Use of Case Study Data to Validate MassMotion for Egress Purposes

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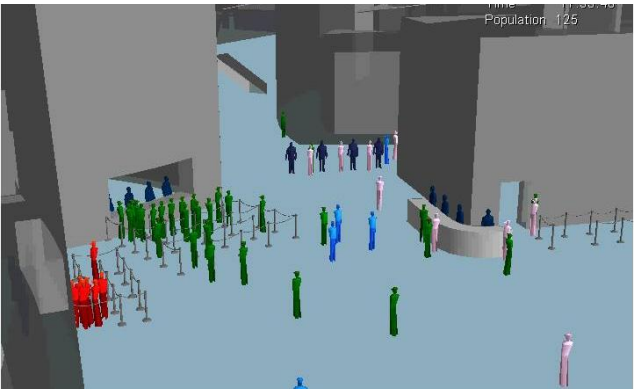
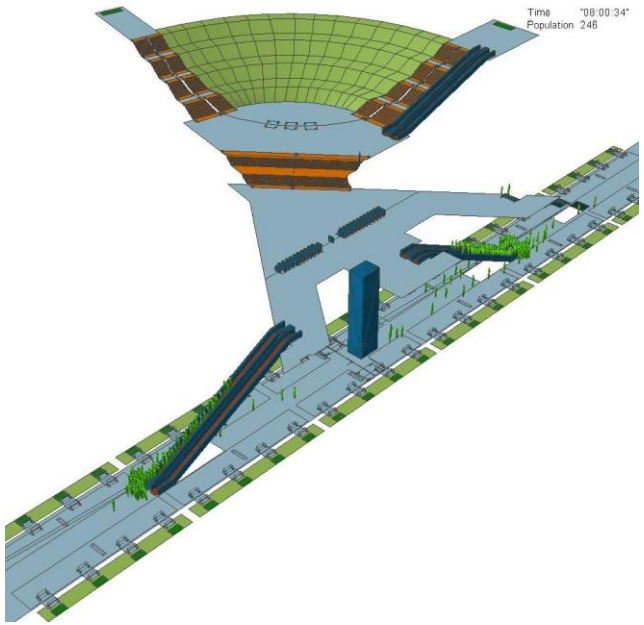
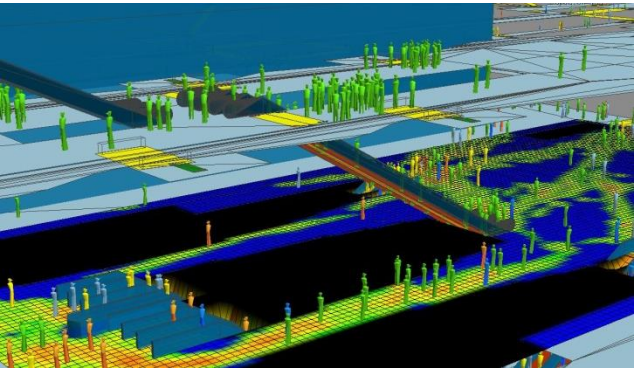
Introduction

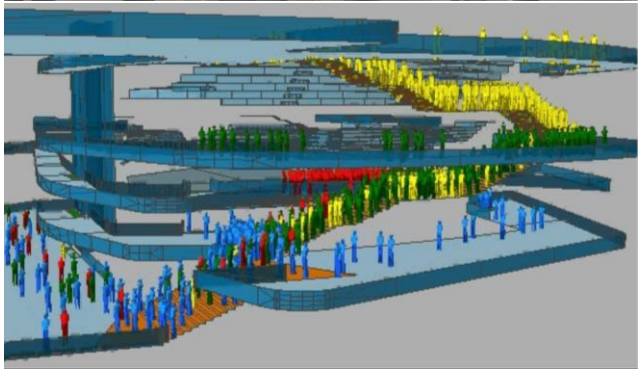
- **Arup Pedestrian Planning**
  - Rail stations
  - Airports
  - Building lobbies
  - Screening processes
  - Urban areas
- **Modeling Tools**
  - Micro-Simulation (Legion, MassMotion, STEPS)
  - Discrete Event (ARENA)
  - Hybrid (PaxSim/TAAM)
  - Deterministic (Excel)

