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King's Cross Underground Station Pedestrian Evacuation Model
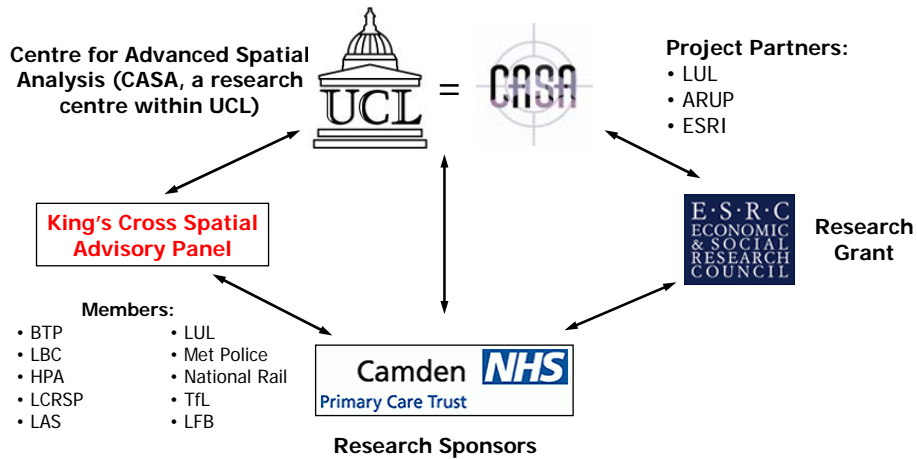
CASA Seminar – 7th March 2007

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UCL

Overview

- Research partners
- Context & Outline
  - Research aim
  - Study area – King's Cross
- Pedestrian Evacuation Software Applications
  - Guidelines and Evaluation
- KX Pedestrian Evacuation Model
  - Inner workings
  - Demo
- Future Work

Research Partners

Centre for Advanced Spatial Analysis (CASA, a research centre within UCL)

UCL = **CASA**

Project Partners:
• LUL
• ARUP
• ESRI

King's Cross Spatial Advisory Panel

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Research Grant

Members:

• BTP	• LUL
• LBC	• Met Police
• HPA	• National Rail
• LCRSP	• TfL
• LAS	• LFB

Camden NHS Primary Care Trust

Research Sponsors

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Context

- Why (at project inception)?
  1) Tokyo (1995), 9/11(2001), Bali (2002), Madrid (2004)...
  2) Civil Contingency Act 2004
  3) Credible threat - Tony Blair, Ken Livingstone, ...

- London - July 2005
  - 56 Fatalities, ~ 700 injured

- KX Redevelopment
  - Underground station
  - 2012 Olympics - 60% increase in passengers
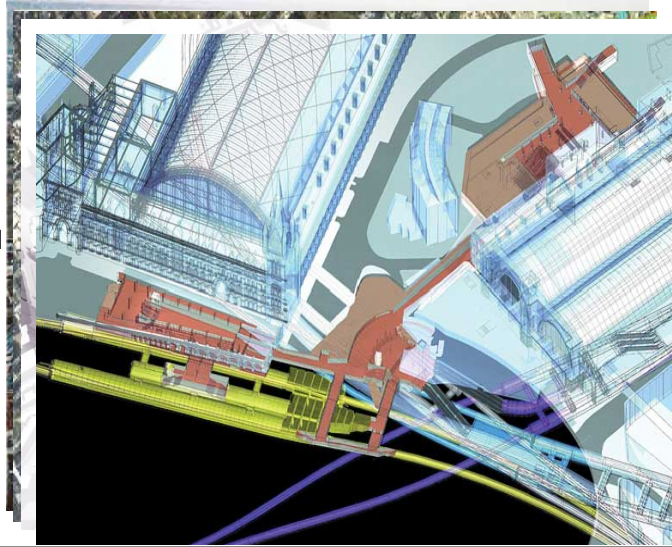
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King's Cross Redevelopment

1) Channel Tunnel Rail Link Link (CTRL) / St Pancras Station

2) King's Cross Central

3) Underground station

Video

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Aims

- Overarching
  - Quantitatively and qualitatively evaluate emergency pedestrian egress from King's Cross Underground station for different incident scenarios, based on future passenger demand forecasts, and variance in user characteristics at different times of the day and week.

