



Pedestrian Simulation Modeling

Pedestrian Simulation Modeling World Trade Center Memorial

**NYMTC Brown Bag Lunch
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Pedestrian Simulation Modeling

Why Use Pedestrian Simulation Software?

- Evaluate Complex Pedestrian Environments
- Analyze to “scale” in two-dimensions in real time
- Accurately Depict Pedestrian Movement
- Model Multiple Pedestrian Behavior
- Add Pedestrian Factor to Design Process
- Can Design Accommodate Pedestrians?



Pedestrian Simulation Modeling

Notable Pedestrian Analysis Tools

- Analytical
 - HCS
 - Fruin Methodology (Spreadsheets)
- Simulation
 - STEPS
 - Myriad (Crowd Dynamics)
 - Legion
 - IATA



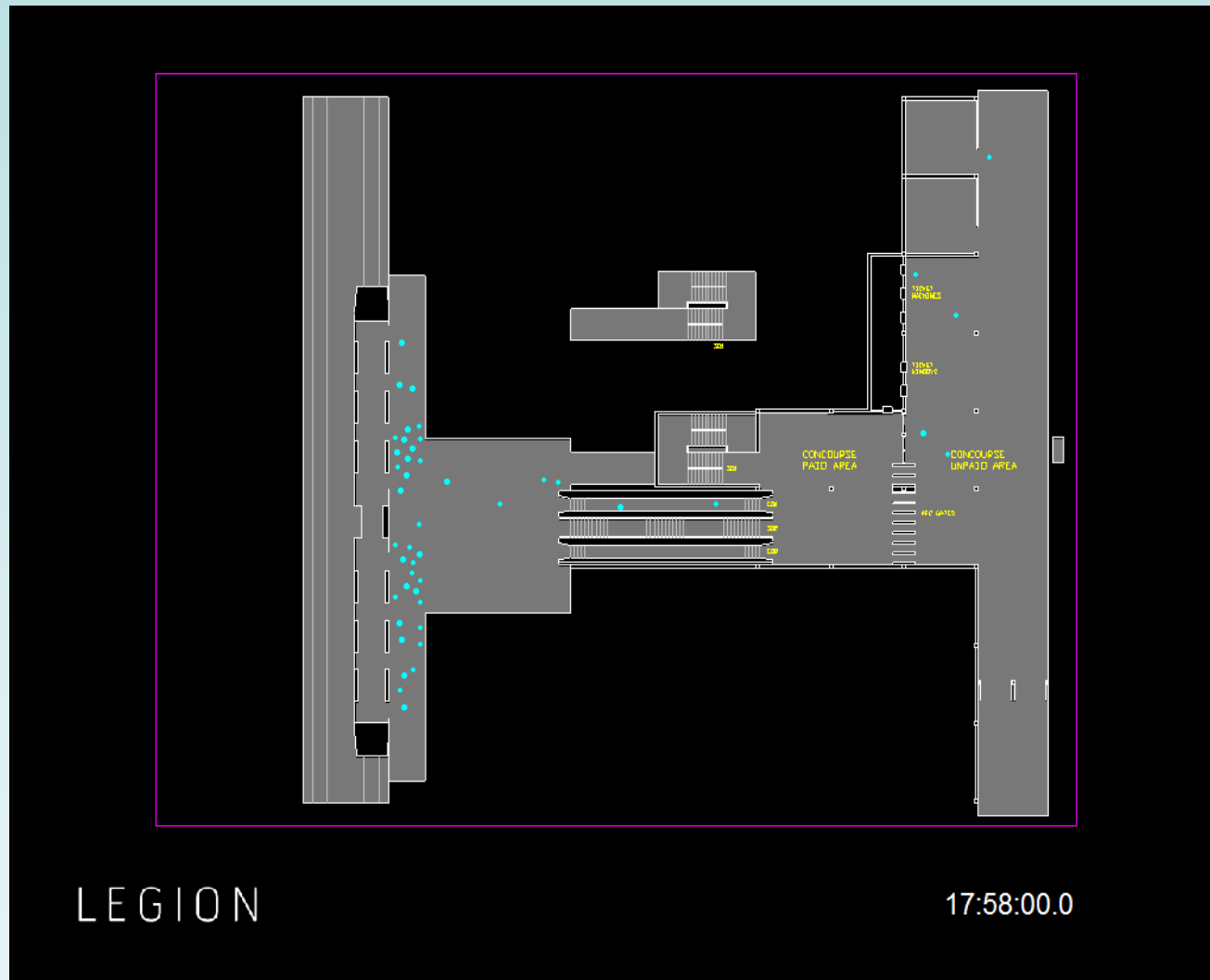
Pedestrian Simulation Modeling

What is LEGION Software?