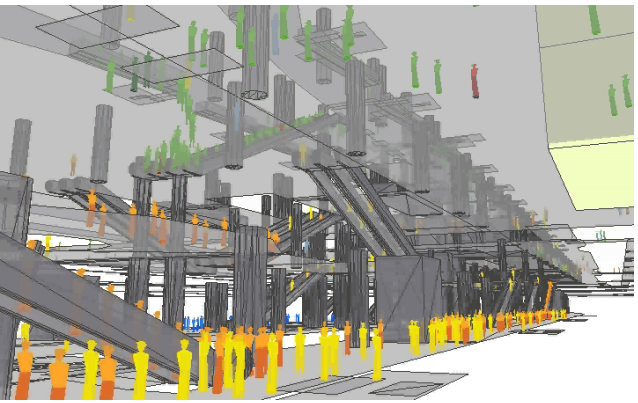
Introduction

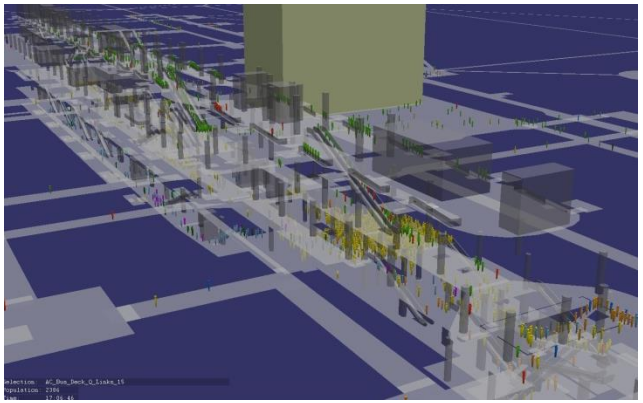












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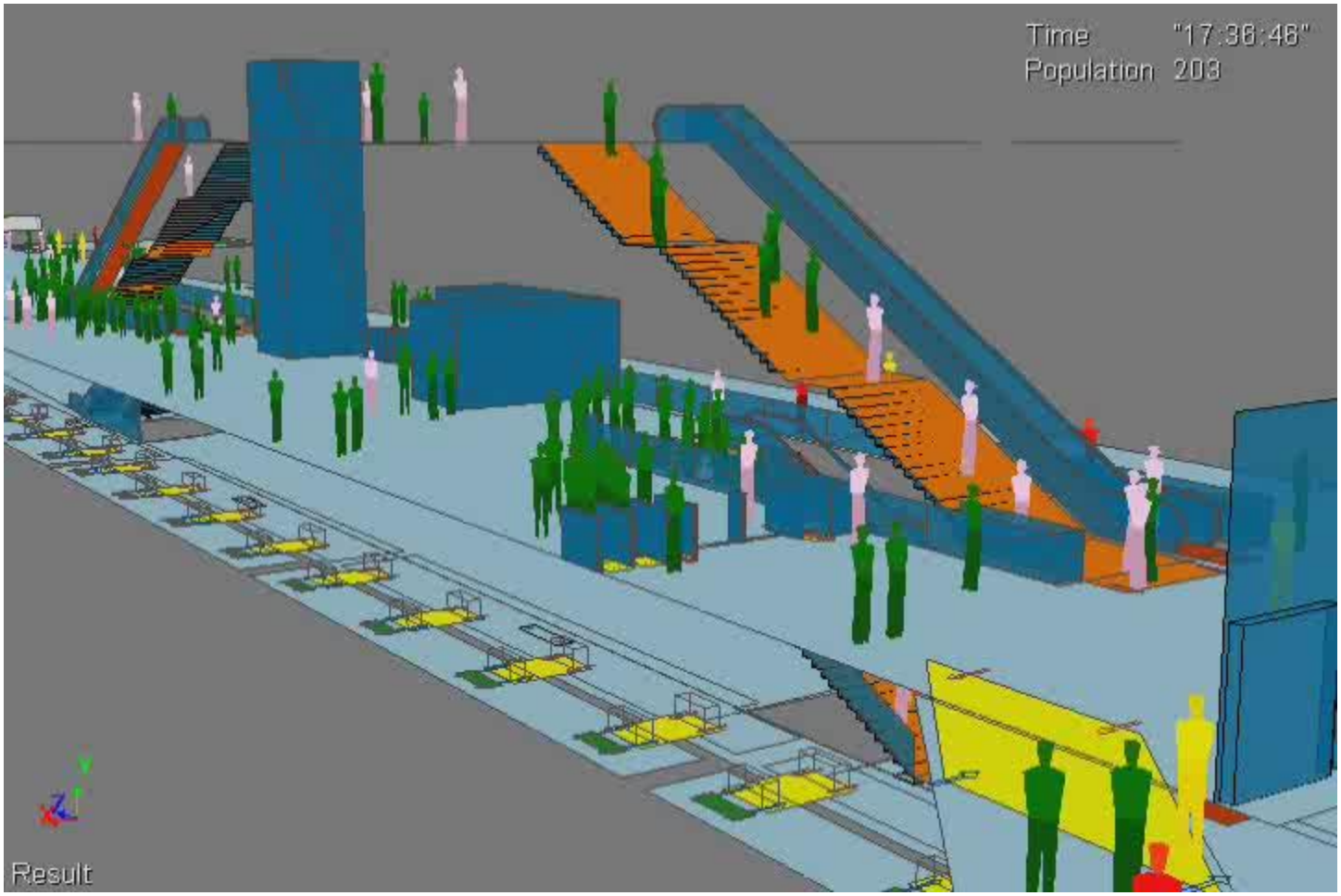
About MassMotion

- **Current uses**
  - Rail stations
  - Airports
  - Building lobbies
  - Venues
  - Stadia
  - Screening processes
  - Urban areas

About MassMotion



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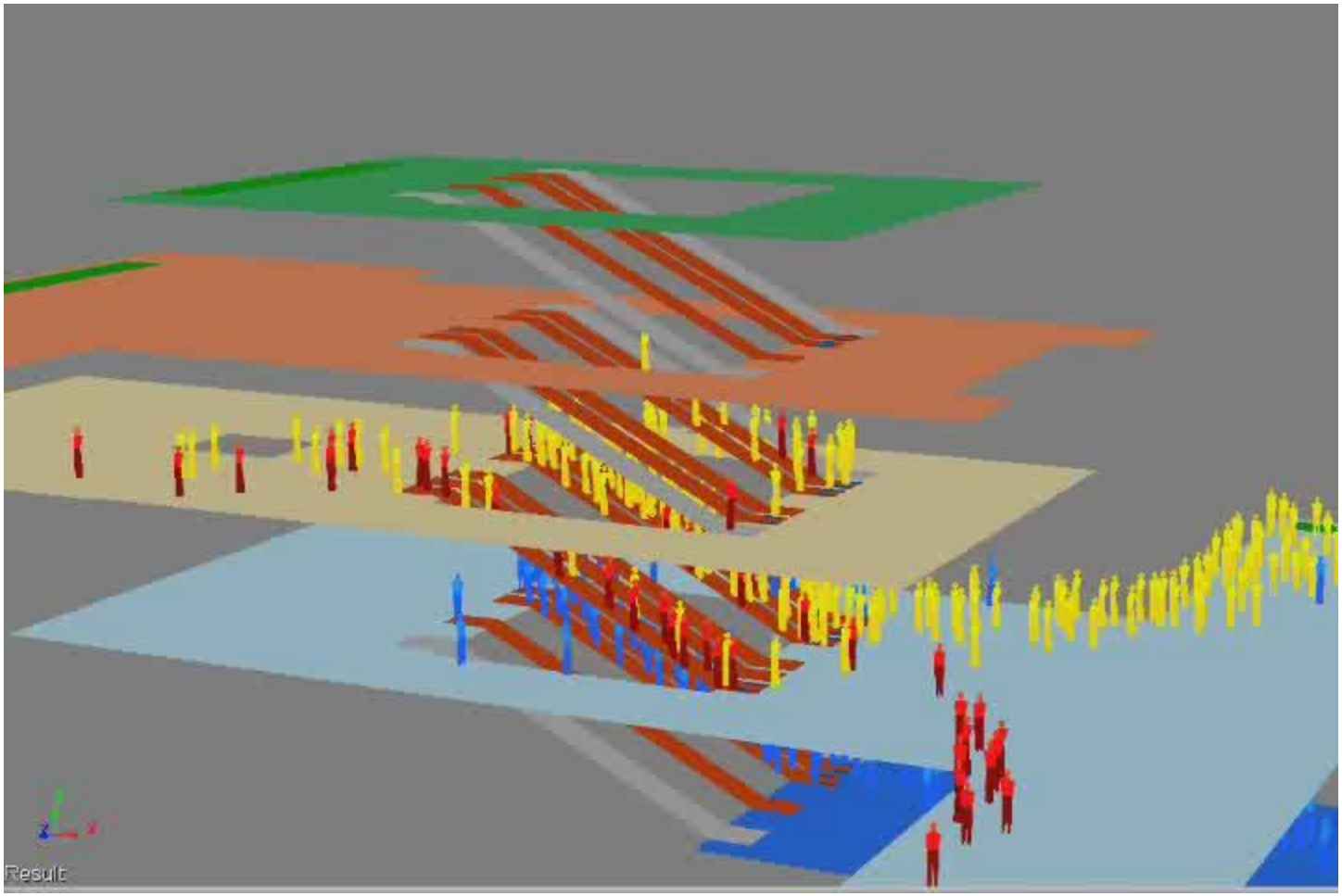
About MassMotion



