

Evacuation Modeling Dependence on Input Parameters

A Case Study

Brian Salyers, Bevan Jones
Holmes Fire

Fire and Evacuation Modeling Technical Conference
August 16, 2011



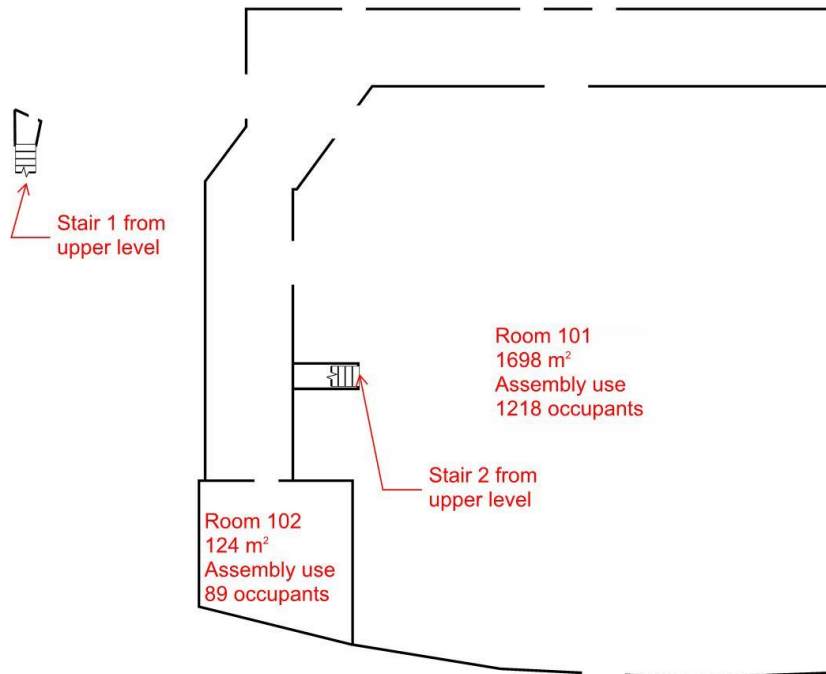
holmesfire



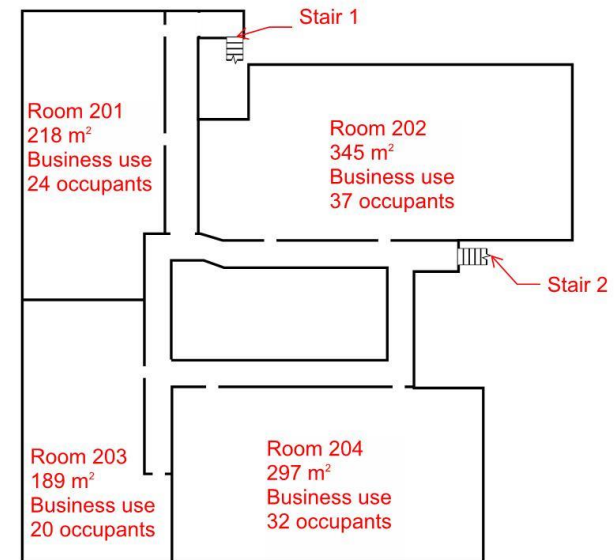
- Evacuation modeling often used for PBD
- Reliance on different methods and possible inputs
- Relevant information:
 - *SFPE 4th edition*; Chapter 3-17 Computer Evacuation Models for Buildings
 - *NIST GCR 06-886*; Guide for Evaluating the Predictive Capabilities of Computer Egress Models



- Two story case study
 - Assembly occupancy on lower floor
 - Business occupancy on upper floor



