Micro-Simulation Modeling of PRM's

Is the London PRM Framework Applicable in North America and Does It Affect Modeling Output?

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Ove Arup - Founded in 1946

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10,000+ Employees Globally

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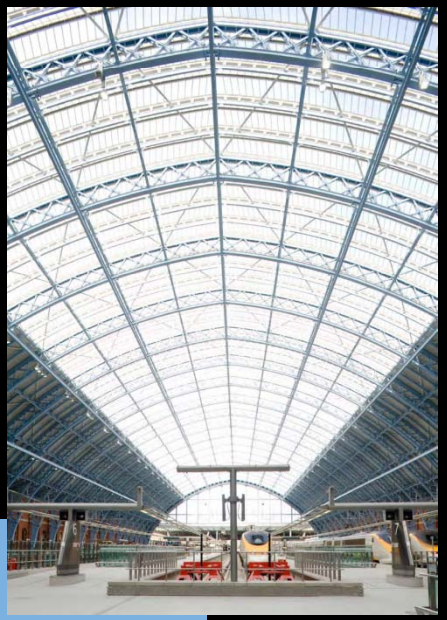
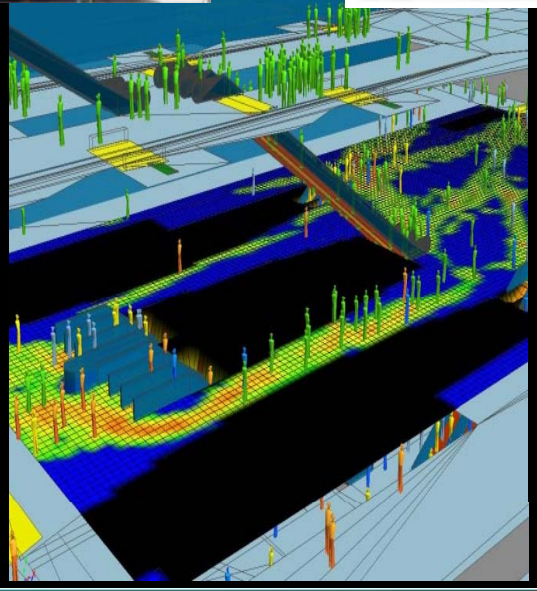
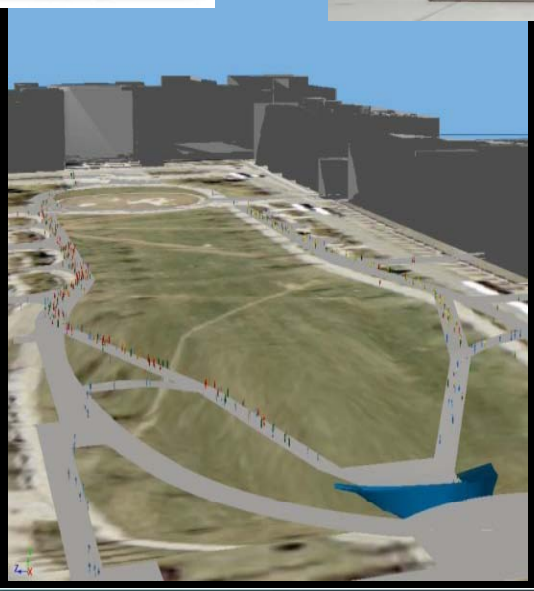
Extensive Pedestrian Planning Experience







Presentation Overview

- **What is the London PRM Framework?**
- **Brief commentary on its applicability beyond London**
- **Analysis of its impact on model output/facility design**
- **Discussion of Shortcomings in Methodology and Further Work Required**

The London Framework: Context

- **Population Growth Projections**
- **Crowded Transit + Modal Shift Policies**
- **Financial Constraints**

…….Space Planning ever more important

- **Demographic and Lifestyle trends**
- **DDA 1995**
- **100 Stations Accessibility Network**

London Context: Similarities with North America?