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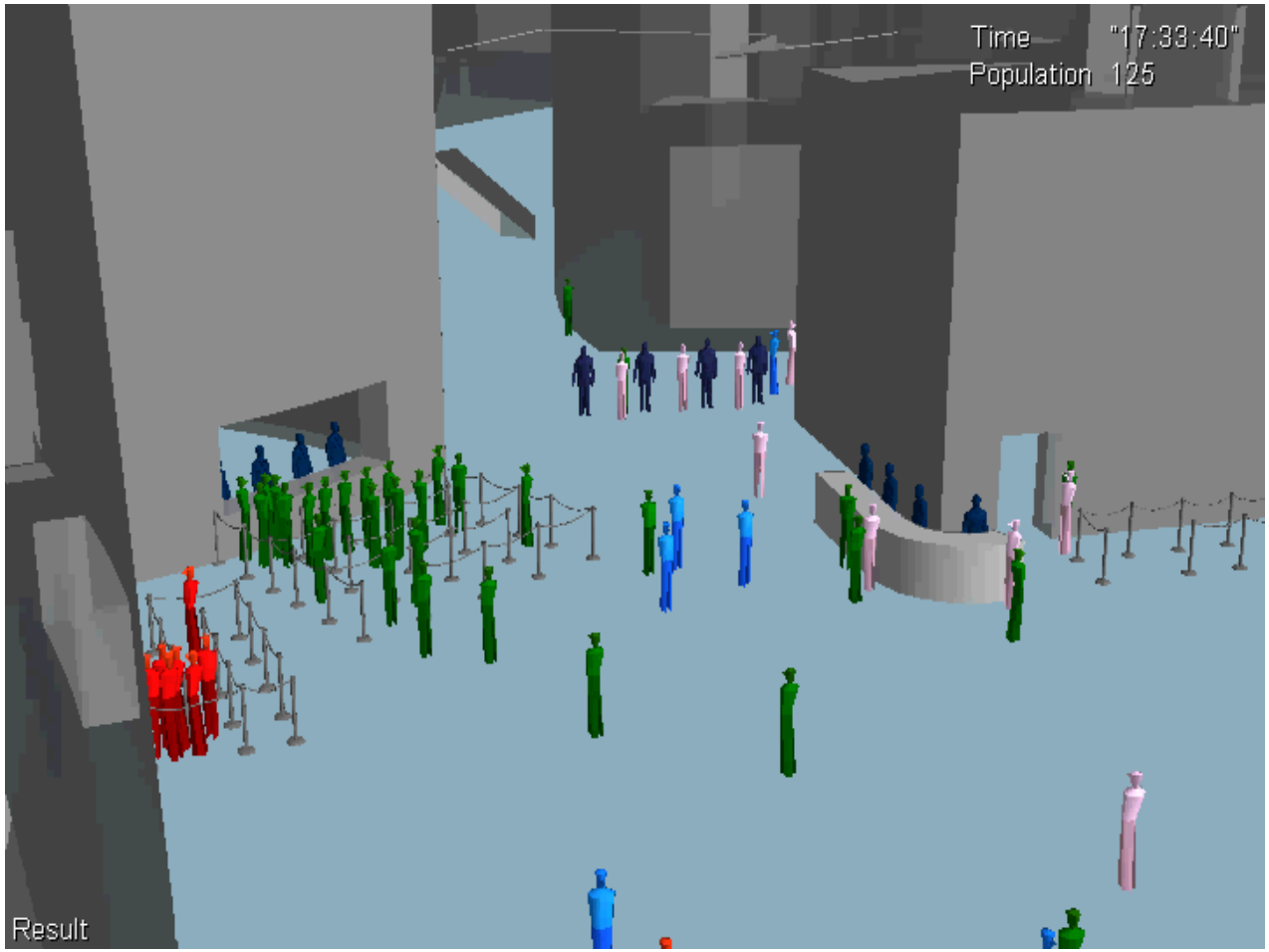
About MassMotion



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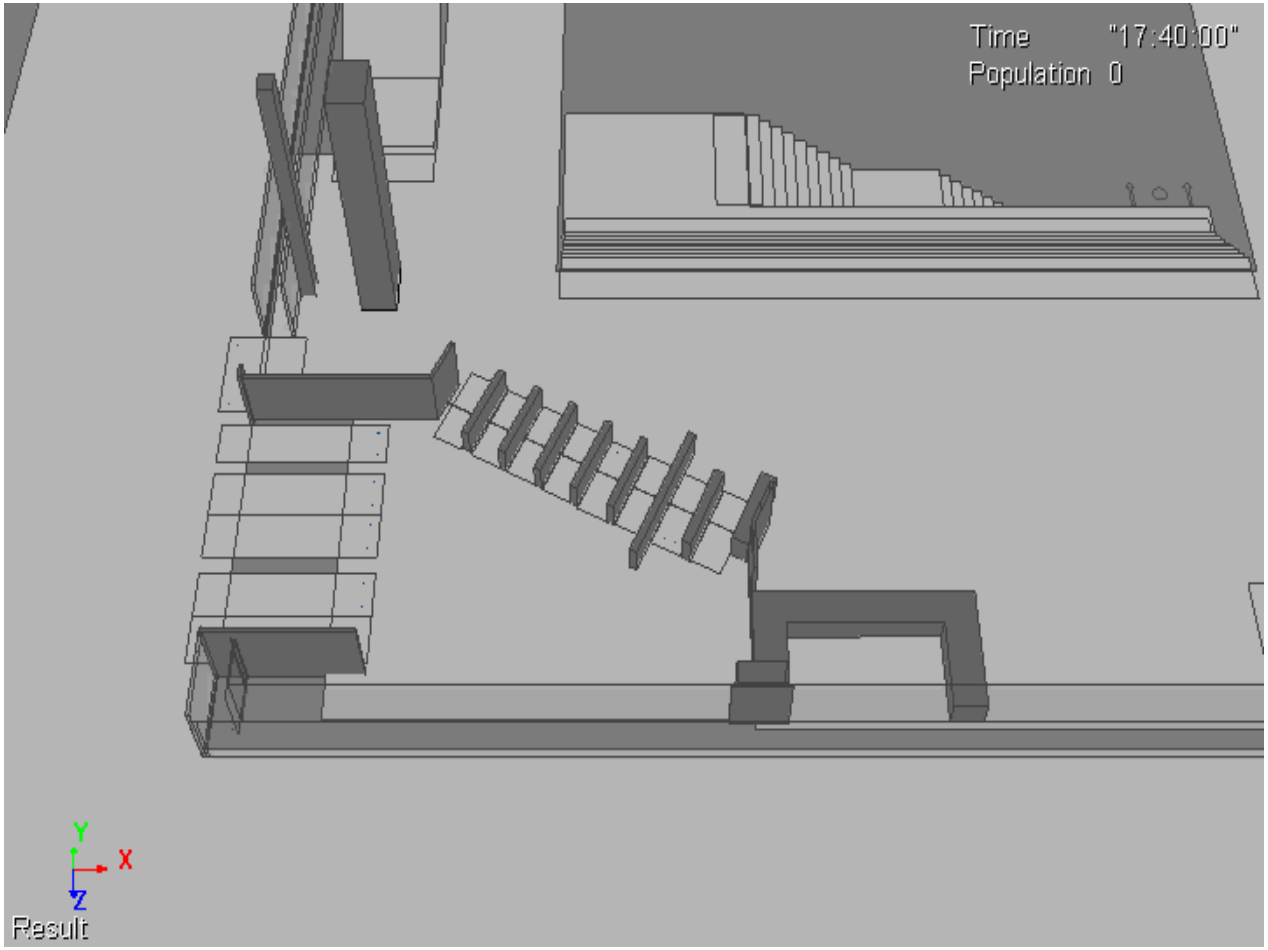
About MassMotion



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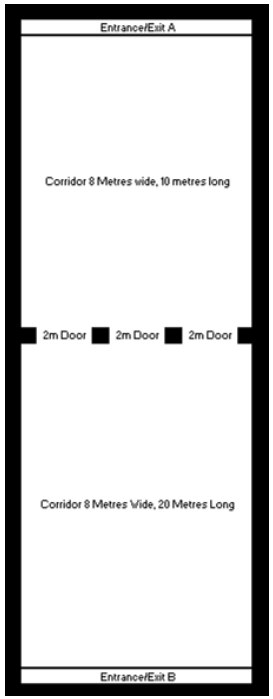
About MassMotion