- Research Questions
  - How will the dynamic of the evacuation process be affected at Kings Cross Underground station, given:
    - Different very short term incident scenarios
    - Predicted longer term increases in passenger demand
    - Different times of day and week

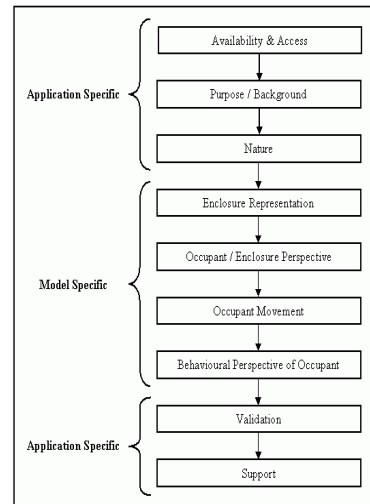- Potential to assist statutory responders

Pedestrian Evacuation Software Applications

- Guidelines
  - Nine topic areas
    - Application specific
    - Model specific
  - Castle (2007) – CASA working paper 115
- Evaluation (Castle & Longely 2007)
  - 27 'available' building evacuation models
  - 4 potential candidates
- However
  - Proprietary, black box, validity …

Application Specific	Availability & Access
	Purpose / Background
	Nature
Model Specific	Enclosure Representation
	Occupant / Enclosure Perspective
	Occupant Movement
	Behavioural Perspective of Occupant
Application Specific	Validation
	Support

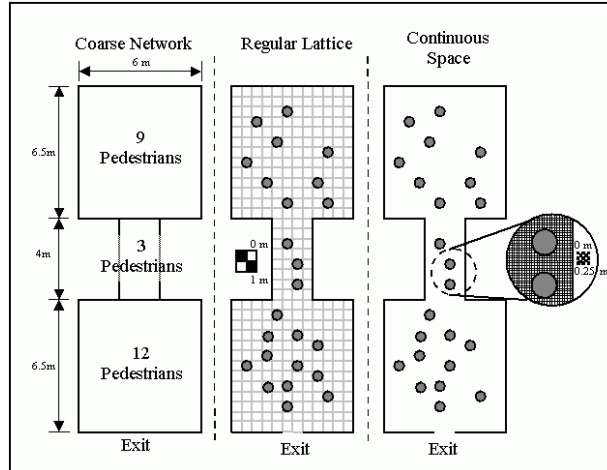## KX Pedestrian Evacuation Model

- One possible solution
  - Agent-based simulation / modelling systems
  - Repast Toolkit
  - Castle & Crooks (2006) – CASA working paper 110
- Inner workings
  - Enclosure representation
  - Occupant / Enclosure Representation
  - Occupant Movement
  - Behavioural Perspective of Pedestrian