- **Population Growth Projections - Yes**
- **Crowded Transit + Modal Shift Policies - Yes**
- **Financial Constraints – Always and Everywhere!!**

…….Space Planning ever more important

- **Demographic and Lifestyle trends - Yes**
- **UK: DDA 1995 – USA: ADA 1990**
- **Station Accessibility Programs – Yes**

The London Framework

- **Disaggregate the Population**
- **Describe movement Characteristics of Disaggregated Groups**
- **Quantify those Groups (recognising spatial and temporal variations)**
- **Modify “UK Commuter” default parameters as appropriate during model construction**

Person with Reduced Mobility: LUL Definition

Table 1, Passenger Size Movement Characteristics [5]

Category	Mean Speed	Mean Size (sqm)	Routing Characteristics
Non-PRM	1.53 m/s	0.087sqm	No restrictions
Wheelchair User	0.58 m/s	0.683sqm	Always use accessible routes
Passengers with permanent or temporary Physical Impairments	0.80 m/s	0.102sqm	Preference for accessible routes
Non-disabled Passengers with medium sized Luggage	1.53 m/s	0.393sqm	Preference for accessible routes
Non-disabled Passengers with Large Luggage	1.32 m/s	0.562sqm	Preference for accessible routes
Adults with Young Children (including Pushchairs)	1.37 m/s	0.682sqm	Preference for accessible routes

Table 1 describes the PRM categories proposed by Pearce, Powell, Duff, Anigbogu and Kerr [5] and currently used by London Underground and the wider TfL transport planning community in London when performing pedestrian modeling studies.

……groups of pedestrians with reduced speed of movement, large footprint size, or other special movement needs

PRM Categorisation: Applicability Beyond London

- **Need for Additional Sub-groups?**
  - **Passengers with cycles**
  - **Passengers with special wayfinding needs (unfamiliar users, sight impaired passengers)**
  - **Group movement**
- **Adaption of footprint and speed profiles to fit local data and/or standards**

……subject to local adaption and dependant on software/data limitations, but otherwise universally applicable

PRM Movement: Population Distributions

- **Extensive Local Survey Data**
- **Network trip generation forecasts due to Accessible Station Programme (+19 million pa**
- **= c. +1.9% Network Growth)**
- **Disaggregation by Station Typologies**
- **Disaggregation by Time of Day**

……framework is universal but population distributions are not: local data is required to understand local context and may require additional typologies (airport, stadium, hospital, etc)…… all subject to software limitations

Should We Bother – Is It Worth the Extra Effort?

- **Intuition/common sense suggests yes……**
  - **Potential Space Planning Impacts (?) +**
  - **Better demonstration of how facilities will be used, helping meet mandates to "mainstream" inclusivity considerations in the design process =**
  - **better design …. and that was enough for LUL**
- **Where data is limited and/or where a client is not convinced of the value - can PRM impacts be quantified?**

Potential Space Planning Impacts for Transit - Static Example of an Accessible Bus Line

Q. maximum capacity of 68 passengers/bus …..or 75?

A. Both - Dependent on use of PRM Space on board.

Potential Space Planning Impacts for Transit

Transit Corridor with Keypoint Demand = 560/hr

Planning Capacity = 75% of Maximum Capacity

Requires service frequency of 10 buses per hour…….or 11 buses per hour?

Affects Planning …….and has a cost implication upwards of $200,000 (per peak bus) per annum

Potential Space Planning Impacts on Transit

- **Space Planning for transit station facilities requires dynamic analysis of space and is much more complex than Static Space Calc (Bus Line)**
- **Requires Pro-active not Re-active Planning**
- **Performance Metrics Influence Design and may be affected if PRM Movement is considered**
  - **Platform clearance times**
  - **Densities**
  - **Journey times**

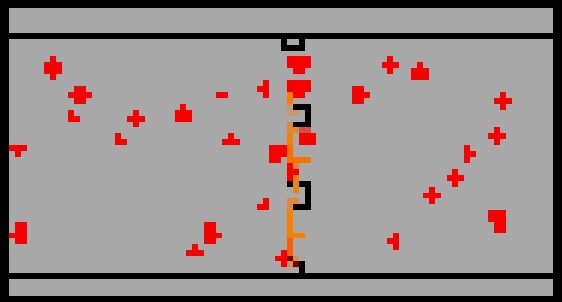
Analyzing the Impact : Study Methodology