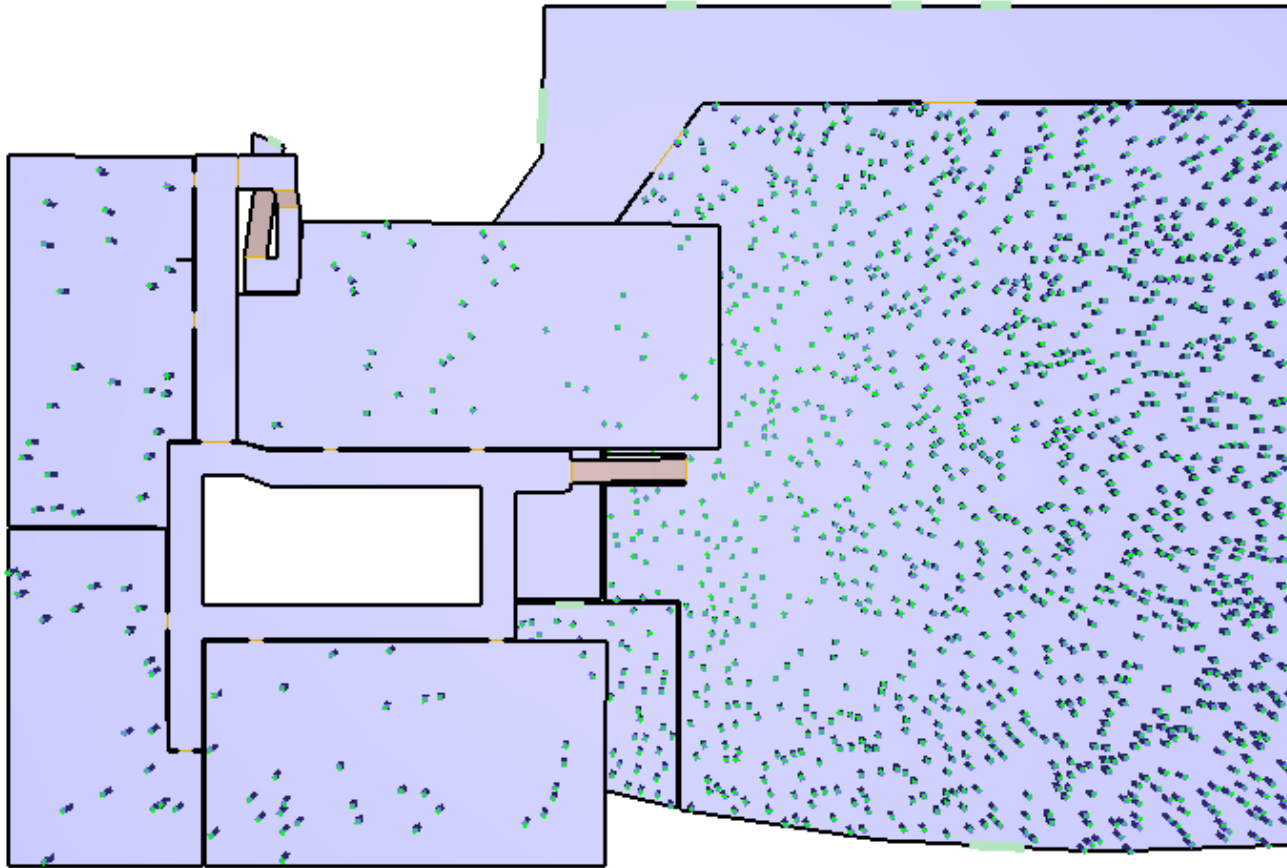
Lower Floor



Upper Floor



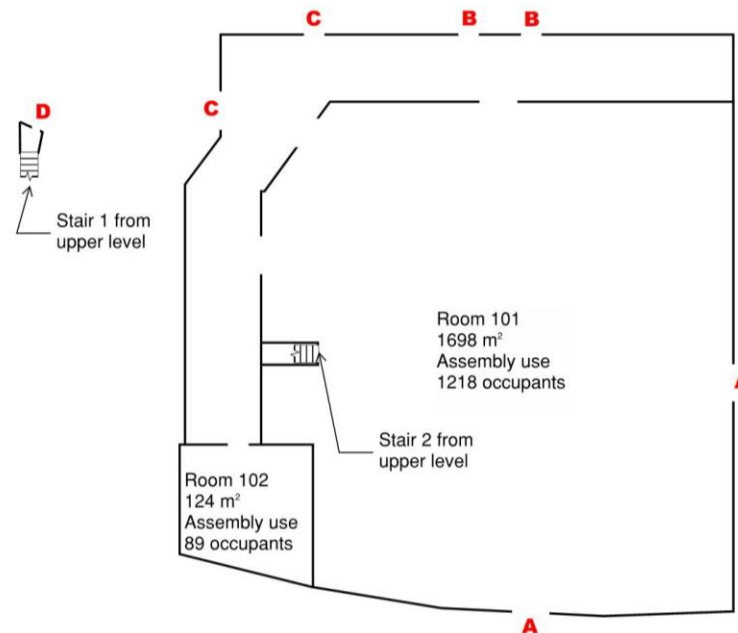
- Typical exhibition space



Plan View



- Hand calculation Setup
 - *SFPE 4th edition*; Chapter 3-13 Employing the Hydraulic Model in Assessing Emergency Movement
 - Hydraulic calculations through egress components
 - Occupants move as groups
 - Optimized potential flow
 - Consecutive loading of groups at final exit



Exit Layout



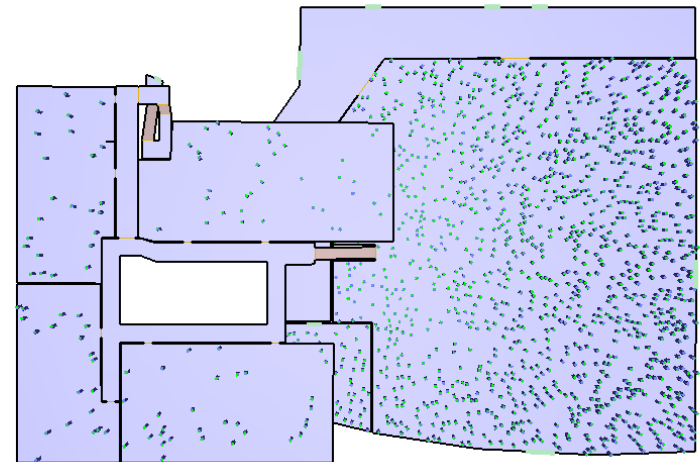
- Movement-optimization
 - Travel and flow optimized for quickest evacuation
 - Evacnet4
 - Coarse grid
 - Nodes
 - Initial room occupant load
 - Maximum occupant capacity
 - Arcs
 - Travel time
 - » Calculated with SFPE movement equations
 - Maximum flow
 - » Calculated with SFPE flow calculations



- Partial occupant behavior
 - Implicitly account for some behavior aspects
 - Pathfinder 2009.2
 - Individuals move through a coordinate-based system
 - Constant or distributed parameters
 - SFPE or steering mode
 - Model creates 3-D building geometry
 - Occupants proceed to closest final exit



- 1420 occupants
 - Less concentrated assembly use: 0.71 persons/m²
 - Business use: 0.1 persons/m²
- Movement calculations per SFPE
 - Note: Pathfinder in steering mode does not modify velocity and flow in the same way
- No pre-movement
- Shoulder width of 46 cm





| | Hand Calculation | Evacnet | Pathfinder, SFPE and Steering |
|---|-----------------------------|----------------|--|
| Base Case | X | X | X |
| Occupant Density | | X | X |
| Velocity | | X | X |
| Shoulder Width | | | X |
| Pre-movement distribution | | | X |
| Pre-movement, shoulder width and velocity distributions | | | X |



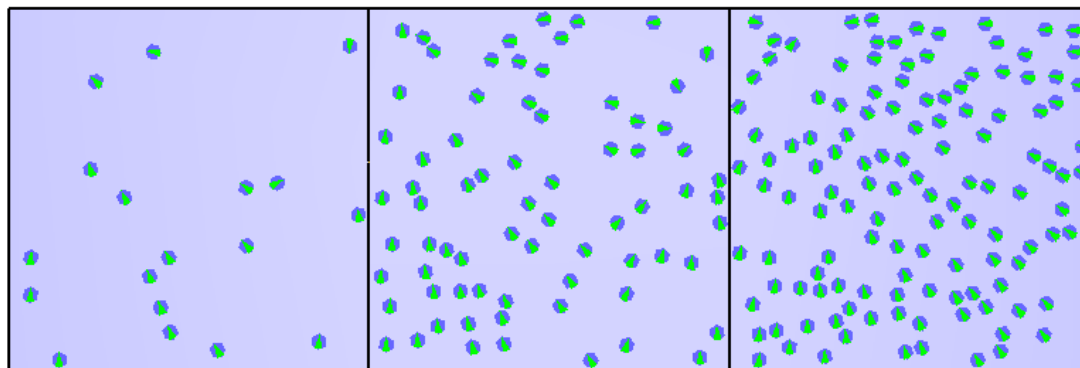
- Occupant density

- 25%-175% of initial 0.71 persons/m² value

- 0.18 persons/m² to 1.25 persons/m² in assembly areas

- LSC comparisons

- Library reading rooms: 0.22 persons/m²
 - Casinos and similar gaming areas: 1.00 persons/m²
 - Concentrated use, without fixed Seating: 1.54 persons/m²



