



LEGION[®] Modeling and Simulation

Simulate People Movement and Test Space Performance to Deliver Fit-for-Purpose Infrastructure

OVERVIEW

LEGION is Bentley's pedestrian modeling, simulation, and analysis solution. It enables users to preview how people will move in virtual spaces so that design and operating alternatives can be assessed and compared, supporting iterative, performance-based development. It ensures that new spaces are fit-for-purpose (with or without social distancing) and helps extend the useful life of existing ones, safeguarding and maximizing return on capital outlay.

LEGION's unique, in-house, and mathematical model has been validated against empirical measurements of real people. Independent acceptance tests by numerous third parties and a 20-year history of projects worldwide confirm its validity. Moreover, its output supports application to important commercial needs, including business case development, capacity enhancement, design optimization, operational improvement, risk mitigation, safety assurance, and policy support.

Common project scopes include metropolitan and mainline railway stations; Olympic parks, sports stadiums, and arenas; airports and maritime ports; bus and coach stations; EXPOs, tall buildings and shopping centers; and urban planning and accessibility work.

CONCEPTS

LEGION simulation represents state-of-the-art technology with:

- ◆ Unique, in-house, microscopic and mathematical model
- ◆ Continuous and varied space
- ◆ Least-effort principle

- ◆ Unbounded-choice movement
- ◆ Macro-navigation
- ◆ Intelligent entities
- ◆ Emergent behavior phenomena

MICROSCOPIC MODELING

- ◆ Represents pedestrians as learning-adaptive agents with individual preferences and objectives.
- ◆ Treats pedestrian movement as a multi-agent complex system.
- ◆ Collective movement patterns arise from the interactions of individual entities—acting on their needs, priorities, and interests—to optimize their experience while achieving their goals.

CONTINUOUS AND VARIED SPACE

- ◆ Works in a continuous, two-dimensional vector-space.
- ◆ Generates an unrestricted spatial environment in which accurate simulation of complex pedestrian movement dynamics can occur.

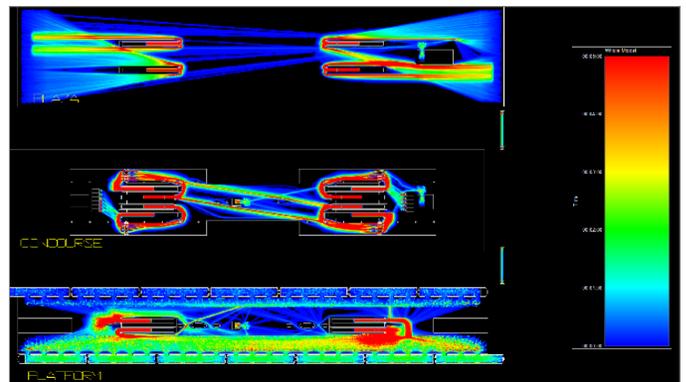
Examples include:

- ◆ Bidirectional flow
- ◆ Complex, multidirectional flow/crossing
- ◆ Overtaking
- ◆ Negotiating through crowds

The result is realistic crowd behavior that responds to spatial context and emerges from the activities of individuals, as a reflection of their preferences and local environment, over time.



Microscopic modeling of learning-adaptive agents.



Multilayer heat maps showing pedestrian simulation data.

SYSTEM REQUIREMENTS

MINIMUM: Intel Core i7 2.5 GHz, 16 GB RAM, 7,200 rpm HDD, 100 GB free space, 4GB graphics card, Microsoft Windows 10 or later, FHD screen

RECOMMENDED: Intel Core i9 3.5 GHz, 64 GB fast RAM, separate OS & data SSDs, 200 GB free, 8GB graphics card, Microsoft Windows 10 or later, QHD screen

LEGION At-A-Glance

LEGION MODEL BUILDER

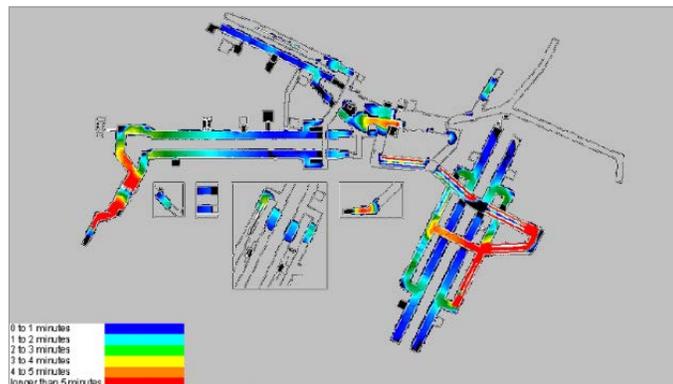
LEGION Model Builder lets users create accurate, two-dimensional models of areas or spaces to be simulated:

- ◆ Import architectural drawings (CAD) to define the physical space
- ◆ Specify the pedestrian demand to introduce to the space
- ◆ Designate areas where interim activities occur, such as queuing or waiting
- ◆ Link operational data to the model
- ◆ Plan routes and automatically lay out navigation maps
- ◆ Check for model errors with LEGION's automated QA
- ◆ Export model files for use in LEGION Simulator

LEGION SIMULATOR

LEGION Simulator simulates how pedestrians move through modeled areas and analyses to:

- ◆ Import model files
- ◆ Play back and view a simulation
- ◆ Record appropriate parts of a simulation as a results file for auditable analysis
- ◆ Record a simulation as a video file for presentations
- ◆ Track individual entities over time to identify their routes
- ◆ View key metrics as color-coded maps
- ◆ Run detailed analyses and display results as time series, stacked bars, or histograms
- ◆ Export analysis results to files, videos, pictures, or tables for inclusion in presentations, reports, and spreadsheets

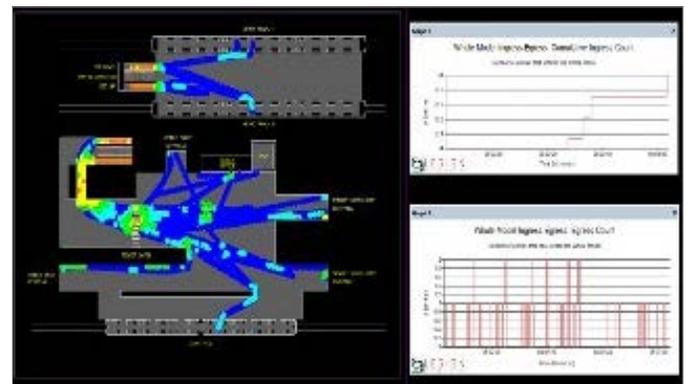


Analyze pedestrians in any space over any threshold.

OUTPUT AND ANALYSIS

A range of graphic and numeric output can be derived from a LEGION model, including animations, graphs, and color-coded maps. Analyses may use the following metrics for assessment of different venue characteristics:

- ◆ **Safety:**
 - » Minimum egress time
 - » Maximum local crowd density
 - » Percentage of people experiencing very high density
- ◆ **Efficiency:**
 - » Space use
 - » Flow rate
 - » Effectiveness of operational procedures
 - » Local density hot spots
 - » Congestion choke points
- ◆ **Capacity:**
 - » Maximum flow
 - » Occupancy level
- ◆ **Experience:**
 - » Journey time
 - » Density experienced
 - » Waiting time
 - » Queueing time
- ◆ **Social Distancing:**
 - » Configurable social distancing levels
 - » Proximity metrics
 - » Breach durations



Simulate passenger behavior to explore the performance of spaces and create better designs.