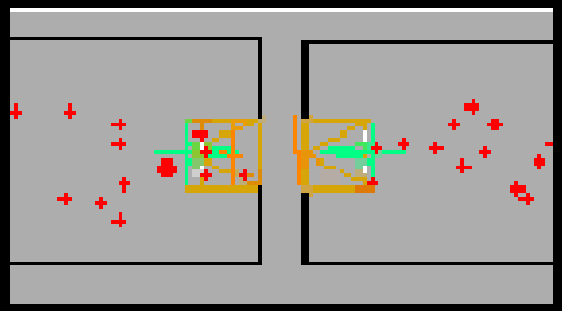
Flow Rate (Max) = Function (Speed, Size)

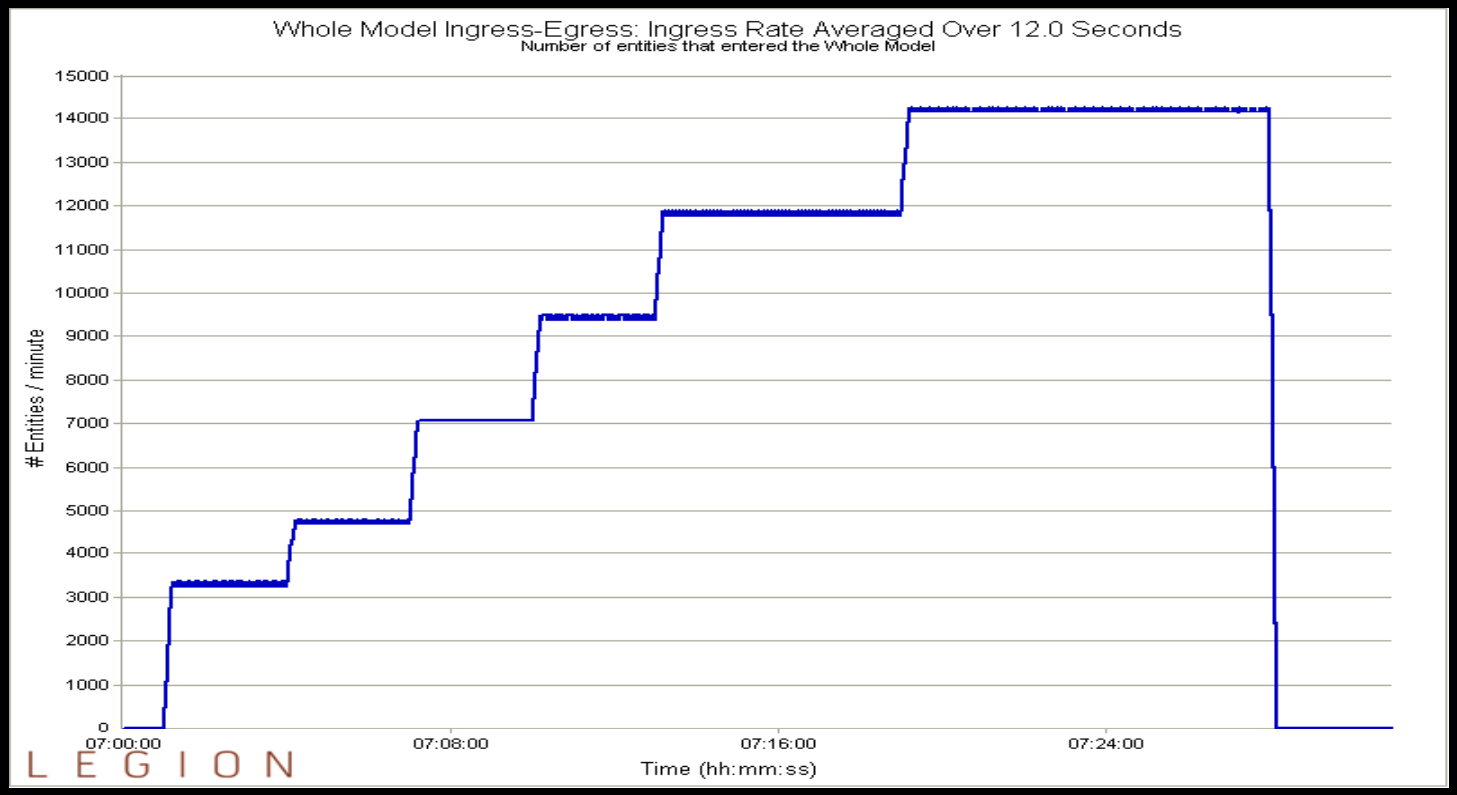
- **4 Simple Models**
  - **Walkway one way**
  - **Walkway two way (50/50 flow)**
  - **Stair one way**
  - **Stair Two way**
- **9 Population Speed Profiles**
- **4 Different Agent Sizes**