0.18 p/m²

0.71 p/m²

1.25 p/m²



- Unimpeded walking velocity
 - 50%-175% of initial 1.19 m/s value
 - 0.60 m/s to 2.08 m/s
 - Standard deviation typically 0.25 m/s (Lord, 2005)
- Shoulder width
 - 50%-175% of initial 46 cm value
 - 23 cm to 80 cm
 - P+M comparison (Predtechenskii, 1978)
 - Child: 30-34 cm
 - Adult with light package: 75 cm



- Pre-movement distributions
 - 5 s to 25 s standard deviations
 - Range that includes queue and pre-movement driven results
- Scenario with velocity, shoulder width & pre-movement distributions
 - Shoulder width
 - 46 cm with 8 cm standard deviation
 - Velocity
 - 1.19 m/s with 0.25 m/s standard deviation
 - Pre-movement
 - 60 s with 10 s standard deviation



Base case occupant distribution for exits:

| Method | Exit | | | |
|-------------------------------|------|-----|-----|----|
| | A | B | C | D |
| Hand Calculation | 46% | 20% | 30% | 4% |
| Evacnet | 46% | 20% | 29% | 5% |
| Pathfinder, SFPE and steering | 56% | 17% | 22% | 5% |

- Pathfinder automatically selects nearest exit
- Evacnet exit distribution alters to optimize evacuation time

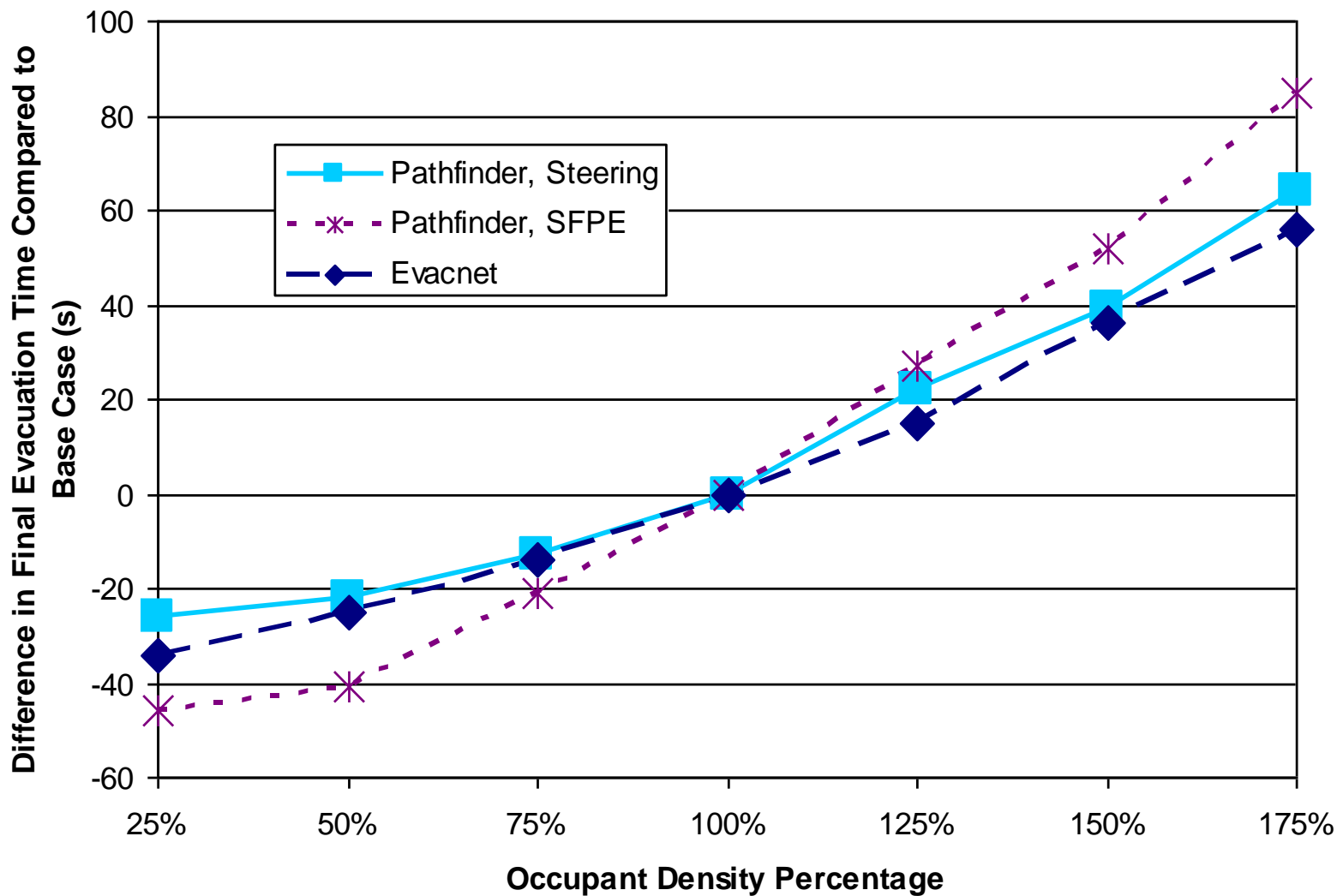


Base case evacuation times:

