied to the analysis of network-based data which need not be in any way related to traffic assignment problems. For example, data relating to accident rates per link, or the last dates of road resurfacings stored, etc may be input and analysed.

Through its general matrix manipulation program **MX SATURN** offers a full range of interactive matrix operations as required by standard transport planning applications, e.g. matrix building, editing, factoring, furnessing, transposing etc. It also provides easy transfer between **SATURN** and other transport and spreadsheet packages.

While originally conceived as a purely traffic assignment package with a fixed user-defined trip matrix **SATURN** now also provides a number of standard modelling steps for matrix estimation, e.g. modal split and distribution. These models have been integrated with the assignment in a self-consistent mode to provide a mathematically convergent form of “Variable Demand Modelling”.

A further long-standing example of matrix estimation within **SATURN** is the ME2 Model (Matrix Estimation from Maximum Entropy) developed at Leeds and University College London by Dr. L.G. Willumsen, enabling O-D trip matrices to be estimated directly from traffic counts, thus reducing significantly the survey costs required to run an assignment model such as **SATURN** as well as increasing its accuracy. In effect ME2 generates the ‘most likely’ trip matrix which is consistent with all available traffic information, including where possible any prior estimates of the trip matrix.

Other important features of **SATURN** include:

- ◆ fully interactive analysis of results, including on-line help files
- ◆ optimum green splits for traffic signals
- ◆ traffic signal co-ordination modelled
- ◆ lane structure of intersections and choice of lane modelled
- ◆ the growth and decay of queues modelled quasi - dynamically
- ◆ facilities to “skim”, e.g., inter-zonal time, distance, etc. matrices
- ◆ bus routes, bus-only roads and bus-only lanes included explicitly
- ◆ both left-hand and right-hand drive accepted
- ◆ special features of Australian and New Zealand rules of the road have been incorporated
- ◆ selected link analysis
- ◆ multiple User Class Assignment differentiating between, e.g., cars, taxis, HGV's, etc.
- ◆ full analysis of O-D routes generated by the assignment
- ◆ network and trip matrix cordoning for sub-areas.
- ◆ a **SATURN** to Tuba interface module (**SATTUBA**) to assist in the economic evaluation of schemes within the UK.
- ◆ modelling tolls or road charges on specified links; and
- ◆ facilities to both “dump” **SATURN** data into ASCII files for input into, e.g., spreadsheets or other suites of transport programs and equally to re-input data files from these external procedures

1.2 Hardware / Software Requirements

SATURN has historically been run on a wide range of platforms including mainframe computers, workstations and micros as well as 16-bit Windows Operating Systems. However, by far the majority of users run 32-bit versions of **SATURN** under the various Windows operating system released over the last 10 or so years (i.e. Windows 2000/XP/Vista and the latest Windows 7) and **all** non-Windows-based are now discontinued.

SATURN does not require a particularly high-spec pc to run (although clearly for large networks number-crunching speed becomes an issue and large-memory high-speed machines are recommended). A typical lower-range specification for a system to run **SATURN** 10.9 would include:

- ◆ Pentium4 processor (2.6GHz or faster)
- ◆ 512 Mbytes RAM

- ◆ 6 Gbytes (or greater) hard disk

A typical higher-end machine would include:

- ◆ multi-core processor (1.6GHz or faster) either on Intel-based Core2Duo/Quad, Core i3/i5/i7, Intel Xeon workstations or AMD-based processors;
- ◆ up to 4Gb RAM; and
- ◆ 7200rpm SATA disk drives or Solid State Disks (SSD).

Experience has shown that **SATURN** is not particularly demanding on disk drives, memory or graphics capabilities. The assignment process is the most intensive and if users are considering purchasing a dedicated **SATURN** machine, it is recommended that they focus on the performance of the processor.

SATURN can also take full advantage of multi-threaded processors (e.g. Intel Core2Duo or QuadCore chips) through the additional purchase of the multi-core version of **SATURN** (**SATURN-MC**) to take advantage of the additional computation power available. **SATURN-MC** was released as part of SATURN v10.8.22 in June 2009. See Section 15.52.

For PC versions executable code is supplied complete with a full set of complementary batch files for all modules plus the **SATWIN** front-end which provides a standardised Windows interface.

1.2.1 64-bit Operating Systems

The SATURN executables are developed as 32-bit Windows applications. Until the release of Windows 7, the overwhelming majority of users ran the software under a 32-bit Operating System (OS) with the 64-bit OS limited to specialist, 'power' users. With the introduction of Windows 7, both 32-bit and 64-bit versions are available under the same licence and the use of 64-bit OS is becoming more commonplace.

