Bentley
*Advancing* Infrastructure

CONNECT Edition


Image Courtesy of Dubai Roads and Transport Authority

# LEGION® Simulator

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

LEGION Simulator is Bentley's pedestrian simulation and analysis application. It enables engineers to simulate people movement in virtual spaces, so design alternatives can be explored and compared efficiently. Data-rich results output also permits in-depth analysis in support of iterative design. The simulation engine has been validated against measurements of real people and has passed acceptance tests of users and independent third parties. Its highly communicable analysis output supports a broad range of infrastructure assets that include rail and metro stations, stadiums, shopping malls, and airports. LEGION Simulator allows you to accurately test designs and operational or commercial plans to enhance footfall, wayfinding, crowd management, and safety and security strategies.

### The CONNECT Edition

The SELECT® CONNECT Edition includes SELECT CONNECT *services*, new Azure-based services that provide comprehensive ***learning***, ***mobility***, and ***collaboration*** benefits to every Bentley application subscriber. *Adaptive Learning Services* helps users master use of Bentley applications through CONNECT Advisor, a new in-application service that provides contextual and personalized learning. *Personal Mobility Services* provides unlimited access to Bentley apps, ensuring users have access to the right project information when and where they need it. *ProjectWise® Connection Services* allow users to securely share application and project information, to manage and resolve issues, and to create, send, and receive transmittals, submittals, and RFIs.

### Collaborate Efficiently, with a Single, Multidiscipline Application

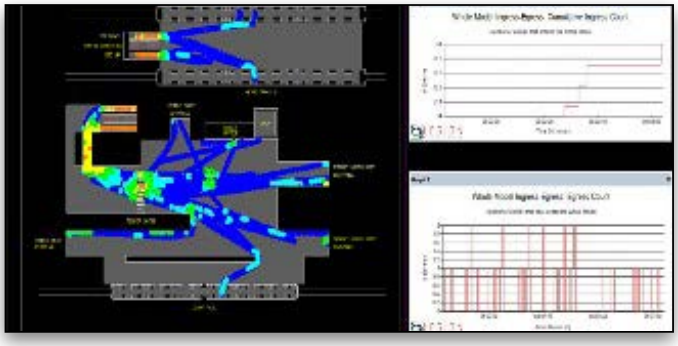
LEGION Simulator allows you to collaborate efficiently in a design environment and work within a shared set of libraries and workflows. And, Bentley's federated data approach lets you work on models simultaneously, even across geographically distributed teams.

### Share Information Regardless of Authoring Application

With LEGION Simulator, you can incorporate existing data from an extensive range of open applications and geospatial formats, reducing your time spent on translations and re-work. You can view and share live design information across multiple formats in real time with project participants, regardless of location, facilitated by flexible file referencing. Using Bentley's iModels, containers for the open exchange of infrastructure information, project team members can share information and interact with complex project data regardless of the authoring application. You can also employ reality modeling of virtually any scale natively within the modeling environment as context for designs.

### Model Freely in an Unrestrictive Environment

With Bentley's OpenBuildings™ Station Designer, LEGION Simulator supports highly complex building geometry and designs of virtually any scale. You can quickly and easily create, visualize, test, and interact with variations of the model, and explore a broad range of "what if" scenarios. Model with total freedom, regardless of geometry or project scale, to create virtually any form, size, or complexity.



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

### Visualize More Clearly and Make Informed Decisions with LEGION Simulator Predictions

LEGION Simulator combines the planning information provided by the LEGION Model input file with its own predictions of how people will move in space to produce intuitive visualizations of venues in operation before they are built. Go further and explore possibilities and make informed decisions and trade-offs by modeling and simulating a range of scenarios.

### Communicate Design Intent with Information-rich Deliverables

OpenBuildings Station Designer and LEGION Simulator produce the highest quality of deliverables with precision 2D and 3D visualizations. Robust design and production standards management deliver reliable documentation in less time.

You can consistently communicate design intent and create 2D and 3D model visualizations. Reviewing and sharing markups of models and documentation is made easy by a unifying production environment that reflects the same up-to-date design. Through hypermodeling, all manner of interrelated design information for interaction is presented within the spatial context of the 3D model, including solids, surfaces, meshes, drawings, specifications, images, videos, documents, business data, reports, and web content.