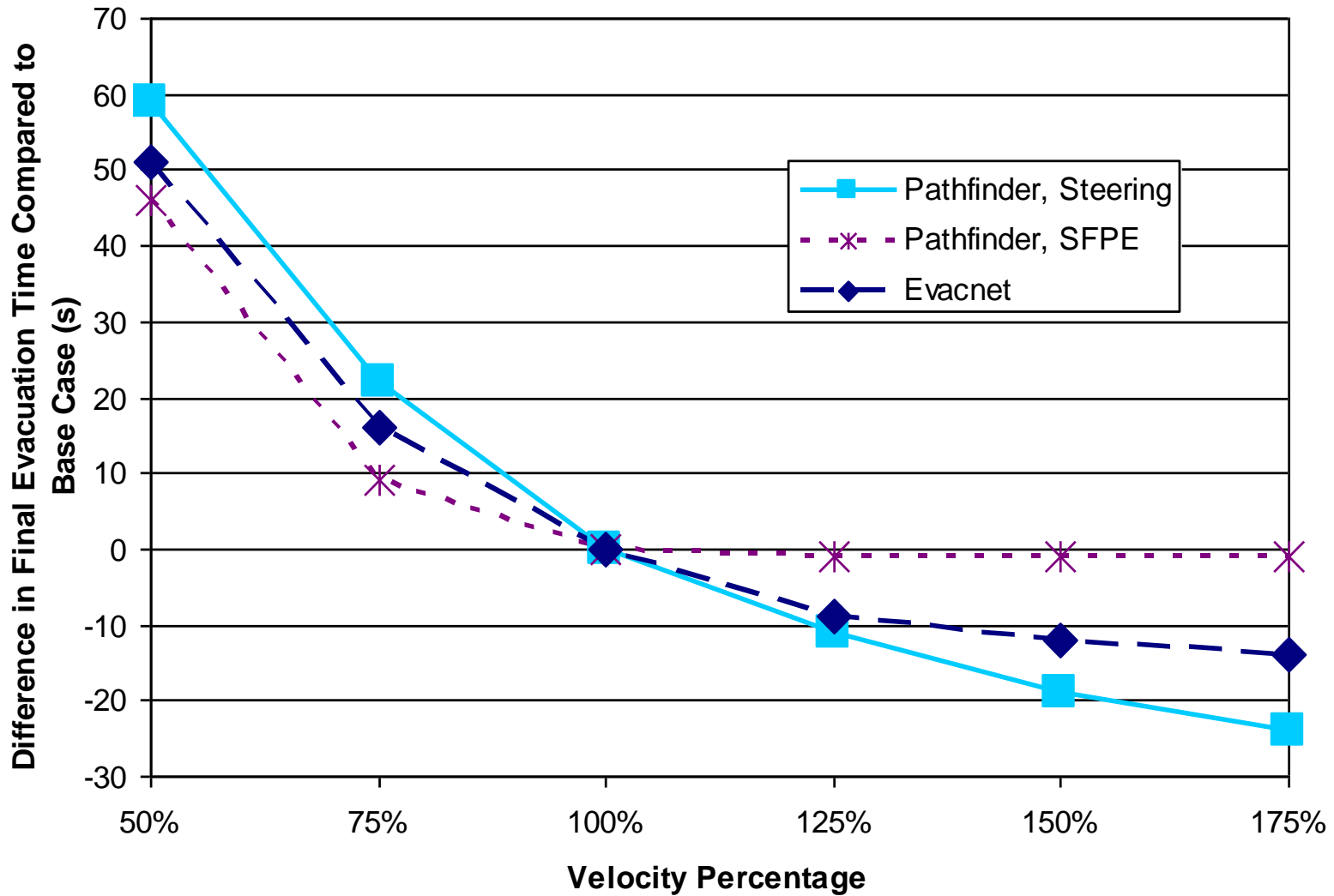
| | Hand Calculation | Evacnet | Pathfinder (SFPE) | Pathfinder (Steering) |
|------------------|------------------|---------|-------------------|-----------------------|
| Evacuation Times | 109 s | 101 s | 103 s | 78 s |

- Pathfinder in steering mode uses different movement equations vs SFPE mode
- Influence of group vs. individual movement

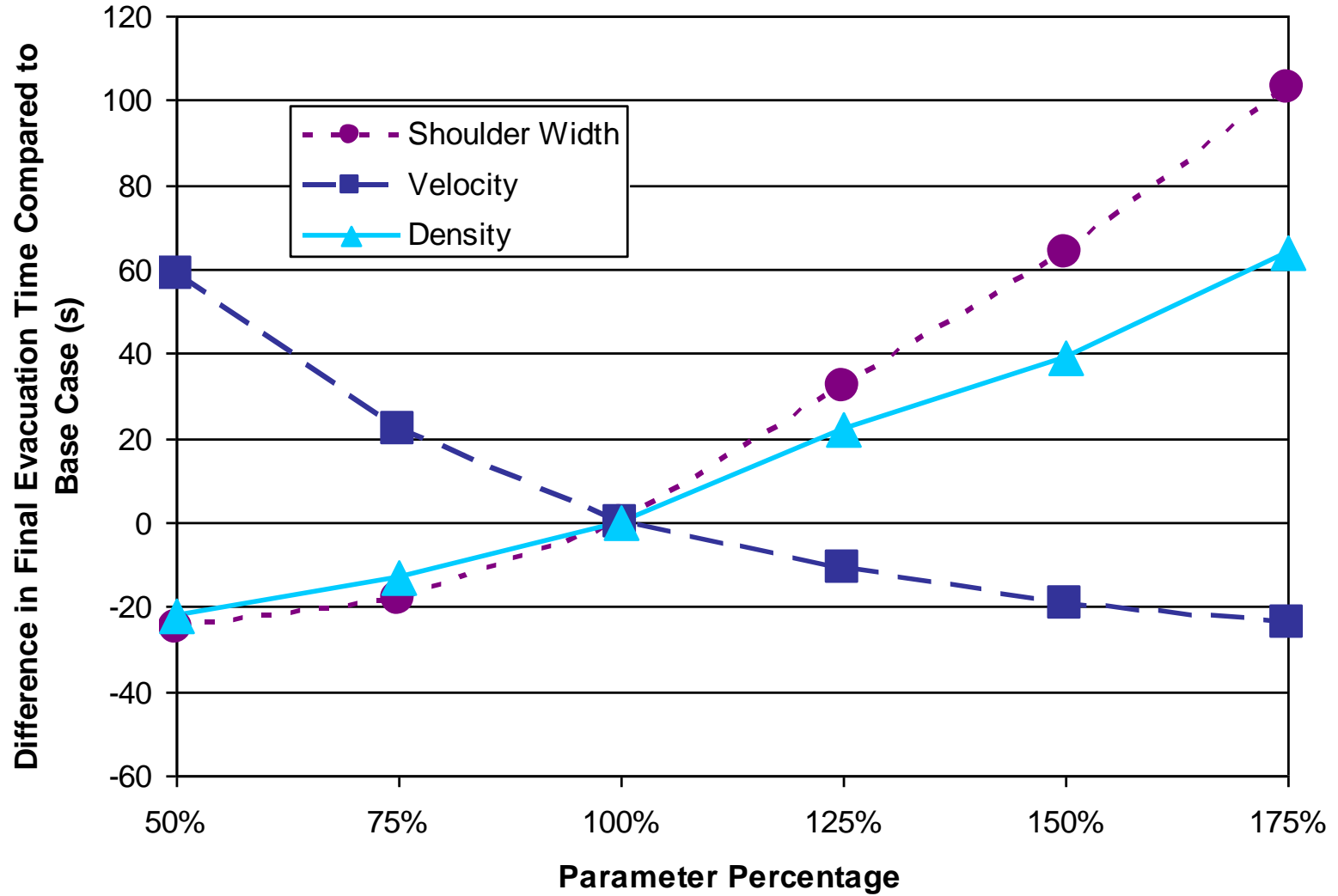
Occupant Density Compared with Base Case



