

Caltrans
Traffic Operations

S2P Version 3.0d

User's Manual

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Glossary

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| Caltrans | California Department of Transportation |
| DOT | Department of Transportation |
| ECE | Electrical and Computer Engineering |
| GIS | Geographic Information System |
| ITS | Intelligent Transportation Systems |
| NCGIA | National Center for Geographic Information and Analysis, UCSB |
| RS | Remote Sensing |
| UCB | University of California, Berkeley |
| UCSB | University of California, Santa Barbara |
| VITAL | Vehicle Intelligence and Transportation Analysis Laboratory, UCSB |

Introduction

Traffic microsimulation is a powerful tool that allows planners to simulate the effects of changing travel demand and congestion, new routes, legal permissions and traffic control strategies. Paramics® by Quadstone Ltd is one of the leading microsimulation packages available today. This software is extensively used in the California Department of Transportation and other agencies to study traffic control issues on freeways and to test planning scenarios. At the University of California, Santa Barbara (UCSB), Paramics has been used to simulate emergency evacuation of residential neighborhoods.

One of the preparatory steps in microsimulation is the creation of a detailed graphic description of the street network, showing each traffic lane, signals and other traffic control devices, and traffic origin zones. This is an extremely laborious process, partly because of the large scale at which this description must occur. Roads are described graphically, using straight line and curve sections, ensuring that sections of the road have smooth transitions between them. Slight variations in alignment slow vehicles down, and affect traffic throughput. It is fair to say that data entry is a significant impediment to the widespread use of microsimulation.

Much of the descriptive information required for microsimulation currently exists in GIS files in the custody of state and local Departments of Transportation, private sector data vendors and other authorities. Unfortunately there is a significant difference between the geometric models used by Paramics and GIS. Once this barrier is overcome using an appropriate tool, it should be possible to convert large volumes of GIS data into Paramics compatible files.

With funding from other California Department of Transportation, Traffic Operations Division, the University of California, Santa Barbara undertook to create such a conversion tool. For this initial development, emphasis was placed on algorithmic issues, while usability issues, though addressed, were not necessarily perfected in this first attempt.

Version 3.0 of "Shapefile to Paramics" (S2P) creates files for Paramics version 4. Because Caltrans uses street network data from Geographic Data Technologies (GDT), the software is packaged with default settings specific to GDT data, but it is customizable to work with other vendors' products.

As Paramics development continues there will undoubtedly be a need for further refinement of the conversion tool. The web sites www.ncgia.ucsb.edu/ncrst/research/microsimulation and www.ncgia.ucsb.edu/vital host up-to-date information on this project.

Basic Principles

In a GIS, a section of road from one intersection to the next (i.e. a “link” in typical network parlance) is typically stored as a connected series of coordinate points, i.e. a polyline. The density of points depends on the sharpness of curves and the scale of representation. Links may be split where attributes change, e.g. where a 4-lane road narrows into 2 lanes.

Paramics takes a different approach to representation, each network link being either a single straight segment or a single circular arc. It is possible to represent a network in Paramics with the same number of links as in a GIS, but this ignores link shape and sacrifices positional fidelity. Alternately, it is possible to treat each segment of each polyline as a straight-line link in Paramics, but since a link could include several hundred polyline coordinates, this can create exceedingly large node and link files, with downstream implications for computing performance. The translation problem is therefore to convert polylines into combinations of straight lines and circular arcs, satisfying the competing alternatives of minimizing the number of links while preserving geometric fidelity.

This is an interesting theoretical problem, and there are several possible approaches to a solution. S2P version 3.0 implements three methods of data reduction. The first applies the well known Douglas-Poiker generalization algorithm, the second is a simple 3-point arc fit, the third is a biarc algorithm. Information on these algorithms is contained in the project report, available at the project web site.

Files

There are three program files, which must reside together in the same folder:

- Executable program — Shape2Paramics.exe
- Dynamic link library — ShapeDLL.dll
- Initialization file — S2P.ini

The program requests an input Shape file (ESRI’s® ArcView® format), which consists of 3 files with extensions .SHP, .SHX and .DBF.