*"For over a decade Steer has successfully been delivering a wide range of pedestrian modeling studies around the world utilizing LEGION Simulator. We are now looking forward to using the full BIM capabilities of OpenBuildings Station Designer."*

*– Mike Nicholson, Associate,*

**Find out about Bentley at: www.bentley.com**

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# LEGION Simulator At-A-Glance

## Principle of Least Effort

- Uses the concept of least effort, or cost minimization, as the cornerstone of pedestrian logic
- Dissatisfaction is caused by physical and psychological factors that degrade journey quality. The following three factors contribute to entity dissatisfaction:
  - » Inconvenience - desire line divergence stress
  - » Discomfort - personal space compression stress
  - » Frustration - preferred speed relinquishment stress

## Unbounded Movement Choice

- Model space is continuous, rather than structured, based on a pixel grid
- Select any vector when optimizing step choice to satisfy individual preferences and objectives in the context of changing physical constraints
- This approach follows a two-stage process:
  - » **Macro-navigation**
    - The selection of an entity's desired direction to its next target, from its current position
    - Represented by a sequence of intermediate, focal targets that trace the shortest path from an entity's location to the place where it leaves the model (or reaches its final target or destination)
  - » **Micro-navigation**
    - Uses advanced, proprietary, artificial intelligence algorithms to apply micro-navigation to its entities, within a simulation
    - Algorithms enable entities to exhibit realistic pedestrian movement
    - Entities have an area of perception that adjusts dynamically, based on instantaneous information and accumulated memories
    - Entities assess information to decide their best immediate step
    - Micro-navigation algorithm takes several important considerations into account, including:
      - › Early detection and avoidance of physical obstacles
      - › Accommodation of personal space, preferred speed and other personal requirements
      - › Maneuvering to avoid collisions
      - › Learning from accumulated memories
      - › Entity adaptation, in the ability to adjust individual preferences and attributes

## Intelligent Entities

- Social, physical, and behavioral characteristics are assigned probabilistically from empirically established profiles
- Social characteristics include gender, age, culture and pedestrian type, all of which shape typical movement preferences
- Physical characteristics determine body sizes
- Behavioral characteristics include memory, adaptability, and preferences for unimpeded walking speeds, personal space, and acceleration

## Output and Analyses

- Numerical and graphical outputs derived from a LEGION Simulator model and user-defined areas, interrogated to provide user-defined combinations of these, based on user-defined thresholds
- Measure and quantify the performance of a site with respect to experience, circulation, and safety
- Examples of key metrics include counts, flows, distances, densities, journey times, speeds, and levels of service
- Heat maps provide intuitive overviews of these, from which to identify areas meriting deeper analyses, including line graphs, histograms, stacked histograms, cumulative data, or even raw data, which can then be used for statistical analyses

## OpenBuildings Station Designer

- OpenBuildings Station Designer is Bentley's multidiscipline station design application that enables BIM strategies and allows designers to efficiently explore design alternatives
- It provides information-rich models for the design, simulation, analysis, and documentation of buildings
- This single application includes capabilities for planning, architectural, structural, mechanical, and electrical systems design and construction documentation

**LEGION Model Builder** is delivered in OpenBuildings Station Designer as a companion application and used to create accurate, predictive models of how a space will be used. In the Model Builder, you can:

- Import architectural drawings (CAD) to define the physical spaces available for use by pedestrians
- Specify the pedestrian demand anticipated for space
- Designate areas where interim activities such as queuing or waiting occur
- Link operational data to the model
- Plan routes and automatically lay out navigation maps
- Export model files for simulation and analysis in LEGION Simulator

Image Courtesy of Anil Verma Associates, Inc.

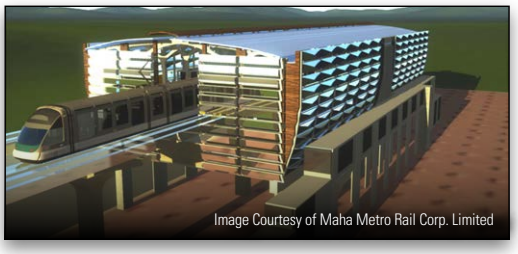

Image Courtesy of Maha Metro Rail Corp. Limited

**For additional information, and to read about the extraordinary projects designed using LEGION Simulator, visit https://www.bentley.com/legion/**

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