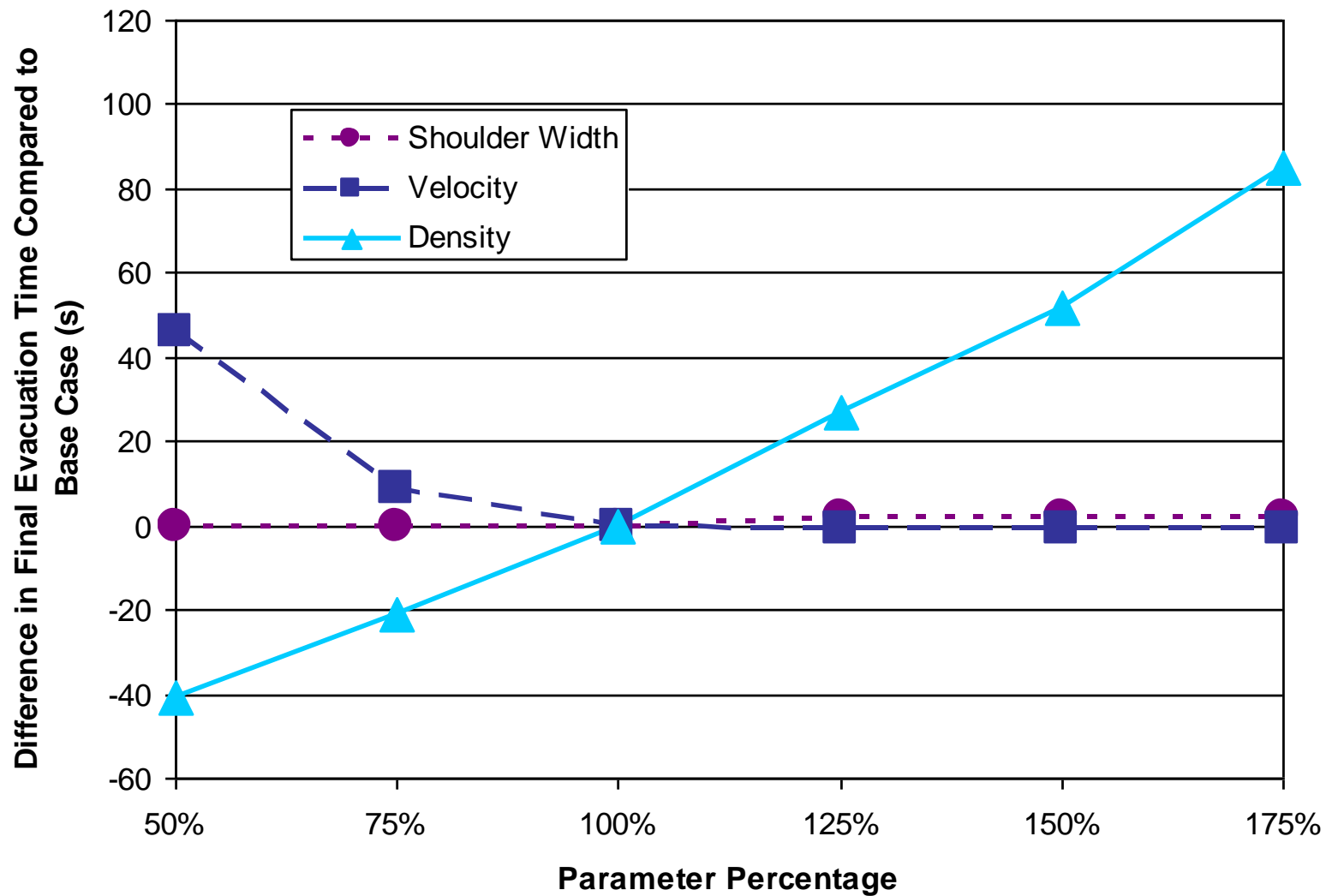
Unimpeded Occupant Velocity Compared with Base Case