- Dynamic Simulation
- Real-time
- 2-D
- Non-grid based
- Smart
- Based on Empirical Data



Pedestrian Simulation Modeling



Legend

Blue Dots = Commuters entering the Station

Red Dots = Commuters leaving the Station

Yellow Dots = Tourists entering/leaving the station



What do the Dots Represent?

- 2-D People with Individual Profiles
 - Age
 - Size
 - Walking Speed
 - Itinerary



Pedestrian Simulation Modeling

What are the Profiles Based Upon?

- Data Collected from:
 - Europe
 - Far East
 - North America
- Pedestrian profile categories include:
 - Commuters
 - Tourists



Pedestrian Simulation Modeling

Model Development Steps

- CAD Base Map – Site Design
- Operational Assumptions
- Pedestrian Origin/Destination Matrix
- Coding
- Model Output
- Recommendations

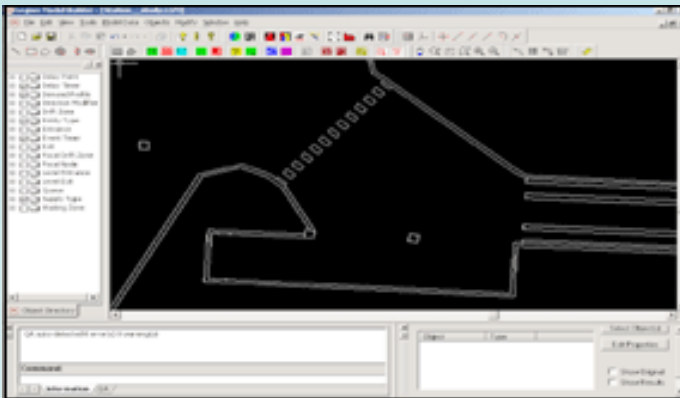


Pedestrian Simulation Modeling

How does the Program work?