Enclosure Representation

Enclosure Representation
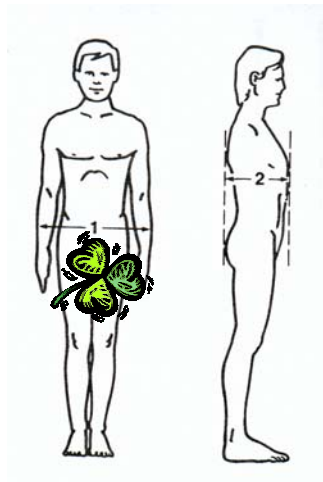
Nationality	Gender	Breadth (cm)			Depth (cm)		
		5th	50th	95th	5th	50th	95th
British	Male	42.0	46.5	51.0	21.5	25.0	28.5
	Female	35.5	39.5	43.5	21.0	25.0	29.5
Swedish	Male	42.0	46.5	51.0	18.5	22.0	25.5
	Female	35.5	39.0	42.5	18.5	24.1	30.0
Dutch	Male	43.0	47.5	52.0	24.0	28.5	33.0
	Female	35.5	40.0	44.5	23.0	29.0	35.0
French	Male	42.5	47.0	51.5	21.0	24.5	28.0
	Female	38.0	42.5	47.0	20.5	25.0	29.5
Polish	Male	40.5	44.0	47.5	21.5	24.5	27.5
	Female	35.0	38.0	41.0	20.5	24.5	28.5
USA	Male	42.5	47.0	51.5	22.0	25.5	29.0
	Female	36.0	40.0	44.0	21.0	25.5	30.0
Brazilian	Male	40.0	44.5	49.0	20.5	23.5	27.5
	Female	-	-	-	-	-	-
Sri Lankan	Male	33.0	37.0	40.0	14.5	17.0	20.5
	Female	30.0	30.0	36.0	13.0	17.0	21.0
Indian	Male	37.5	41.0	44.0	14.5	17.0	20.5
	Female	-	-	-	-	-	-
Hong Kong Chinese	Male	38.0	42.5	47.0	15.5	19.5	23.5
	Female	33.5	38.5	43.5	16.0	21.5	27.0
Japanese	Male	40.5	44.0	47.5	18.0	20.5	23.0
	Female	36.5	39.5	42.5	17.5	20.5	23.5

Occupant / Enclosure Representation

- Occupant Representation
  - Individual
    - Typically regular lattice or continuous space
    - Unique characteristics – movement & behaviour
  - Globally
    - Typically coarse scale network
    - Homogeneous ensemble – average density & speed
- Enclosure Representation
  - Individual
    - Bounded-rationality
  - Globally
    - Rationale-choice paradigm

Occupant Movement

- Speed of Occupant Movement
  - Flow / Hydraulic Equation
  - Pedestrian Speed of Movement Data
    - Secondary):
      - Hankin and Wright (1958)
      - Fruin (1971)
      - Predtechenskii and Milinskii (1978)
      - Ando *et al.* (1988)
      - Pauls (1995)
      - Nelson and Mowrer (2002),
      - Etc

Occupant Movement – Fruin (1971)
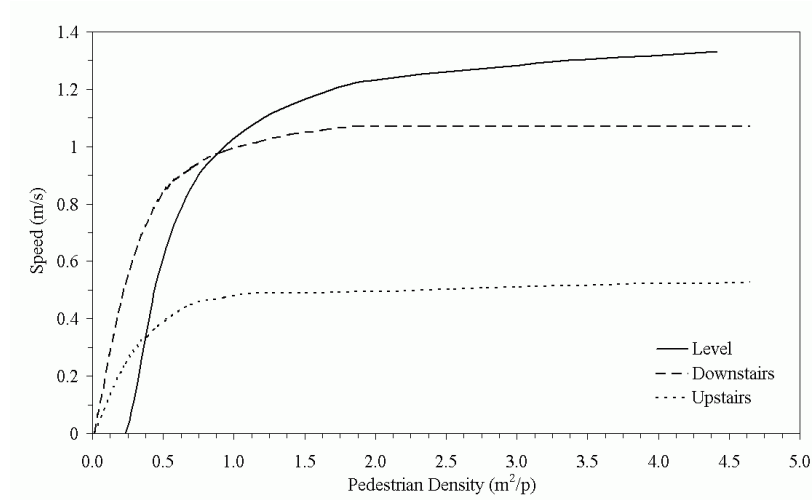
Occupant Movement – Ando (1988)
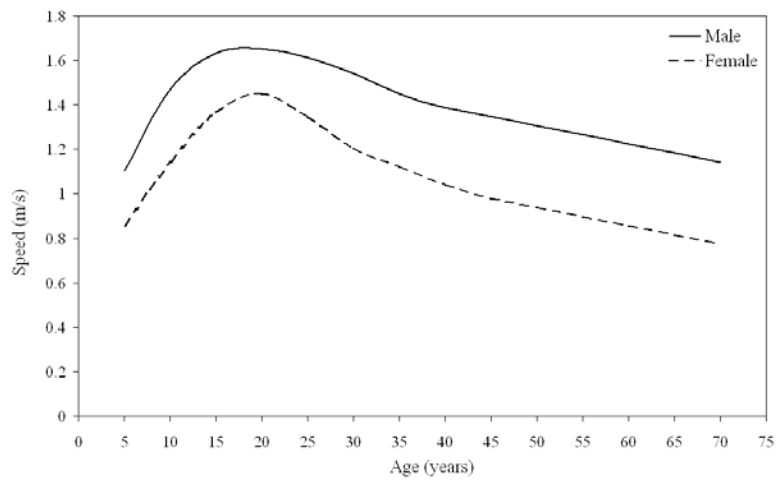
Occupant Movement