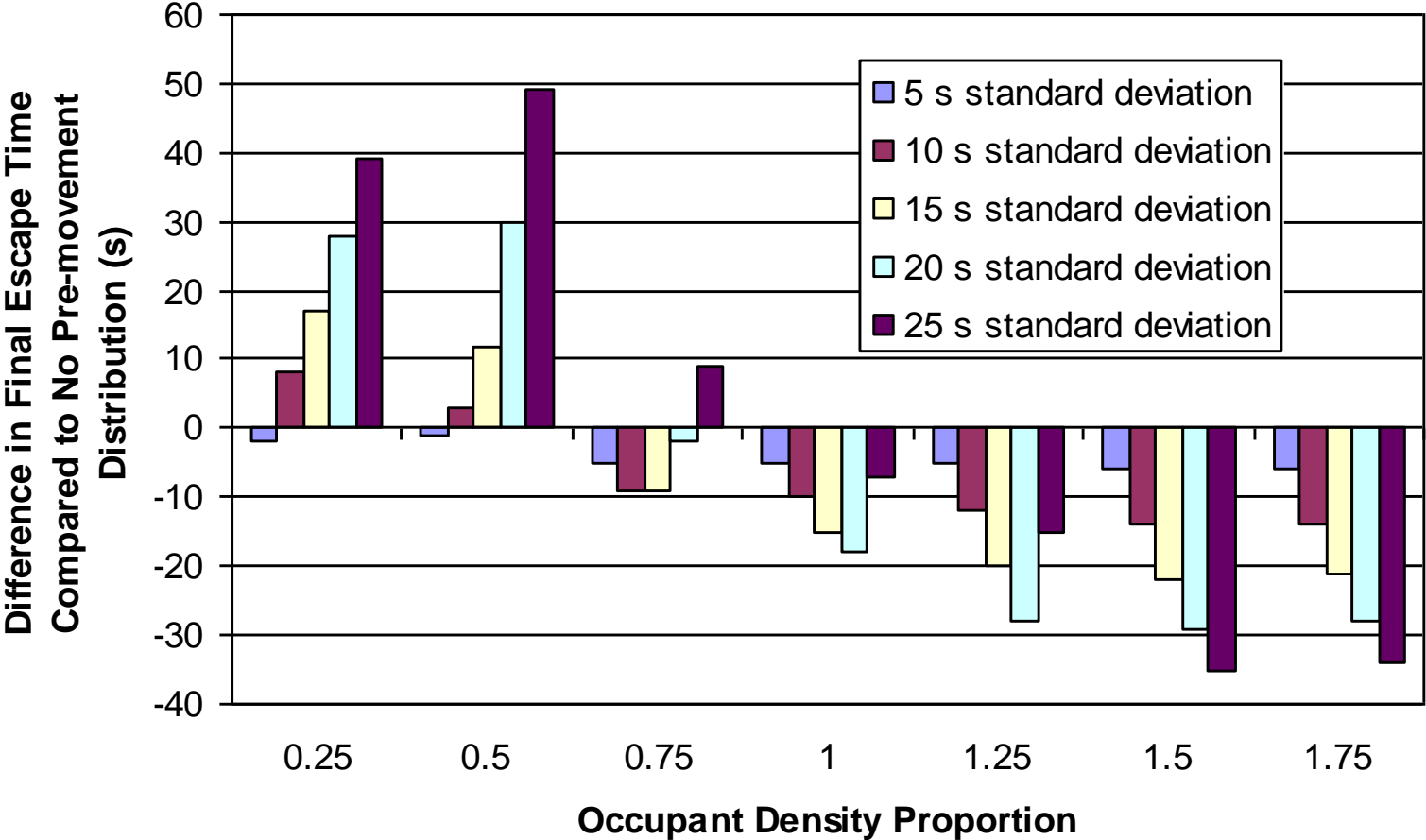
Input Parameter Comparison (Steering)



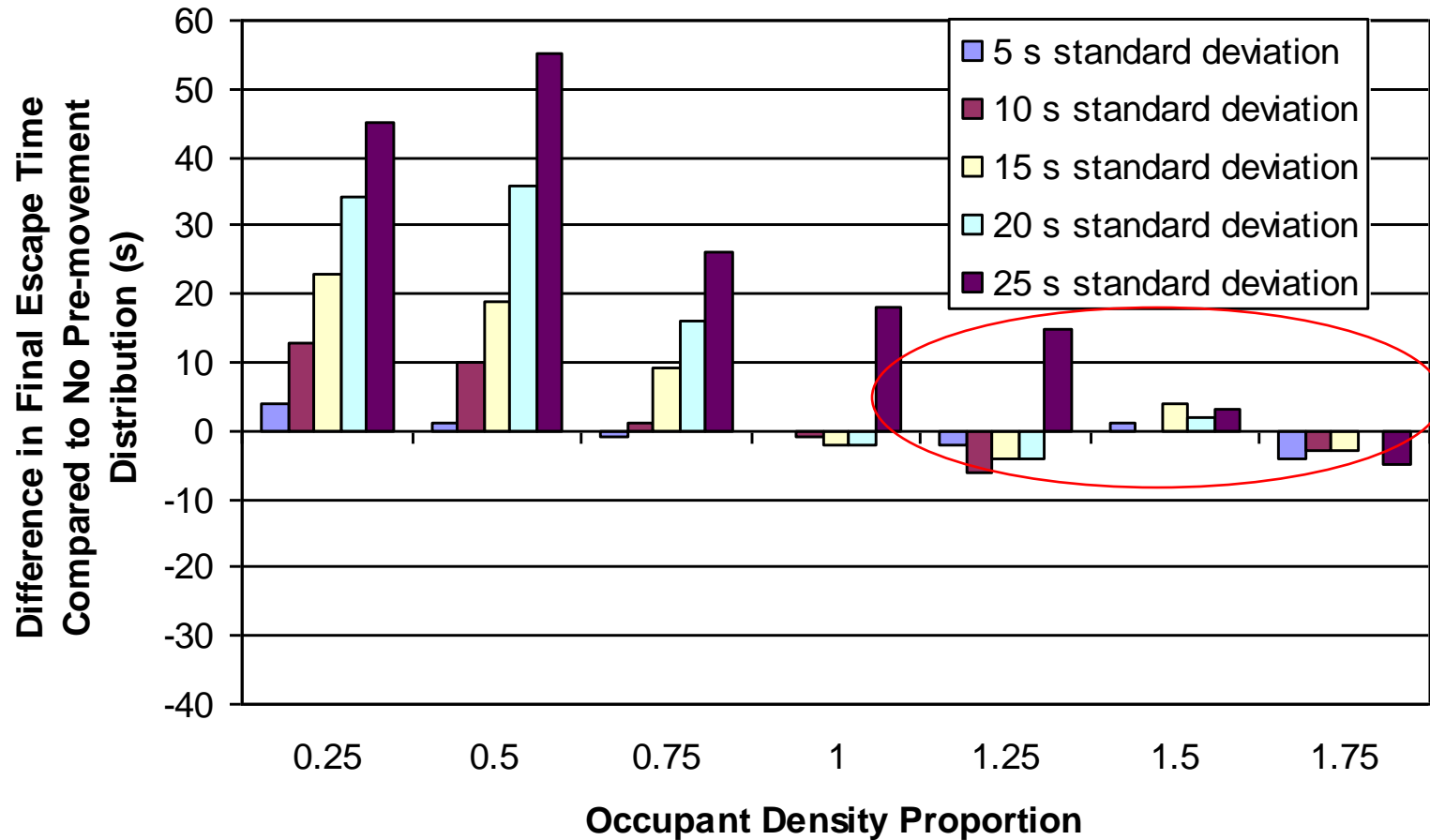
Input Parameter Comparison (SFPE)