The program outputs 6 Paramics files: *nodes*, *links*, *centres*, *categories*, *linktypes* and *vehicles*. To classify each road in its appropriate category based on the GIS data, the DBF and Shape file must contain relevant attribute information (see Basic Information below).

Operational Settings

There are three aspects of interaction between the user and the software:

- Basic information on the input Shape files: coordinate units and field names
- View control such as zoom and pan
- Generalization parameters for the curve reduction algorithms

1 — Basic Information

Coordinate units

Shape files come in a variety of coordinate units, and the usual shape file set (SHP, SHX, DBF) does not specify the coordinate unit. This information must therefore be provided to the software. A small selection of

typical units is offered, e.g. meters, feet kilometers, miles, and S2P converts these to its internal working units, meters. The software detects latitude-longitude files from the coordinate domain, and offers an option to convert these to UTM coordinates in meters.

Field names

Some of the attribute information that Paramics requires is contained in the DBF fields of the Shape file. the Paramics categories file requires information on width, speed limit, number of lanes and road type: urban, rural or highway. Since these values could be coded into any field in the DBF file, S2P must be told where to find them, and what values to use as defaults if the data are not available. This information is contained in the initialization (INI) file, S2P.INI.

Field names are listed below with a brief explanation. These statements are customized for GDT input files. If another vendor's files are used, some of these statements would have to be modified.

- FIELD.SPEEDLIMIT=Speed,50. The speed limit variable is represented by the DBF field Speed, and the default value for speed limit is 50 km/h.
- FIELD.FREEWAY=FCC,A15,A25. Values of A15 and A25 in the FCC (feature class code) field indicate a freeway. Roads joining these are treated as ramps.
- FIELD.RAMP=FCC,A63. A ramp is indicated by a FCC value of A63. S2P needs to know if a road is a highway or a ramp, to code merge and exit ramps.
- FIELD.ROADTYPE=null,Urban. The road type field is used in the categories file. "Null" indicates that road type is not in the data file. "Urban" is the default.
- FIELD.LANES=Lane,2 GDT codes the number of lanes as the field "Lane." If this named field cannot be found in the DBF file, or if the value is zero, the default of 2 is to be used
- FIELD.ONEWAY=ONE WAY,FT,TF. The oneway field indicates whether the road is one-way. The value FT indicates traffic flow only in the direction in which the link is digitized, while a value of TF indicates flow only in the opposite direction.
- FIELD.ELEVATION=F_ZLEV,T_ZLEV. The elevation field is used at non-grade intersections. In many GIS files, intersection nodes exist even at non-grade intersections. In GDT, each shape has an elevation at the from- and to-end, with field names F_ZLEV and T_ZLEV respectively. Elevations are ordinal, not absolute. The lowest ramp is assigned an elevation of 1, and upper ramps are assigned values of 2, 3, 4, etc. To distinguish between at-grade and non-grade intersections, S2P examines elevations at the extremities of each incident shape.

The INI file also contains information on preferred display colors, and default parameters used by the software.

- PARAM.ELEVATIONMULT=6. In databases such as GDT, node elevations are ordinal. S2P multiplies ELEVATIONMULT by this ordinal elevation to produce absolute elevation in meters, which is entered as the z-coordinate of the appropriate node. Note that this can create fictitious elevations, because non-zero elevations are assigned only at non-grade intersections.
- PARAM.RAMPCATEGORY=highway minor. This is the parameter used to represent ramps in the output categories file
- PARAM.LANEWIDTH=4. This is the width of each lane in meters. S2P uses this value to shift some entrance ramps off the centerline node to provide for an acceleration lane.

GIS files sometimes contain attribute errors, and the output of S2P is only as good as the quality of the input data.

State and local DOTs often store road information in linearly referenced files. It requires extremely accurate centerline coordinate data to translate literally referenced data into link attributes as in the shape file structure. S2P is not equipped to do this.

Memory Allocation

The *centres* file contains a parameter that tells Paramics how much memory to allocate for its operations. This number is typically proportional to the number of nodes in the *nodes* file. S2P prompts for a value to be multiplied by the number of nodes, to create this memory allocation request. If there are problems importing the files into Paramics, it may be appropriate to increase this number.