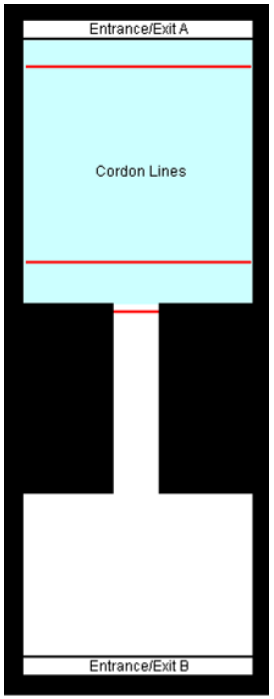
- **Environment**
  - Individual agents with vision
  - 3D
- **Agent Locomotion**
  - Route choice function, for global movements and decision making
  - Social forces algorithm, for agent interactions
  - Speed profiles, for preferred speed
  - Density and grade functions, for modified speeds

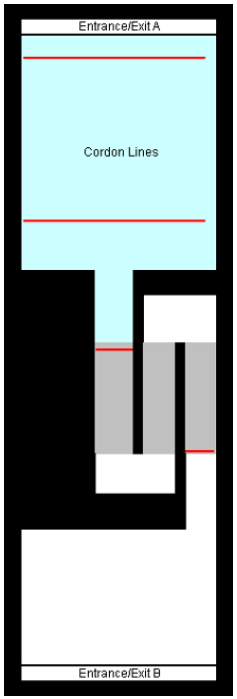
MassMotion Validation

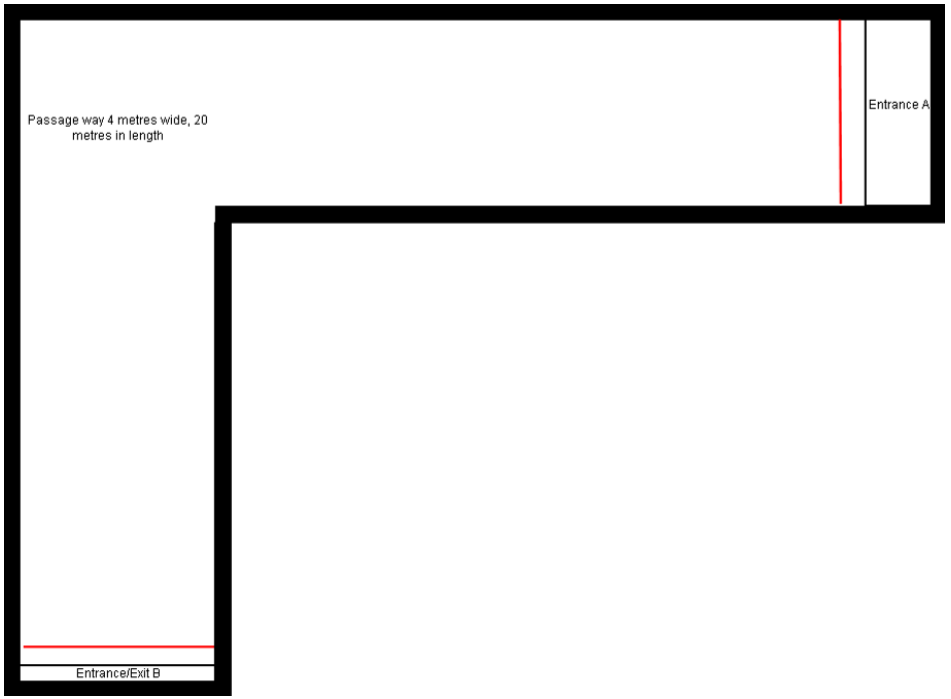
- **Opportunities with egress modeling**
  - Create a better built environment
  - Encourage collaboration and integration across disciplines
  - Increase efficiencies and reduce costs
- **Research Purpose**
  - Validate MassMotion for use in egress modeling

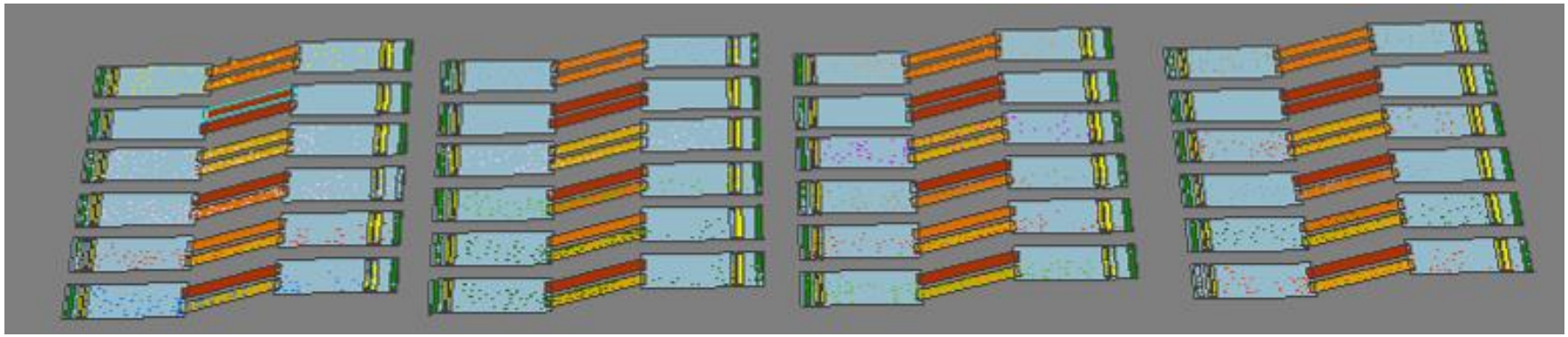
Validation – Normal Movement Scenario











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Validation – Egress Scenario

- **Guidelines**
  - National Cooperative Highway Research Program
    - Testing model on empirical data not used to calibrate the model
  - London Underground Limited
    - Journey times +/- 10%
- **Measured emergent behaviors**
  - Total evacuation time
  - Individual journey times
  - Achieved flows
  - Individual movement behaviors

MassMotion Validation Phase 1

Arup New York

155 Avenue of the Americas

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Egress Drill

- Planned egress drill
- Floors 2, 10, 11, 12, 13, 14
- 232 evacuees
- ~70% of Arup population
- 7:24 total egress time

Egress Drill

- **Egress floor door counts**
  - Counts for calibration of population and stair choice
  - Achieved flows for validation