……144 tests/data points with which to analyze the relationship

Analysing the Impact : Study Methodology







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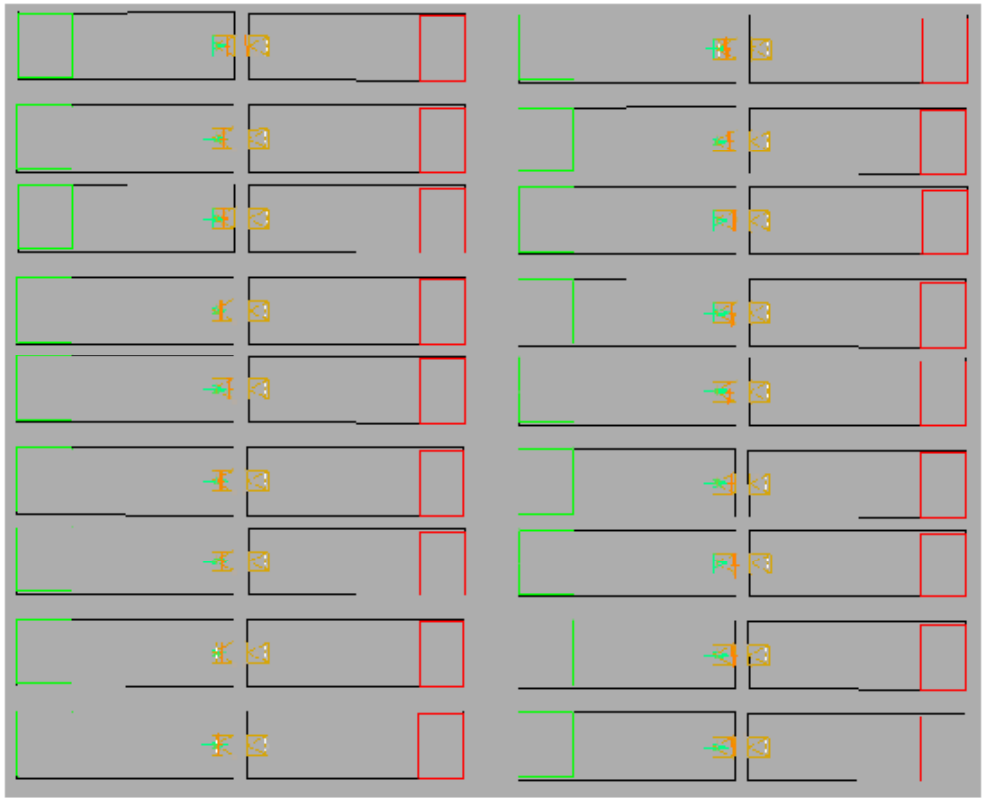
Analysing the Impact : Study Methodology



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Results

Appendix A

Test No	Test	Speed	Footprint Size	Max Flow/Metre	Max Flow Door 1	Max Flow Door 2	Max Flow Door 3	Max Flow Stair
10	Walkway 1 way	0.924	0.1	61	115	130	120	
11	Walkway 1 way	1.024	0.1	67	130	140	130	
12	Walkway 1 way	1.124	0.1	75	150	150	150	
13	Walkway 1 way	1.224	0.1	82	160	170	160	
14	Walkway 1 way	1.324	0.1	89	175	180	180	
15	Walkway 1 way	1.424	0.1	96	185	195	195	
16	Walkway 1 way	1.524	0.1	101	200	200	205	
17	Walkway 1 way	1.624	0.1	108	210	230	210	
18	Walkway 1 way	1.724	0.1	113	225	230	225	
19	Walkway 1 way	0.924	0.21	48	80	90	85	
20	Walkway 1 way	1.024	0.21	48	95	100	95	
21	Walkway 1 way	1.124	0.21	52	100	110	100	
22	Walkway 1 way	1.224	0.21	55	110	115	105	
23	Walkway 1 way	1.324	0.21	60	125	120	115	
24	Walkway 1 way	1.424	0.21	63	120	130	125	
25	Walkway 1 way	1.524	0.21	66	130	130	135	
	Walkway 1							

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Results : Walkway Tests

- **As Speed Increases, so does Maximum Capacity**
- **As Size Increases, maximum capacity reduces**

The data allows the relationship to be described in greater detail as shown by equation 1:

$$Y = 50.6 + 36.8X_1 - 150.8X_2$$

Where Y = *Maximum Flow (per metre per minute)*
X_1 = *Average Population Speed (metres per second)*
X_2 = *Average Population size (square metres)*

This equation produces predicted values that exhibit a Pearson correlation coefficient of 0.84 with the output from the tests.