2 — View Control

S2P provides basic zoom, pan and positioning functionality. Toolbar buttons control zoom in and out, and pan in four directions. The 1:1 button restores the original display scale. The Reposition button (hand) centers the display at the geographic location where the mouse is next clicked. Zoom and pan can also be controlled with +/- and directional arrows on the numeric keypad.

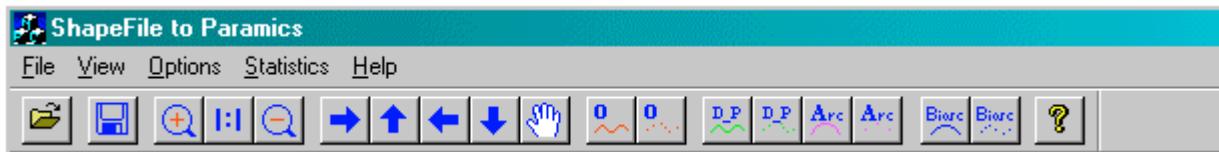


Figure 1. S2P menu showing map view tool bar

The eight buttons to the right toggle layers in the display, the first and second button in each pair controlling links and nodes respectively. The O buttons If the original GIS file polylines and nodes (in red). The D_P buttons display generalized links and nodes (default: green), while the Arc buttons display circular arcs and nodes (default: red), and the Biarc buttons display Model 2 results (blue). Only those buttons relevant to the currently active model are enabled.

3 — Generalization Models

The broad purpose of generalization is to reduce the amount of data in the Paramics output files. Two models of generalization are available.

Model 1 — Douglas Poiker and Circular Arcs

Model 1 is based on the Douglas-Poiker algorithm and a simple circle fit. It is controlled by two tolerance parameters. **Douglas-Poiker tolerance** is the maximum distance that a straight line link in the Paramics output file may stray from the original GIS polyline position. **Circular tolerance** is the corresponding maximum for a circular-arc link in the output file.

With a low Douglas-Poiker tolerance, output links follow the polyline segments closely, and with a tolerance of 0, they are coincident. This results in large files with good positional fidelity. Conversely, high tolerance results in small files with longer links, that are positionally inaccurate and visually less appealing. Moreover, line segments tend to meet at sharp angles, and this can affect simulation results because vehicles must slow down at these corners.

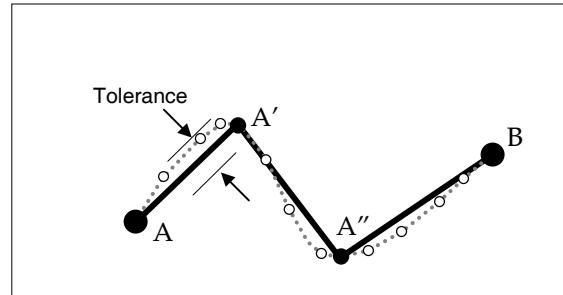


Figure 2. Original (stippled) and generalized (heavy) polyline in which a subset of the original shape points are selected

Circular arc generalization operates in conjunction with Douglas-Poiker generalization, in that the software first attempts reduction of the shape to a single circular arc (subject to tolerance), failing which it applies the

Douglas-Poiker method (subject to tolerance) creating multiple links. It is important to monitor results on the screen because it is possible to obtain undesirable results with some combinations of tolerance.

Generalization operates on each original link at a time. Sometimes when links are broken at points other than intersections (e.g. due to change in attribute), generalization may result in sudden changes in

orientation; no attempt has been made to correct this in the current version. The biarc method (below) explicitly enforces tangent continuity at such transition points within shapes.

Model 2 — Biarcs

The second model computes a sequence of continuous curves (biarcs) to approximate the path of the polyline. This is superior from an esthetic point of view, and because the model enforces continuity of tangents between curves, it should be expected that traffic flows more smoothly compared with Model 1. In practice this may not be true because vehicles are made to negotiate curves rather than straight lines.