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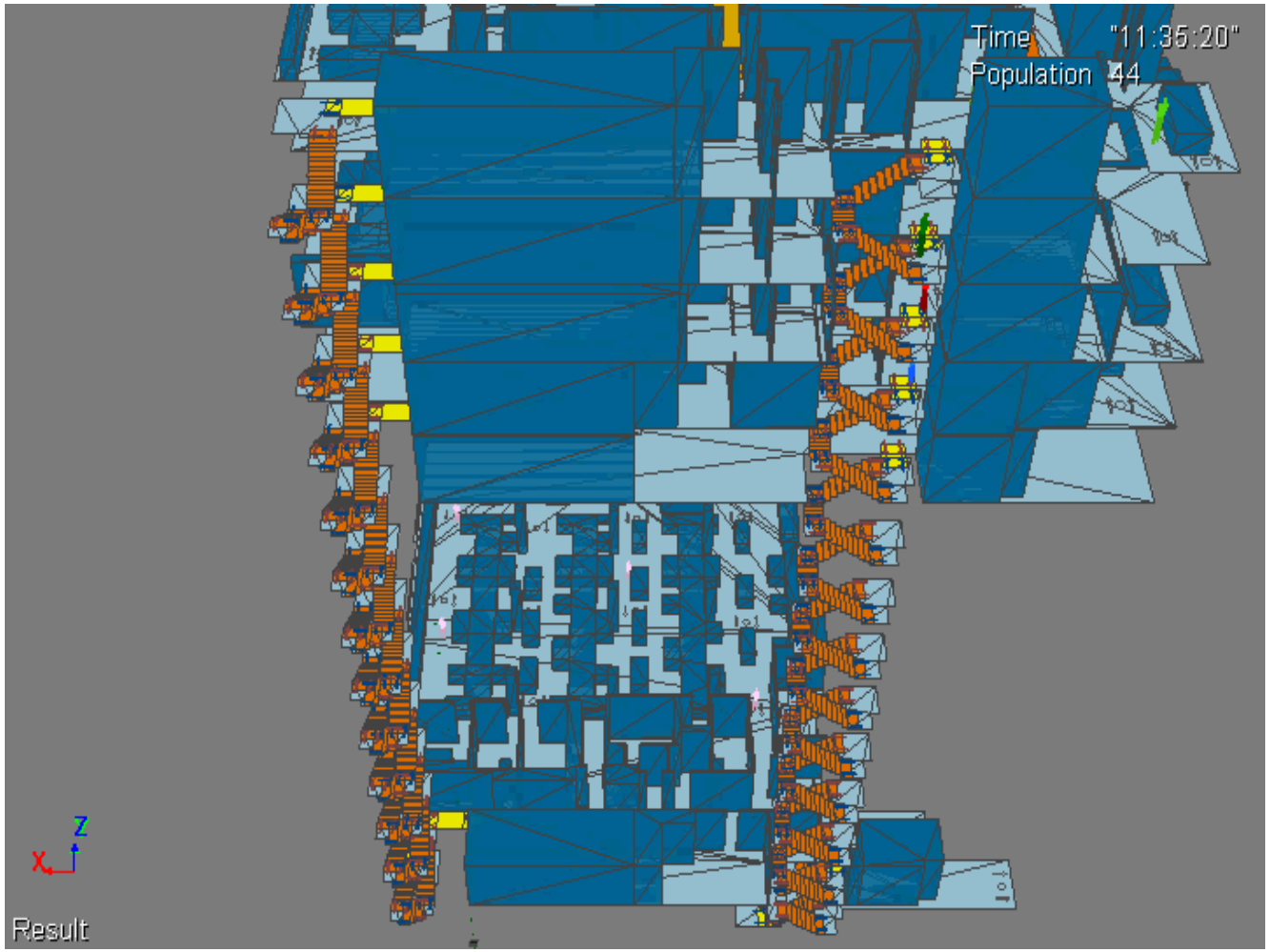
Egress Drill

- **Video on 11th and Ground floors**
  - Stairwell movement behaviors
  - Individual journey times

MassMotion Model



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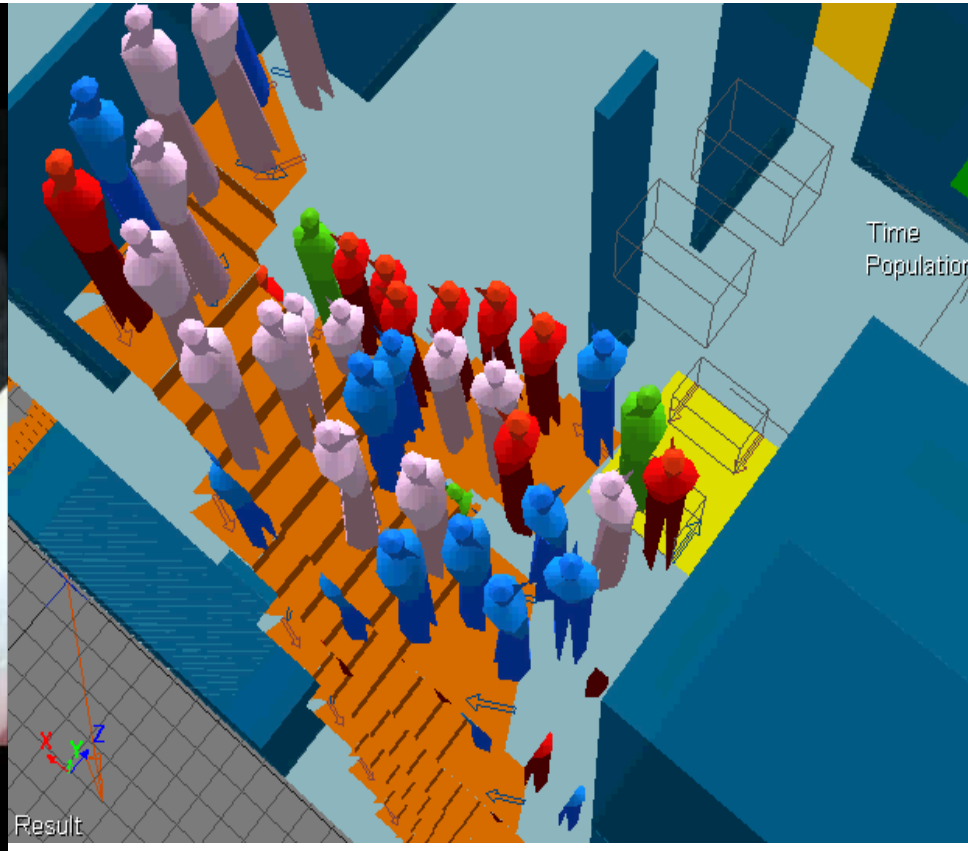
Validation

- **Stairwell Movement Behaviors**



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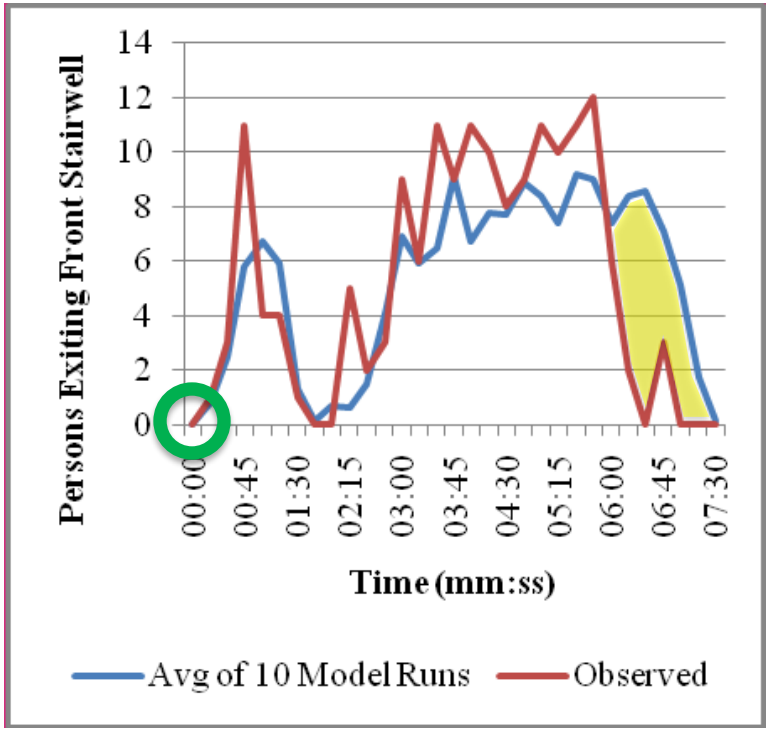
Validation

