

# Computer Models For Fire and Smoke

<i>Model Name:</i>	Legion Studio
<i>Version:</i>	2006 Enhancement Pack 3
<i>Date:</i>	3 August 2007
<i>Classification:</i>	Multi-agent pedestrian simulation model
<i>Very Short Description:</i>	Legion Studio is a patented multi-agent, vector-space pedestrian simulator used worldwide to model normal operation and evacuation scenarios at transport terminals, stadia, special events, airports, tall buildings and town centres. Studio is based on extensive empirical data collected around the world. It interoperates with CAD software (dxf, dgn, dwg); NIST's Fire Dynamics Simulator (FDS); and the traffic simulator Aimsun by TSS. Current users include Transport for London, Madrid Metro, Santiago Metro and MTR Hong Kong; AECOM, ARUP and Parsons Brinckerhoff; and the last four Olympic Game Organising Committees.
<i>Modeler(s), Organization(s):</i>	Legion International Limited, 20 Commercial Arcade, St. Peter Port, Guernsey, Channel Islands, GY1 1JX
<i>User's Guide:</i>	Legion Studio 2006 User Manual
<i>Technical References:</i>	"Method and apparatus of simulating movement of an autonomous entity through an environment", United States Patent No. US 7,188,056
<i>Validation References:</i>	Berrou, J.L., Beecham, J., Quaglia, P., Kagarlis, M.A., and Gerodimos, A. "Calibration and validation of the Legion simulation model using empirical data", Proceedings of the third International Conference on Pedestrian Evacuation Dynamics (PED) 2005, Vienna, 2007.

<i>Availability:</i>	Legion Limited, 22-26 Albert Embankment, Vauxhall, London, SE1 7TJ
<i>Price:</i>	Depends on license duration (annual, perpetual) and type (commercial, academic)
<i>Necessary Hardware:</i>	AMD or Intel-based PC (desktop or laptop), Pentium 4 class CPU with clock speed above 2.4 GHz or equivalent, 1 GB of RAM, resolution of 1024 x 768 or higher, Windows 2000 or Windows XP Professional.
<i>Computer Language:</i>	Visual C++
<i>Size:</i>	Model files: 1MB - 10MB, Results files: 1MB-several GB, depending on model complexity.
<i>Contact Information:</i>	info@legion.com

*Detailed Description:*

Legion Studio simulates and analyses movement within pedestrian environments. It has been designed to reproduce the complex dynamics of multi-directional movement and to deal with activities commonly encountered in real-life venues. Simulations are based on intelligent Entities; i.e. autonomous individuals that continuously interact with each other and with their physical environment. Entity preferences are based on empirical measurements that Legion obtains by filming real pedestrians around the world.

The software has an impressive track record of projects world-wide and outputs have been validated against real-life measurements by customers and independent third parties. Its array of highly visual outputs supports a broad range of applications including business case development, design optimisation, operational management and safety assessment.

**Legion Simulator**

The Legion simulator:

- is a microscopic model; i.e. it is based on intelligent Entities
- models space as a continuum and allows for the introduction of semantic information through Spatial Objects
- uses navigation algorithms based on the least-effort principle and the notion of *dissatisfaction*
- contains entity profiles derived from empirical data collected around the world
- backed by extensive qualitative and quantitative validation carried out by Legion and third parties

## **Navigation and the least effort principle**

Legion Studio uses the concept of 'least effort' as the cornerstone of pedestrian logic. Entities attempt to minimise their personal dissatisfaction when choosing their next step.

Dissatisfaction is caused by physical and psychological factors that degrade the quality of their journey. The following three factors contribute to an Entity's dissatisfaction:

- Inconvenience—the physical effort needed to travel distances
- Discomfort—the perceived lack of adequate personal space
- Frustration—having to slow down in congested spaces

Navigation in Legion is a three-stage process:

- choice of destination
- macro-navigation
- micro-navigation

Choice of destination refers to the process of translating an objective (“to leave the venue”, “to buy a ticket”) into a physical destination (“exit”, “ticket machine”). Entities are then capable of making a choice of the most efficient alternative, in keeping with the least effort principle.

Macro-navigation refers to the identification of the shortest route from their current position to their next destination. This shortest route takes into account the geometry of the site. It is the path of “least effort” and as such serves as a general ‘compass’.

In practice, the path a Legion Entity takes usually results in an individual trajectory that reflects their specific circumstances, preferences, congestion and the obstacles they encounter.

This individual trajectory is the result of congestion-avoidance and micro-navigation. The Legion micro-navigation algorithm takes several important considerations into account, including but not limited to the following:=-

- Accommodation of personal space, preferred speed and other personal requirements.
- Detection and avoidance of physical obstacles.
- Identification of neighbours as either 'friends' or 'foes' in order to synchronise with or avoid them.
- Manoeuvring to predict and avoid collisions with other pedestrians.
- Ability to adjust individual preferences and attributes according to the context.
- Ability to respond to local congestion and change its route
- Learning, adaptation, and the accumulation of memories to reduce future effort.

## **Entity Profiles**

Legion Entities are assigned social, physical, and behavioral characteristics probabilistically from empirically established profiles.

Social characteristics include gender, age, culture, and pedestrian type, all of which shape typical movement preferences. The physical characteristic addressed is body size. Behavioural characteristics include memory, willingness to adapt, and preferences for unimpeded walking speeds, personal space, and acceleration. The latter preferences also reflect the effects of different types of terrain and facilities, such as flat ground, escalators, stairs, etc.

## **Legion Studio Overview**

The application comprises three modules:

### Legion Model Builder

This application is used to create an accurate model of the space to be simulated. In the Model Builder a user can create a Legion Model (.LGM) file by:

- Importing (.DWG, .DXF, .DGN) files to define the physical space.
- Importing (.CSV) or creating data relating to pedestrian demand
- Designating areas where interim activities such as queuing or waiting occur.
- Linking operational data to the model.

### Legion Simulator

In the Simulator a user can:

- Import .LGM files.
- Play and view the simulation.
- Record appropriate parts of the simulation as a results (.RES) file
- Record the simulation as a video (.AVI) file for presentations.

### Legion Analyser

This application is used to run a series of analyses on the simulation results. In the Analyser a user can:

- Import .RES and .LGM files.
- Playback selected parts of the simulation.
- Track individual Entities and visualise their walking path over time
- Visualise key metrics in the form of default or custom maps.
- Run detailed analyses in any area and plot time series, stacked bars or histograms.
- Export results files, video, pictures or tables

### Outputs

Legion Studio computes the following metrics which can then be used to produce a broad range of numerical and graphical outputs including maps, charts and tables.

- Origin-Destination Matrix:
- Ingress, Egress and Occupancy counts
- [Normalised] Flow:
- Speed
- Entity and Space Density
- Journey Time
- Inconvenience, Frustration, Discomfort and Dissatisfaction