The controlling parameter for Model 2 is a lateral **biarc tolerance** stated in meters. Whereas Model 1 in the worst case (i.e. tolerance=0) creates a link for every polyline segment, its nodes are always a subset of the original shape points, therefore it does not exceed the level of detail in the shape file. At low tolerances, Model 2 can create extremely short links and winding paths. Model 2 is also liable to create nodes off the path of the original shape. Sometimes this is desirable; at other times it is not.

Limitations

The output of S2P is only as good as the quality of the input data. There are numerous aspects of inaccuracy in street network data, including position, connectivity, and attributes (lanes, speed limits). These are all carried into the Paramics files.

To some degree, S2P can compensate for quality inconsistencies in coordinate data, using the generalization models described above. Road centerlines described with a low density of coordinates can be enhanced using Model 2 or circular arcs, while roads described in too much detail can be generalized using the Douglas Poiker algorithm. However, all the generalization methods operate on one shape at a time. This means that if roads are fragmented into several shapes, the software does not join them into longer sections. Similarly if the GIS file does not contain nodes at intersections, the software will not insert them.

The following limitations of the conversion process should be noted:

- Freeway overpasses are sometimes represented as at-grade intersections in GIS files. Typically an associated DBF table then specifies the legal turn permissions at such an intersection, and it is only by consulting these tables that one can distinguish between an overpass and a regular 4-way intersection. In the case of GDT, this determination is made most easily by examining the elevation values at the start and end of the shapes, therefore this is the method employed by S2P.
- Divided roads pose special problems. They are variously interpreted as a single 2-way road or multiple one-way roads. The latter treatment is more flexible, because it can handle HOV lanes and other special purpose configurations.
- Some vendors code even divided city streets as individual shapes for each traffic direction, and turn/U-turn opportunities then have to be represented as links connecting the carriageways. GDT goes so far as to divide these connecting links into 2 shapes. Some of these shapes are no more than a couple of meters long. This poses a problem for Paramics, because very short links are not easily converted into polygonal road tracks that Paramics models.
- Ramps that merge with freeways are given special treatment in Paramics, specifying the length of the acceleration lane and move out distance for vehicles already in the freeway. S2P detects such ramp connections and codes them appropriately, but to do this it must be given the feature code associated with freeways in the shape file. A peculiarity of Paramics is that it allows only right-hand acceleration lanes in a right-hand drive system such as in North America. Ramps that join from the left are therefore coded as regular intersections.

If a road configuration seems entirely intractable, it may be resolvable by editing the shape file in a GIS, or by editing the output in Paramics.

Tutorial: Generalization

The purpose of this section is primarily to illustrate the effect of the generalization algorithms and parameters. Screen captures below are taken from an early test version of S2P where the model choice dialog box is less obtrusive, prompting for only the Douglas Poiker and circular tolerance parameters.

Sample data files used in this tutorial (as well as updated code, documentation and INI files) can be downloaded from the project web page: www.ncgia.ucsb.edu/nrst/research/microsimulation

- Launch S2P. The initial demonstration will not be with a GDT file, therefore an alternate INI must be loaded: **File | Load alternate INI**. Load itms.ini from the installation folder.
- Import a GIS file: **File | Open**. Select the Los Angeles demonstration file, itms_la. Using the **Options | Control Parameters** menu item, apply Model 1 with a Douglas Poiker generalization tolerance of 200 m, and circular arc tolerance of 0. Circular arcs are not generated at zero tolerance. Generalization will take several seconds.
- Select the Reposition (hand icon) function from the toolbar. Click on State Route 2 near I-210 in the San Gabriel area (see Figure 2). Lean on the + key for a second to zoom in. Both original (red) and generalized (green) shapes are visible under sufficient magnification. Use a variety of different Douglas-Poiker and circular tolerances to observe the effect of the generalization routines on the green and blue generalized shapes (Figures 3, 4). When selecting these parameters in practice, the view should be set to high magnification to check for undesirable results with circular arcs and biarcs. Click the Douglas-Poiker nodes button (the second D_P button in the view toolbar) to display the selected nodes explicitly.