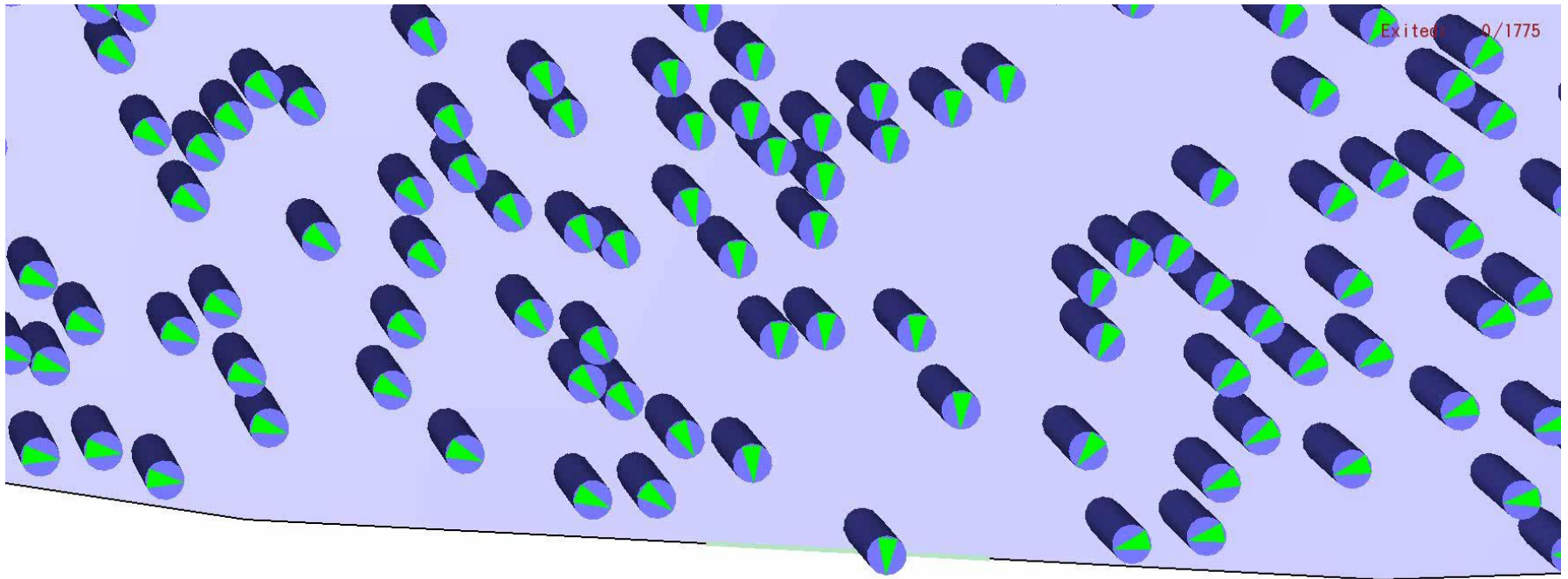
Pre-Movement Distributions (SFPE)



Pre-Movement Distributions (Steering)