- **Individual journey time**
  - Average of samples from egress drill
  - Average of all agents in model

Scenario	11X to Exit (mm:ss)	11Y to Exit (mm:ss)
Observed Average of Samples	2:59	2:16
Modeled Average of All Agents	3:39	3:04
Difference from Observed	+22.4%	+35.1%

Validation

- **Comparison of ground floor exits**
  - Pattern correlation
  - Attempt to eliminate pre-movement time
  - Actual faster than modeled



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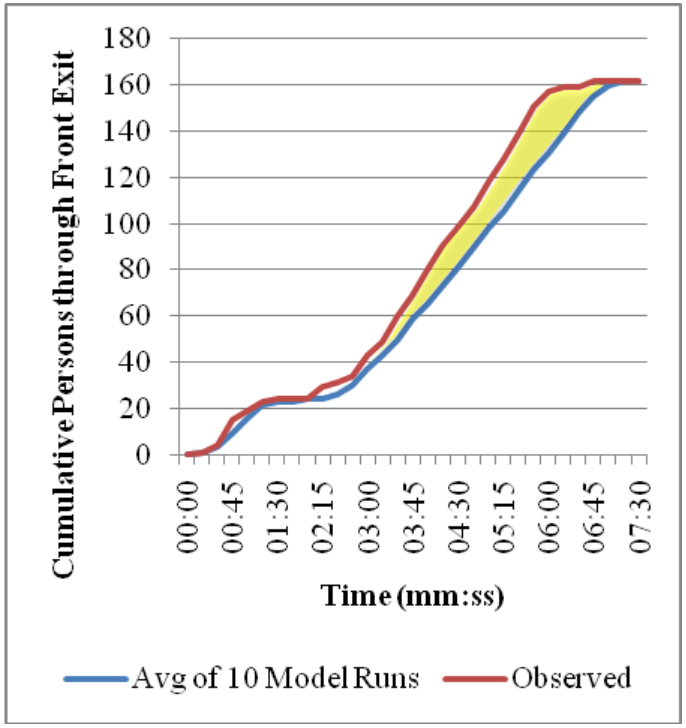
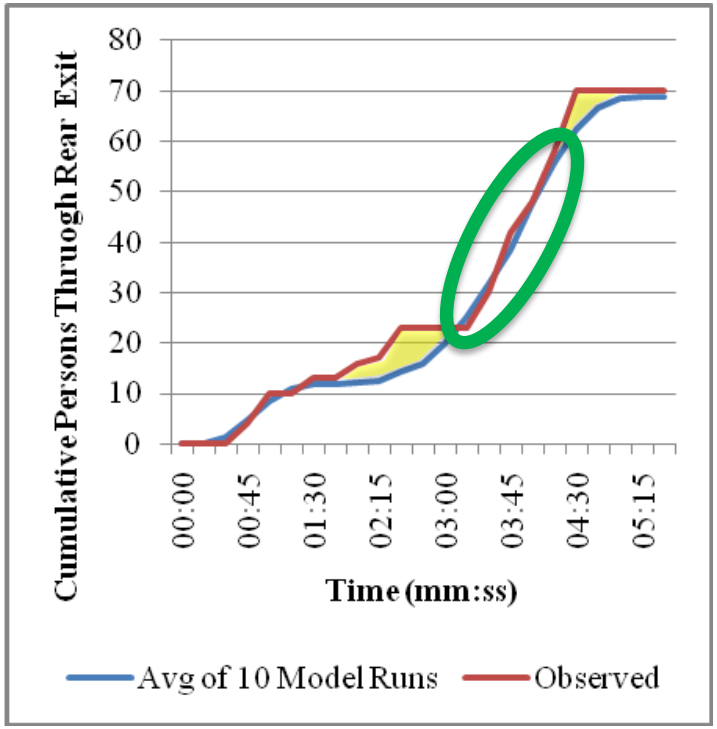
Validation

- **Comparison of cumulative stairwell exits**
  - Some slope correlation in rear stairwell Y
  - Actual faster than modeled





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Validation

- **Comparison of overall evacuation time**

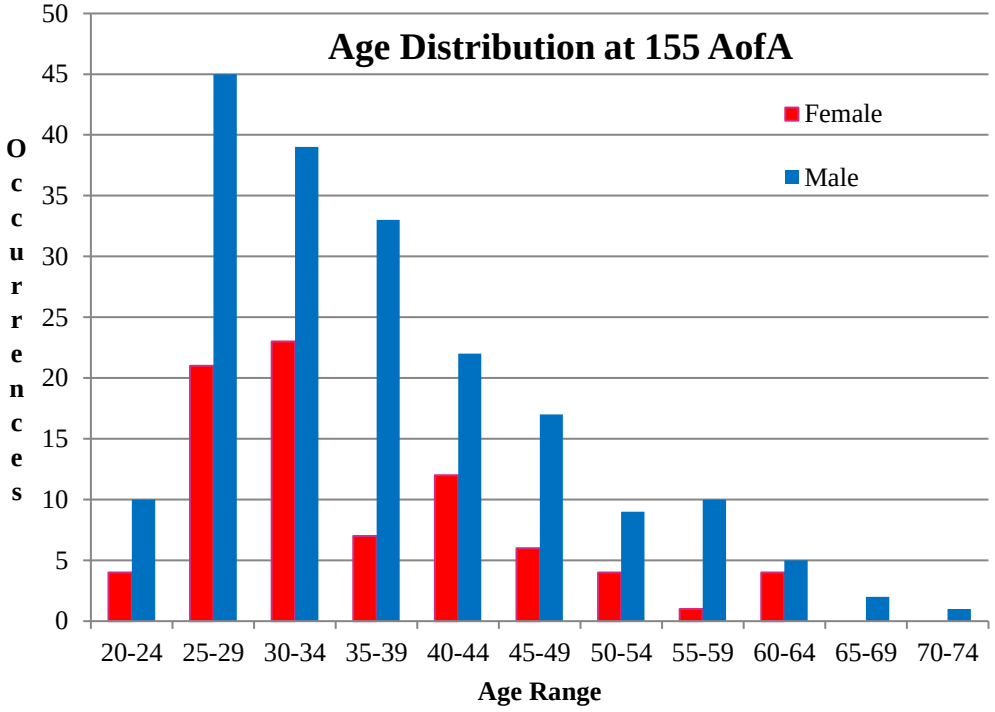
Scenario	Time (mm:ss)
Observed Evacuation Time	7:24
Modeled Evacuation Time	7:49
% Difference	+5.6%

- **Comparison of stair flows**

Stairwell X	Persons/15-seconds
Observed	14
Modeled	15

Validation

- **Differences: Population or MassMotion?**
  - Young, fit, and/or homogenous
  - Female: 32.9 median, 35.9 average age
  - Male: 34.8 median, 37.3 average age



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MassMotion Validation Phase 2

Three More Towers

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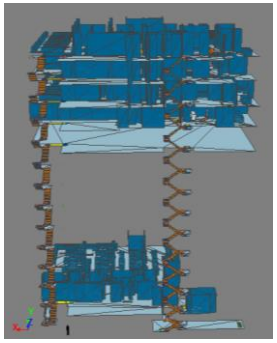
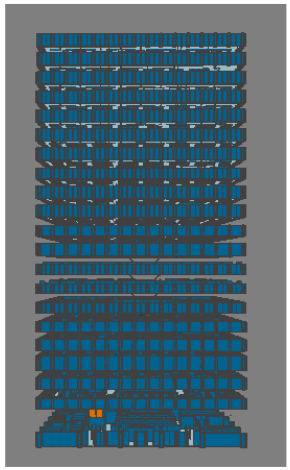
Three More Egress Models