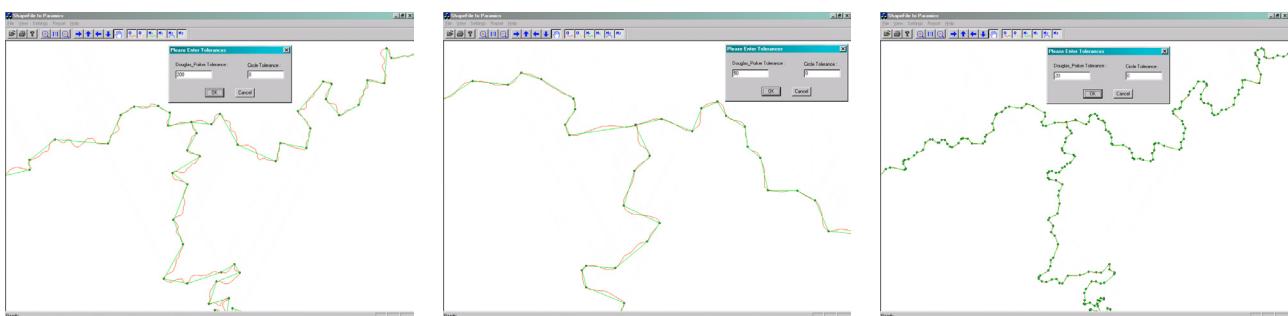


Figure 3. State Route 2 in the San Gabriel area, showing different levels of Douglas-Poiker generalization

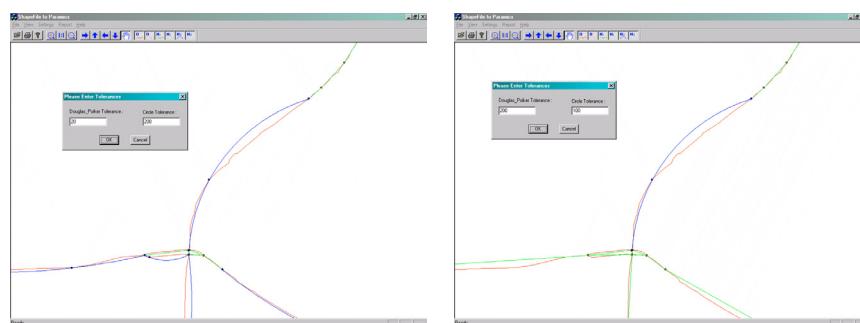


Figure 4. I-10 at 110: undesirable eastbound arcs (left) caused by inappropriate parameters

- Examine the data reduction statistics (**Statistics | Data Reduction Statistics**)
- For information, examine the names of the fields in the DBF file (**Statistics | Database Field Names**).
- Experiment with Model 2, raising and lowering the tolerance, and observing the effect on the output. Turn on the Biarc nodes in the toolbar to observe where new nodes have been inserted.
- Save the Paramics files (**File | Save As Paramics Files**). Standard Paramics files (*nodes, links, categories, centers, linktypes, vehicles*) are placed within the selected folder.
- Exit the program. Import the files into Paramics.

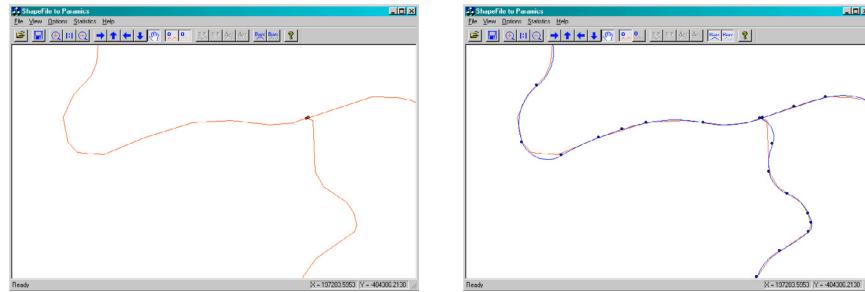


Figure 5. Model 2 (biarc) is capable of producing considerable detail. These are before and after screen shots with a generous tolerance of 30 m

If you find you are consistently using tolerance parameters other than the defaults, you can modify the default values by editing S2P.INI.

For additions and updates to this document, please see the S2P web page at www.ncgia.ucsb.edu/ncrst/research/microsimulation or www.ncgia.ucsb.edu/vital