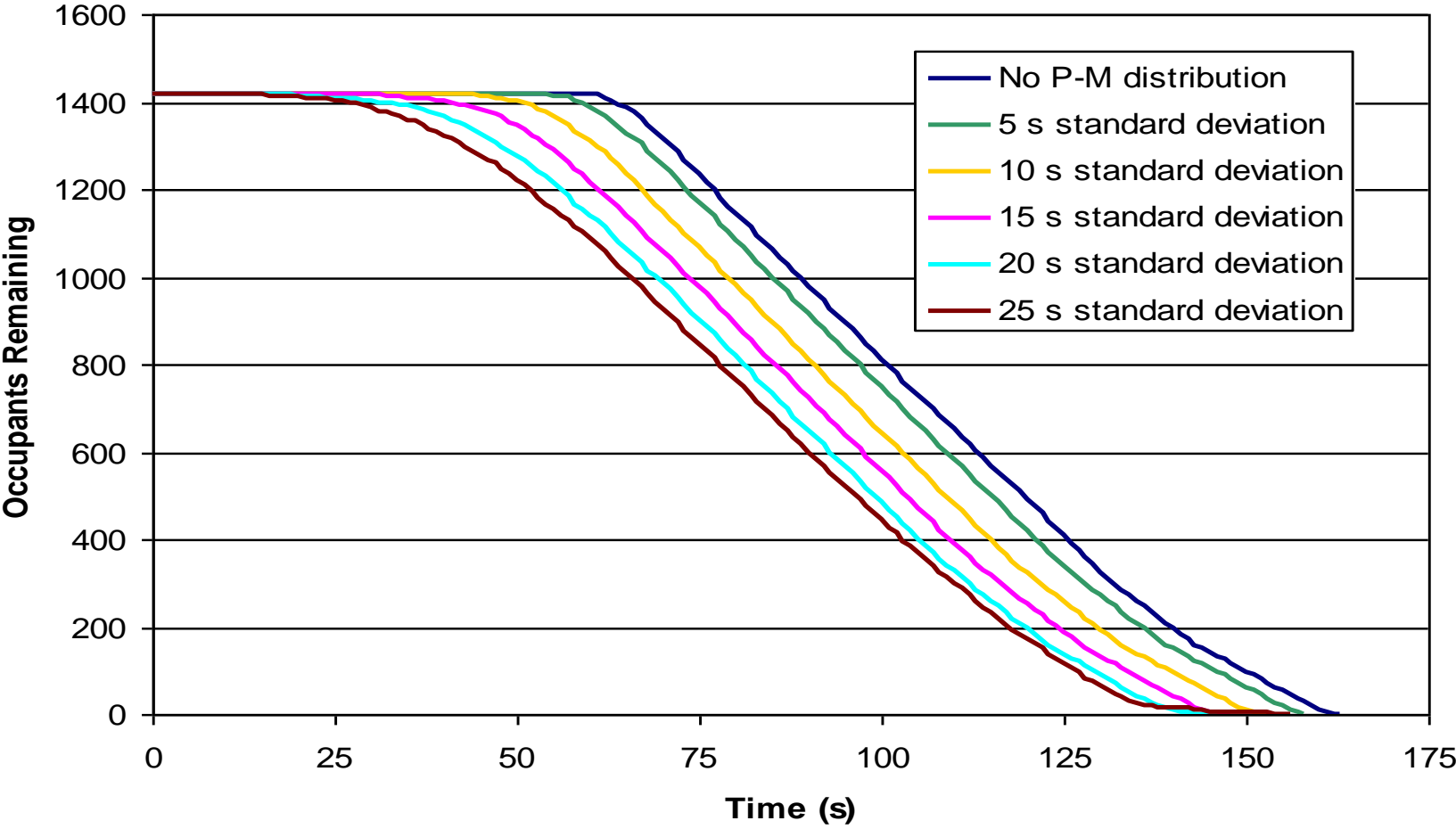


Intermediate Queuing (Steering)

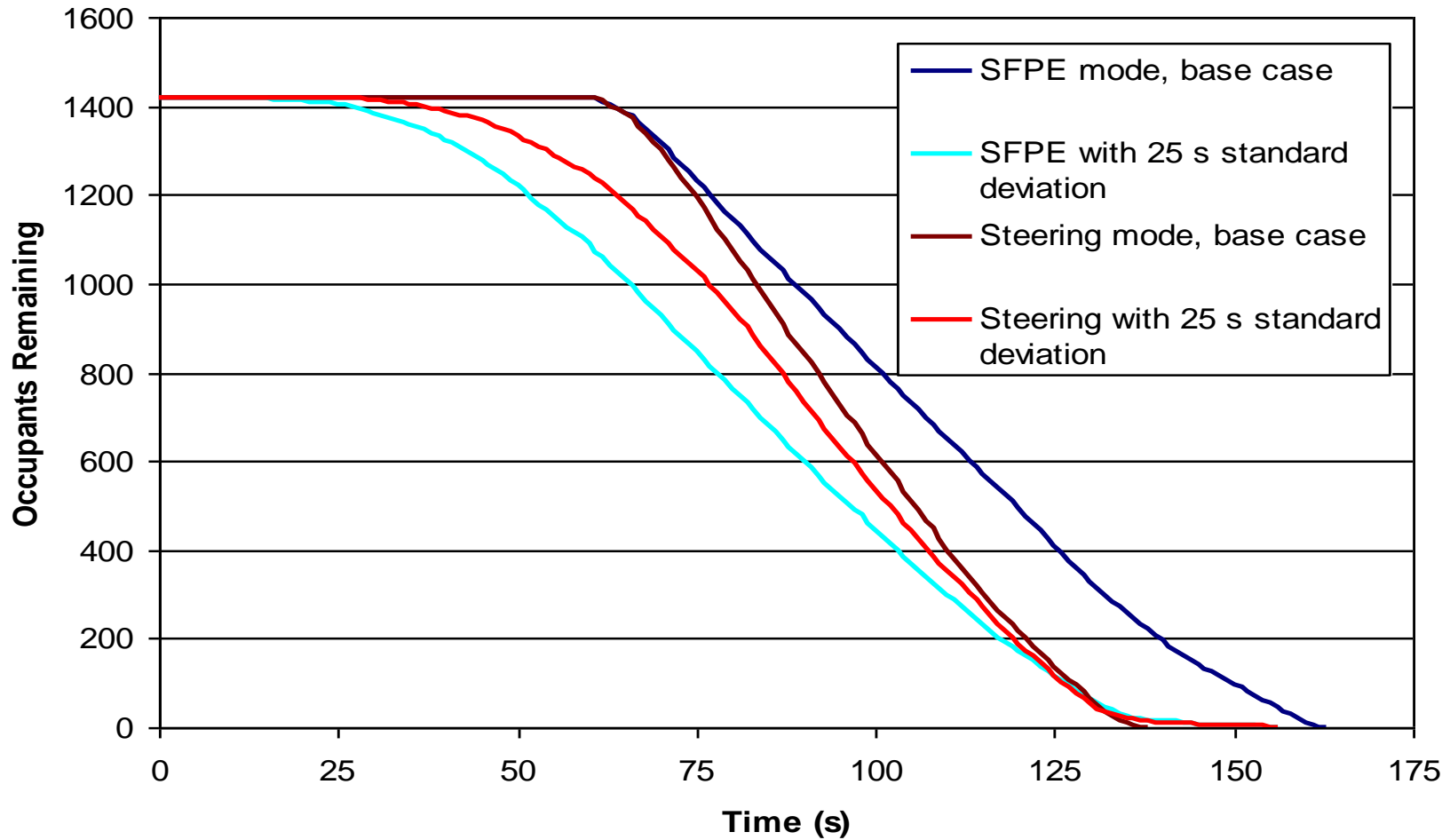


0.1

Pre-Movement Distributions (SFPE)



Pre-Movement Distributions (SFPE vs. Steering)





- Steering mode
 - Increased by 17 s when compared to base case scenario
 - Increase seen from velocity distribution with minimal effects from pre-movement and shoulder width
- SFPE mode
 - Decreased by 5 s when compared to base case scenario
 - Decrease comes from pre-movement distribution, while velocity distribution adds time



- **Findings:**
 - Exit decision
 - Network structure
 - Pre-movement and intermediate queuing
 - Flow control at doorways
 - Velocity distribution

- **Pathfinder 2011**
 - Modified path decision and intermediate queuing

Thank you



holmesfire

brian.salyers@holmesfire.com