155 Avenue of the Americas



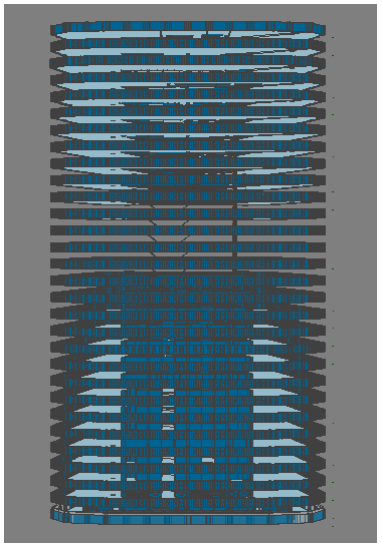
Floors: 15 (6 modeled)
Evacuees: 232

10 Hanover Square



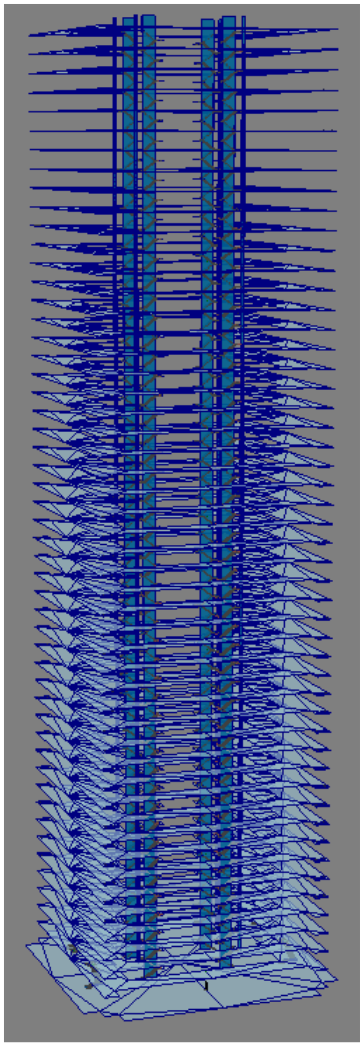
Floors: 22
Evacuees: 1,130

85 Broad Street



Floors: 30
Evacuees: 1,385

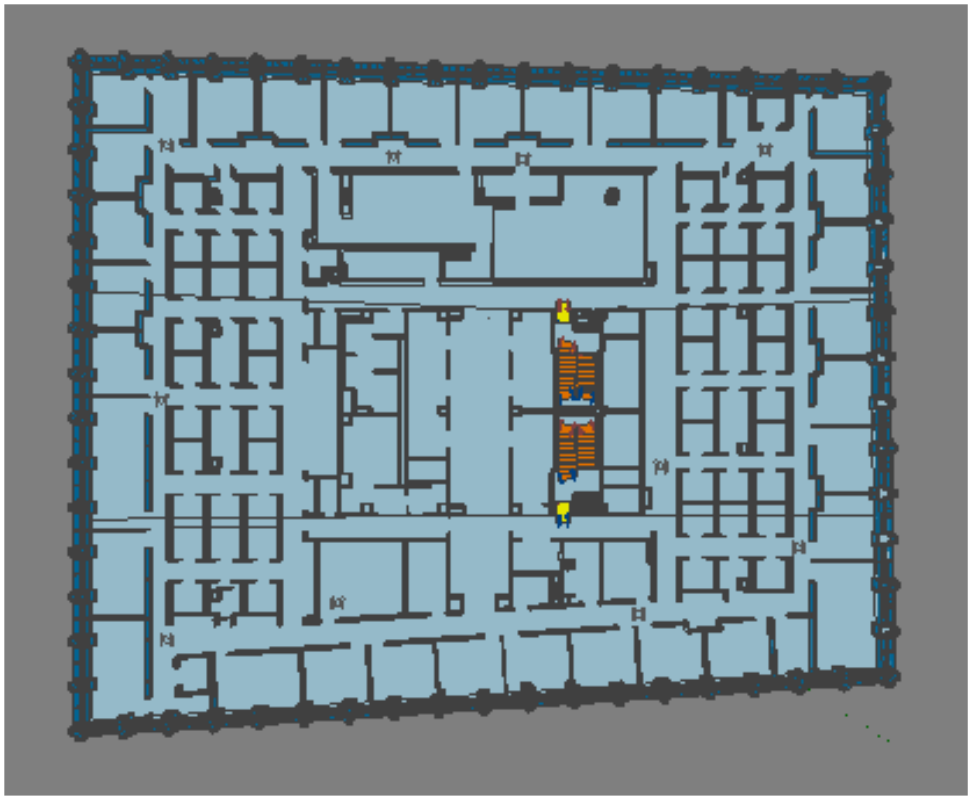
Canary Wharf

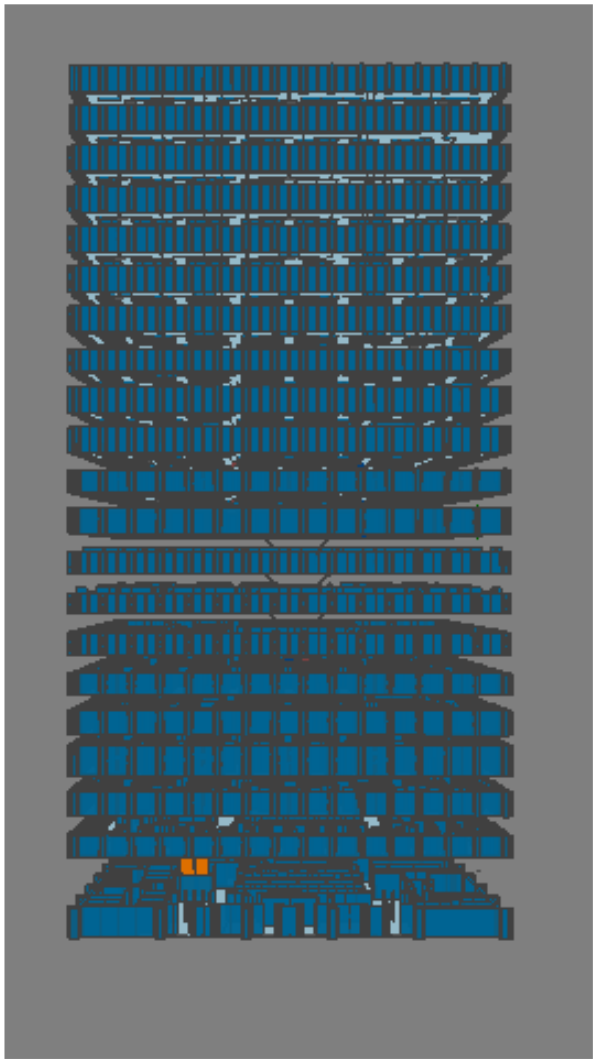


Floors: 50
Evacuees: 5,469
(53% on stairs)