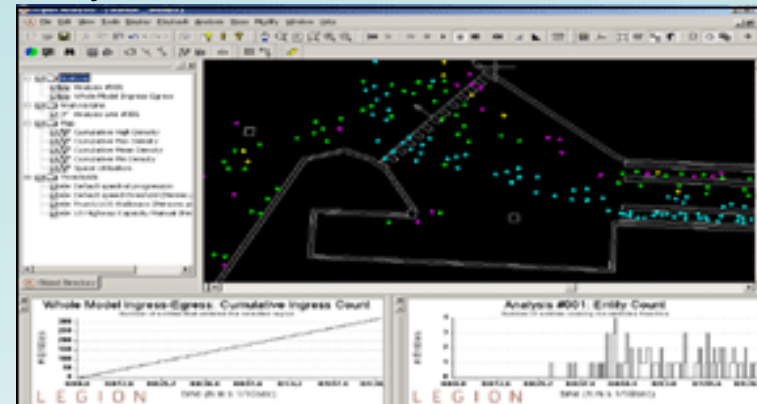
THE MODEL BUILDER

Defines the environment



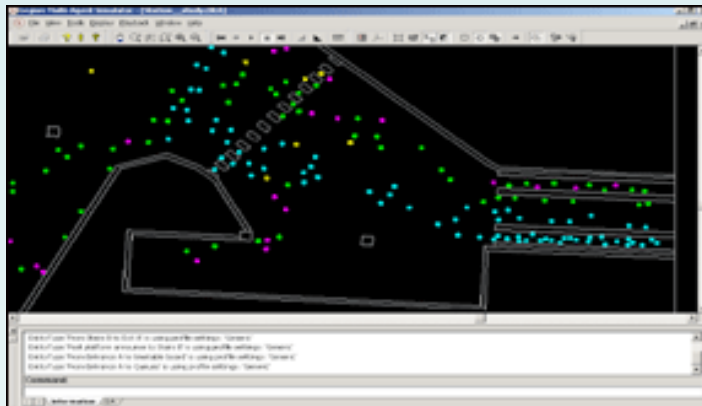
THE ANALYSER

Plays the results



THE SIMULATOR

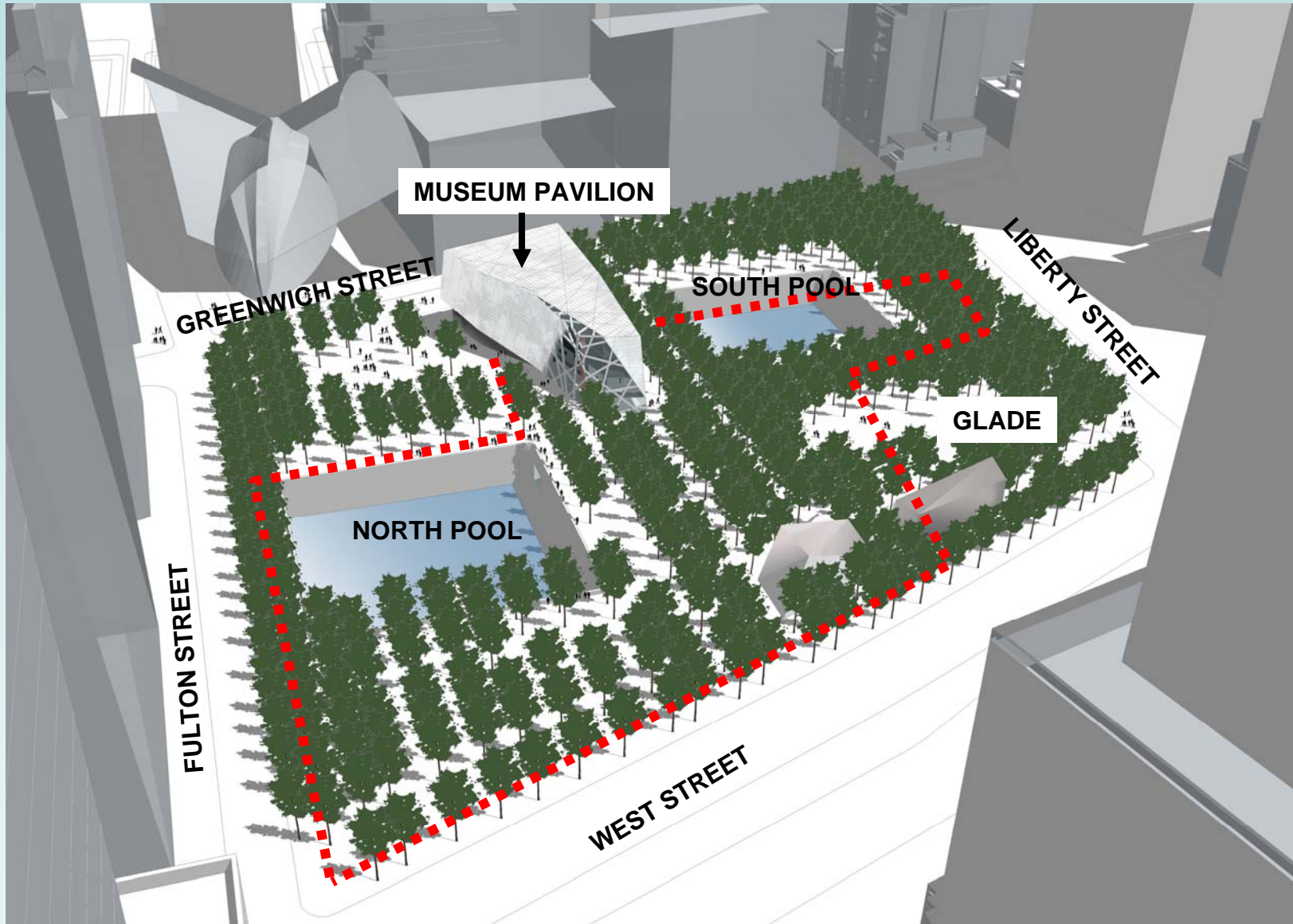
Compiles the data and performs analysis





Pedestrian Simulation Modeling

The World Trade Center Memorial





Pedestrian Simulation Modeling

Memorial Plaza





Pedestrian Simulation Modeling

Need for Pedestrian Simulation

- Physical design – queuing, ticketing, landscaping
- Visitor experience
- Operational efficiency
- Security and safety concerns
- A customized, fine grained analysis