Results : Stair Tests

- **Visual review of results appears to indicate similar trends but with more variability**

For stairway tests, a visual review of the results appears to show a more variable pattern of results. However, using the same methodology, the relationship between the variables can be described with a similar degree of confidence as described by equation 2:

$$Y = 31.9 + 28.6X_1 - 119.6X_2$$

Where Y = *Maximum Flow (per metre per minute)*
X_1 = *Average Population Speed (metres per second)*
X_2 = *Average Population size (square metres)*

This equation produces predicted values that exhibit a Pearson correlation coefficient of 0.80 with the output from the tests.

Results : Applying the Equations

Station Type	Time Period	Access/Egress	Average Speed	Average Size	Walkway Max Flow	Stairway Max Flow
Terminus	AM Peak	Access	1.53	0.099	92.0	63.8
Terminus	Midday	Access	1.52	0.116	89.0	61.5
Terminus	PM Peak	Access	1.52	0.129	87.1	59.9
Terminus	Weekend	Access	1.52	0.135	86.2	59.2
Terminus	AM Peak	Egress	1.53	0.099	92.0	63.8
Terminus	Midday	Egress	1.52	0.117	88.9	61.4
Terminus	PM Peak	Egress	1.52	0.129	87.1	59.9
Terminus	Weekend	Egress	1.52	0.136	86.0	59.1
Tourist	AM Peak	Access	1.53	0.096	92.4	64.2
Tourist	Midday	Access	1.52	0.11	89.9	62.2
Tourist	PM Peak	Access	1.52	0.12	88.4	61.0
Tourist	Weekend	Access	1.52	0.125	87.7	60.4
Tourist	AM Peak	Egress	1.53	0.094	92.7	64.4
Tourist	Midday	Egress	1.52	0.105	90.7	62.8
Tourist	PM Peak	Egress	1.52	0.112	89.6	62.0
Tourist	Weekend	Egress	1.52	0.117	88.9	61.4
				Maximum	92.7	64.4
				Minimum	83.5	57.1

- **Walkway Maximum – 83.5 to 92.7 pmm**
- **Stair Maximum – 57.1 to 64.4 pmm**

Conclusions

- **The London Framework is universally applicable subject to appropriate local modification**
- **Relationship between Maximum Flow Rates and population characteristics can be described with reasonable but not precise accuracy**
- **Fruin remains conservative (NB - only if 1.53 m/s is realistic average speed for non-PRM passengers)**
- **This relationship indicates variability of c. 10% associated with LUL PRM population forecasts**

……design best practice requires movement of PRM's to be fully factored into the design process, ……depending on local circumstance, it may alter design guidance output from studies

Limitations of the Study

- **Iteration of results (ideally 144 tests x 10 iterations)**
- **Validation against real-world survey data**
- **Software limitations**
- **Simplistic test geometries**

Future Work

- **Software Development (software is seriously lagging behind end user requirements)**
- **Knowledge Development (data, data, data……)**

…. Pragmatic approach to meet stakeholder requirements…….it's a good start

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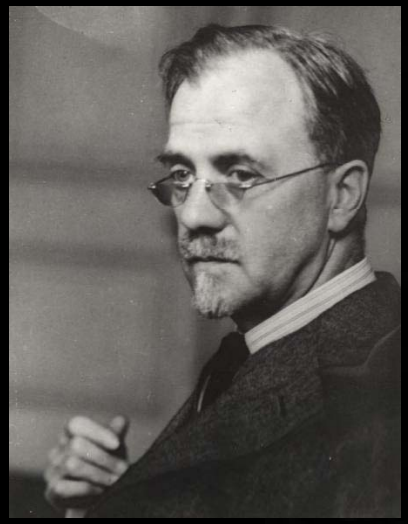
Legacy of today's decisions will last beyond our lifetime.

Positive Legacy?



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..... or not so Positive?

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.....thank you

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