10 Hanover Square, Lower Manhattan

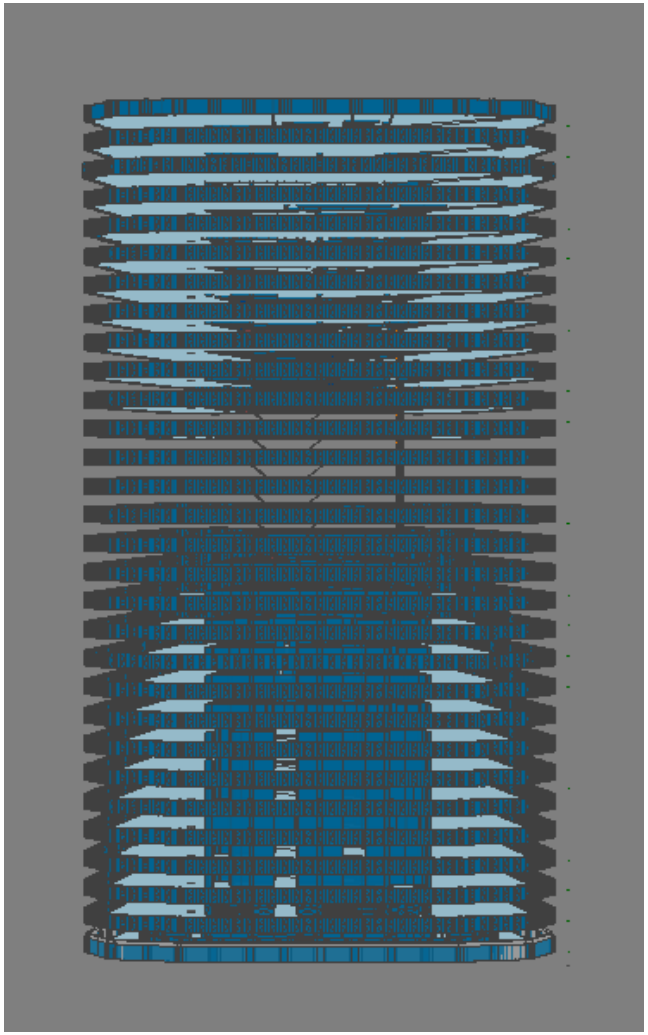
Scenario	Time (minutes)
Observed Evacuation Time	13:00
Modeled Evacuation Time	13:14





85 Broad Street, Lower Manhattan

Scenario	Time (minutes)
Observed Evacuation Time	18:00
Modeled Evacuation Time	16:41



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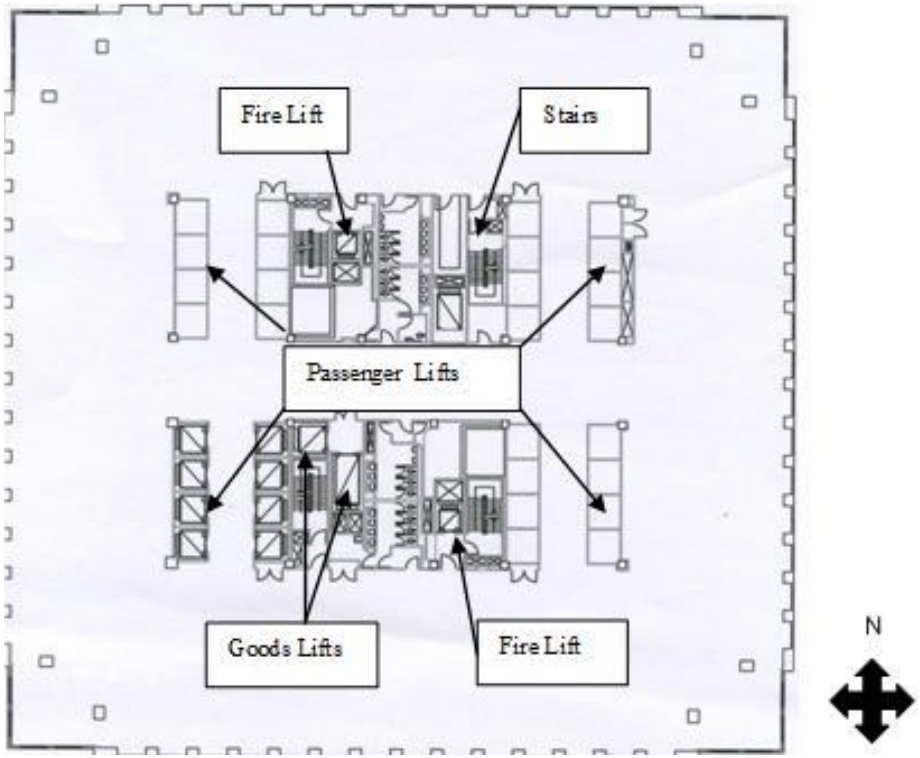
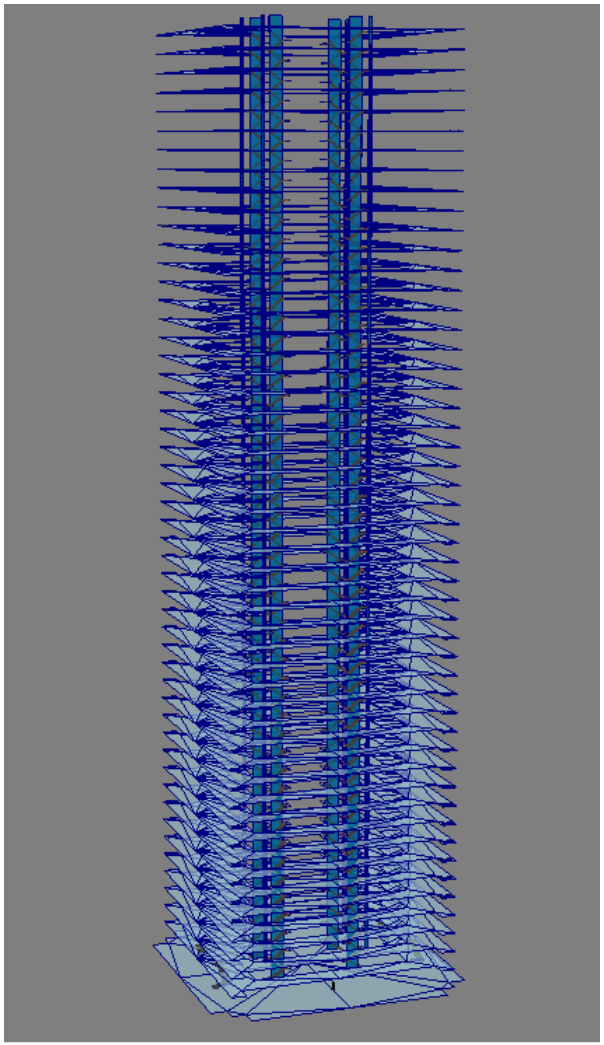
1 Canada Square, Canary Wharf

Scenario	Time (minutes)
Observed Evacuation Time	20:00
Modeled Evacuation Time	21:53





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Results

Building	Scenario	Total Evacuation Time (mm:ss)
155 Avenue of the Americas	Observed	7:24
	Modeled	7:49
	% Difference	**+5.6%**
10 Hanover Square	Observed	13:00
	Modeled	13:14
	% Difference	**+1.4%**
85 Broad Street	Observed	18:00
	Modeled	16:41
	% Difference	**-7.3%**
One Canada Square	Observed	20:00
	Modeled	21:53
	% Difference	**+9.5%**

Conclusions and Next Steps

- < 10% difference across 4 case studies of varying sizes and population
- Suitable for building egress models
- Desire to test more data sets

- **Thank you**