The existing SATURN (32-bit) executables will happily run under both versions of the OS and they will produce the same results. The principle advantage for SATURN when running within a 64-bit OS is the ability for the individual programs to access (or 'address') more memory. The practical limit for 32-bit SATURN is around 1.5Gb of RAM and this may be exceeded for very large OBA-based models.

There is no 64-bit version of SATURN available due to limitations of the Salford Fortran language (which the majority of the SATURN source code was written). These limitations include the absence of options to compile SATURN code for 64-bit OS and multi-threaded environments. Some of these limitations were overcome by the development of the SATURN Multi-core routines using an alternative Intel Visual Fortran (IVF) compiler linked into the existing Salford code. We will continue to explore the migration of the computational intensive elements of the SATURN suite into 64-bit IVF over the coming months.



1.3 Documentation

Documentation for SATURN is available at a number of levels

- ◆ **SATURN** User Manual (this document)
- ◆ an On-line Help System
- ◆ reprints of Journal and Conference Articles

The needs of most users will be provided by the User Manual alone which is available in both word processed printed copy available through Atkins Transport Planning and included on the **SATURN** Installation CD as standard Adobe PDF documents. They may also be downloaded from the **SATURN website**:

- ◆ <http://www.saturnsoftware.co.uk>; or
- ◆ see Appendix C for a list of various relevant publications and background technical files.

1.4 Distribution of SATURN

SATURN is distributed exclusively by Atkins Limited as agents for Dirck Van Vliet and Leeds University / Institute for Transport Studies and is available with full technical support.

Charges for **SATURN** are divided into three main categories:

- a) PROGRAM FEE - for the supply of the **SATURN** suite (normally as executable code for Windows 2000/XP/Vista/Win7 PCs);
- b) PURCHASE PRICE - for unlimited site use of the model (but without any rights to re-sell).
- c) MAINTENANCE - for the supply of any updates to the Suite at an annual charge.

Charge a) is paid by all customers; educational institutions who wish to use **SATURN** purely for teaching and/or research pay only a). Planning agencies, consultants, etc. must pay b) while c) is optional.

In addition full support services are available from Atkins for staff training, advice on installation and applications, etc. Prices for the above services vary depending on the type and location of the purchasing organisation. For details, please contact:

Ian Wright
SATURN Product Director
Atkins Limited,
Sir Williams Atkins House
Woodcote Grove,
Ashley Road
Epsom KT18 5BW

or call: Ian Wright, Epsom +44 (0) 1372-756272 or, alternatively, via e-mail at saturnsoftware@atkinsglobal.com.



1.5 Contents of the Suite

As supplied to pc users on a set of disks the **SATURN** Suite consists of the following types of computer files:

- ◆ FORTRAN program executables (.exe files);
- ◆ the SATWIN Windows-based interactive front-end
- ◆ various documentation files (including PDF version of this document);
- ◆ sample data files for checking purposes;
- ◆ .bat files plus associated .key files for the software operation; and
- ◆ help files.



1.6 Version Control

JOB NUMBER: 5101396		DOCUMENT REF: Section 1.doc				
Revision	Purpose / Description					
		Originated	Checked	Reviewed	Authorised	Date
1	Re-formatted (Final to DVV)	TF / BG	NS	IW	IW	06/05/06
3	Upgrade to V2 Template	IW				22/06/06
3.2	Web Release – Sept 06	DVV	NP	IW	IW	08/09/06
3.3	Web Release – Jan 07	DVV	NP	IW	IW	04/01/07
3.4	SATURN v10.7 Release	DVV	NP	IW	IW	12/03/07
3.5	Web Release – Jul 07	DVV	NP	IW	IW	19/07/07
3.6	SATURN v10.8 Release	DVV	NP	IW	IW	25/03/08
3.7	Web Release – Jul 08	DVV	NP	IW	IW	07/07/08
3.8	Web release – Dec 08	DVV	NP	IW	IW	12/12/08
3.8.21	Web release – Feb 09	DVV	NP	IW	IW	16/02/09
3.8.22	Web release – Feb 09	DVV	NP	IW	IW	16/06/09
10.9.10	SATURN v10.9 Release	DVV	DG	IW	IW	04/09/09
10.9.12	SATURN v10.9 Release (Full)	DVV	DG	IW	IW	22/10/09
10.9.22	Web release – Dec 10	DVV	AG	IW	IW	06/12/10
10.9.24	SATURN v10.9 Release (Full)	DVV	AG	IW	IW	06/05/11
11.1.09	SATURN v11.1 Release (Full)	DVV	AG	IW	IW	31/03/12