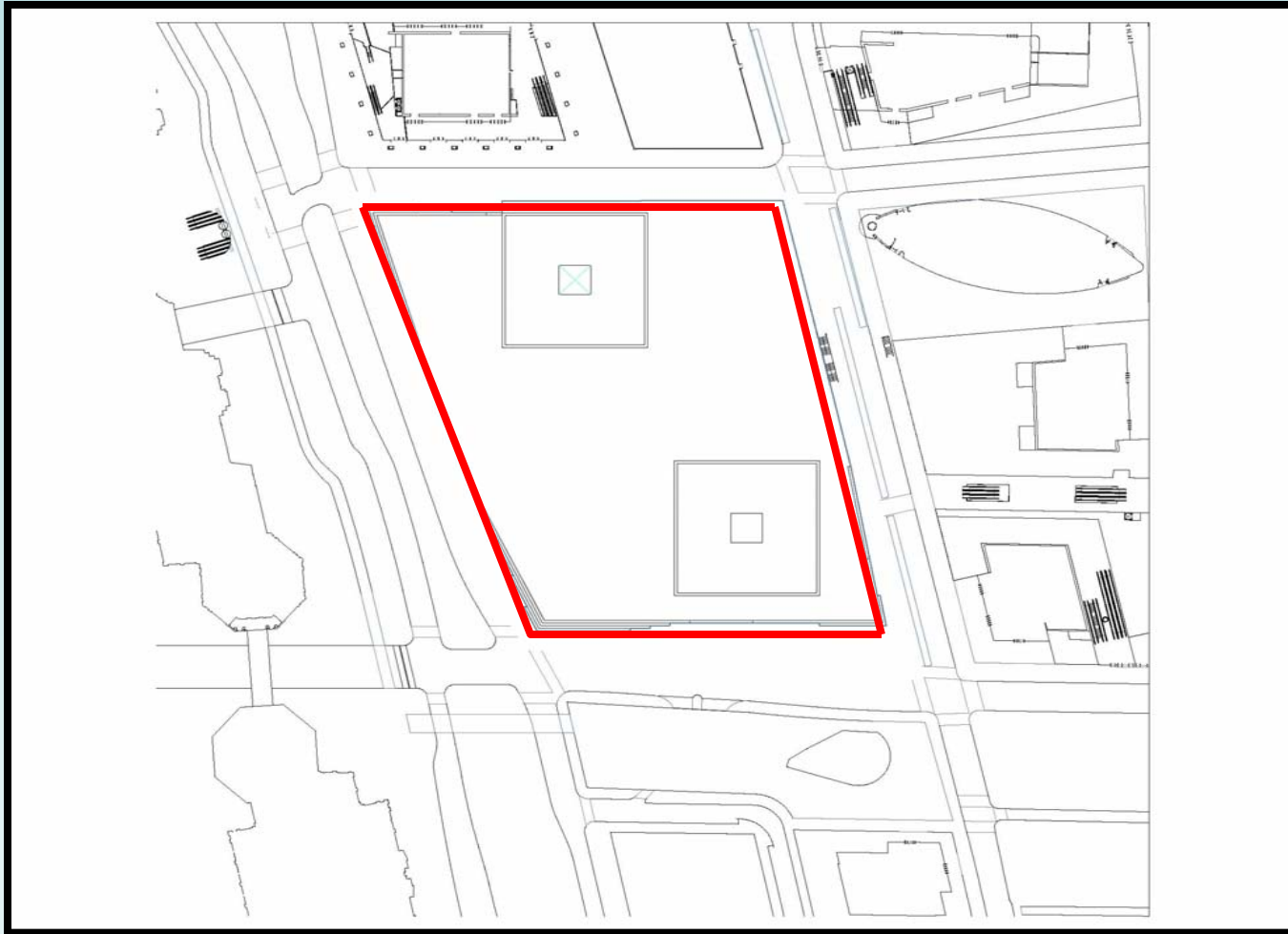
Pedestrian Simulation Modeling

Client Process

- Joint effort with LMDC, began August 2005
- Funded through project design budget
- Berger chosen for leadership in field, experience with site, and partnership with Legion
- Development of assumptions was educational
- Iterative process responded to design changes
- Results suggest the need for a district-wide, multi-modal study



Pedestrian Simulation Modeling



— Memorial Quadrant



Key Model Analyses

- Plaza Level
- Queuing
- Security Screening
- Vertical Pedestrian Circulation
- Streetscape
- Activity Areas
- Delay Points
- Bus Operations



Pedestrian Model Outputs

- AVIs (Video):
 - Pedestrian Movements
 - Desire Lines
- Maps:
 - Density maps
 - Space Utilization
- Graphs:
 - Journey times
 - Waiting times/delay
 - Densities experienced
 - Satisfaction experienced