- Direction of Occupant Movement
  - Coarse scale network
    - Only movement between rooms
  - Regular lattice
    - Cell based
    - Cost surface, potential field, or flood fill map
  - Continuous Space
    - Velocity based vector
  - Functional-Analogy Approach
    - Fluid Dynamics / Gas-Kinetic Models (Henderson, 1971)
    - Social Force Model (Helbing and Molnár, 1995)
    - Magnetic Model (Okazaki and Matsushita, 1993)

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Behavioural Perspective of Pedestrian

- Behavioural Perspective
  - No behaviour
  - Implicit behaviour
  - Rule-based behaviour
    - Deterministically
    - Stochastically
    - Deterministically / Stochastically Implicit behaviour
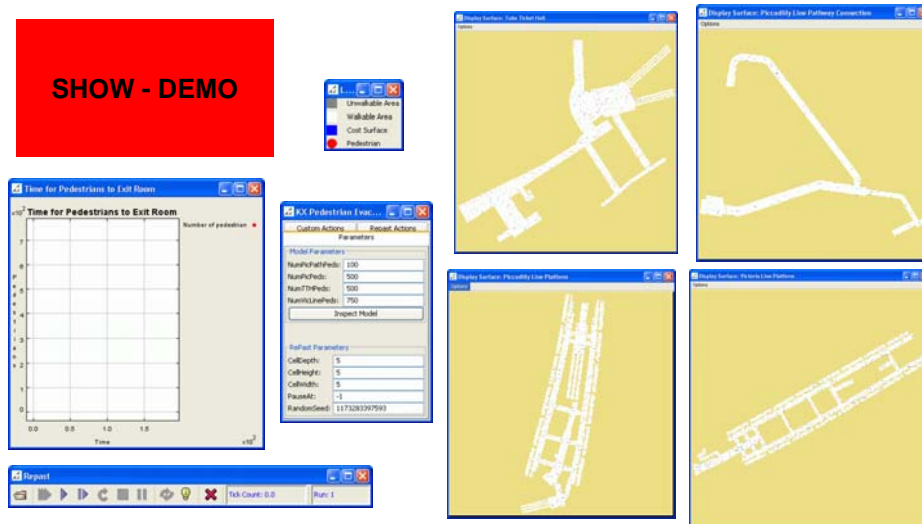 - Artificial Intelligence (AI) behaviour

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KX Pedestrian Evacuation Model

SHOW - DEMO

Future Work

- KX Pedestrian Evacuation Model – To do…
  - Speed as a function of:
    - Density
    - Age
    - Gender
  - Over taking
  - Pre-evacuation time
  - Cost surfaces
    - Distance transform 5x5, 10x10, 25x25…(de smith, 2004)
    - Top down vs bottom up
  - Etc..

Thank You

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