Pedestrian Simulation Modeling

Simulation to be provided

World Trade Center Memorial Site



Pedestrian Simulation Modeling

Simulation to be provided

**World Trade Center Memorial Site:
Northeast Quadrant**



Pedestrian Simulation Modeling

Simulation to be provided

**World Trade Center Memorial Site:
Southeast Quadrant**



Pedestrian Simulation Modeling

Simulation to be provided

**World Trade Center Memorial Site:
Southwest Quadrant**



Pedestrian Simulation Modeling

Simulation to be provided

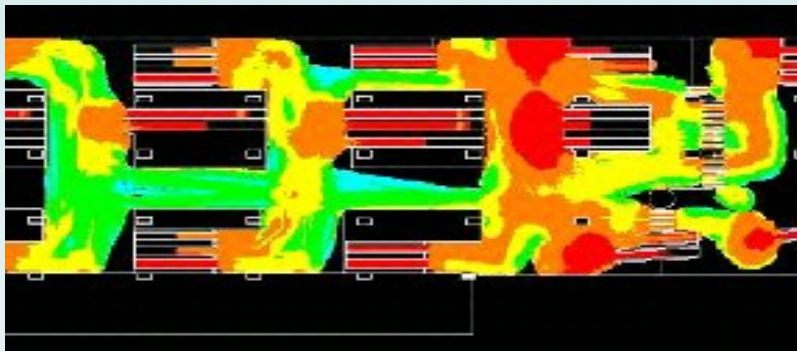
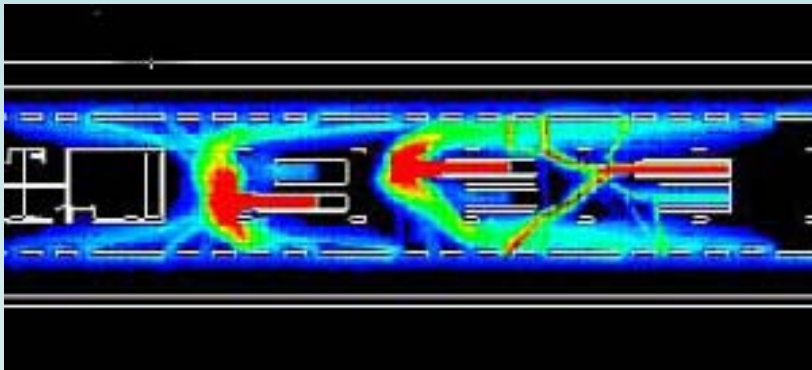
**World Trade Center Memorial Site:
Northwest Quadrant**



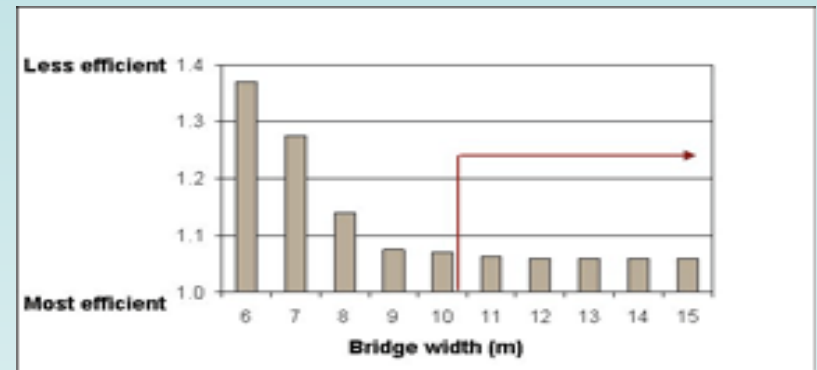
Pedestrian Simulation Modeling

Additional Model Outputs:

MAPS



Graphs





Pedestrian Simulation Modeling

Map to be provided

Cumulative Mean Density (LOS) Map



Pedestrian Simulation Modeling

Map to be provided

Space Utilization Map



Pedestrian Simulation Modeling

Map to be provided

Discomfort Map



Pedestrian Simulation Modeling

- Study Results
 - Design
 - Operations
 - Validation



Pedestrian Simulation Modeling

- Results - Design
 - Programming
 - Paths
 - Signage
 - Portal Locations
 - Building size



Pedestrian Simulation Modeling

- Results - Operations
 - Queuing
 - Security
 - Pools
 - Benches
 - Buses
 - Viewing Areas



Pedestrian Simulation Modeling

- Results - Validation
 - Congestion
 - Space Utilization
 - Discomfort



Pedestrian Simulation Modeling

Questions????