People Movement Modelling

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SMART Space

Optimising the Interface between People and Places

A Perfect world!

Max comfort

Min congestion

Max efficiency

The Real world!

Max comfort

Min congestion

Max efficiency

Simulating the real world

SMART Move

Simulating the real world

Widening corridors to solve congestion problems -
is like loosening your belt to cure obesity!

Why worry about crowd flow?

To minimise congestion (to maximise comfort)

City of Makkah during Hajj

Swiss National Day event in Basel

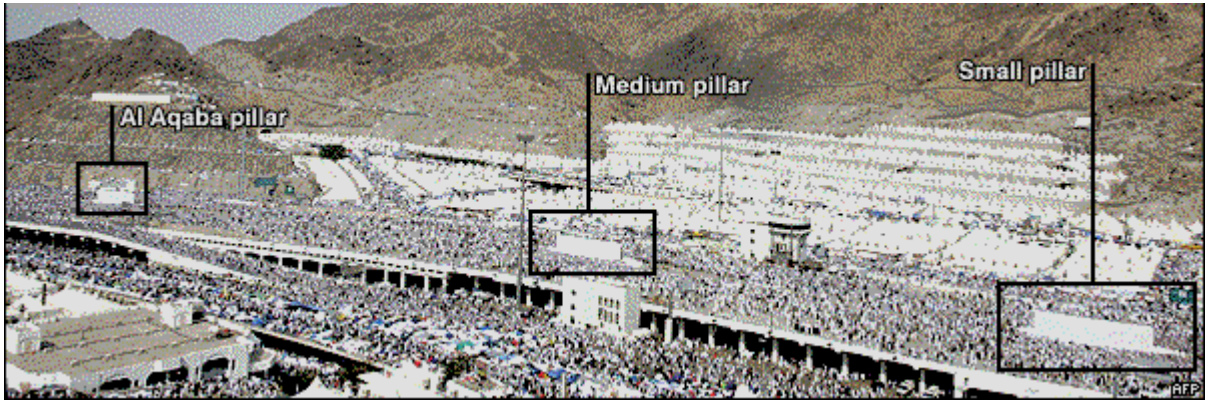
Cardiff city centre after Match day

Why worry about crowd flow?

To minimise accidents (to maximise safety)

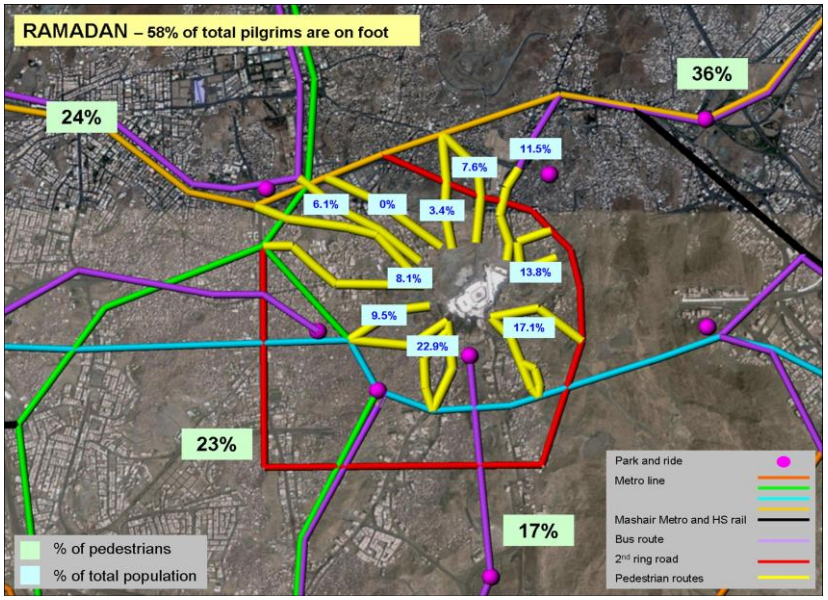
Love Parade disaster, 2010

Maha Kumbh Stampede, 2003/08/11



Hajj stampede, 2006

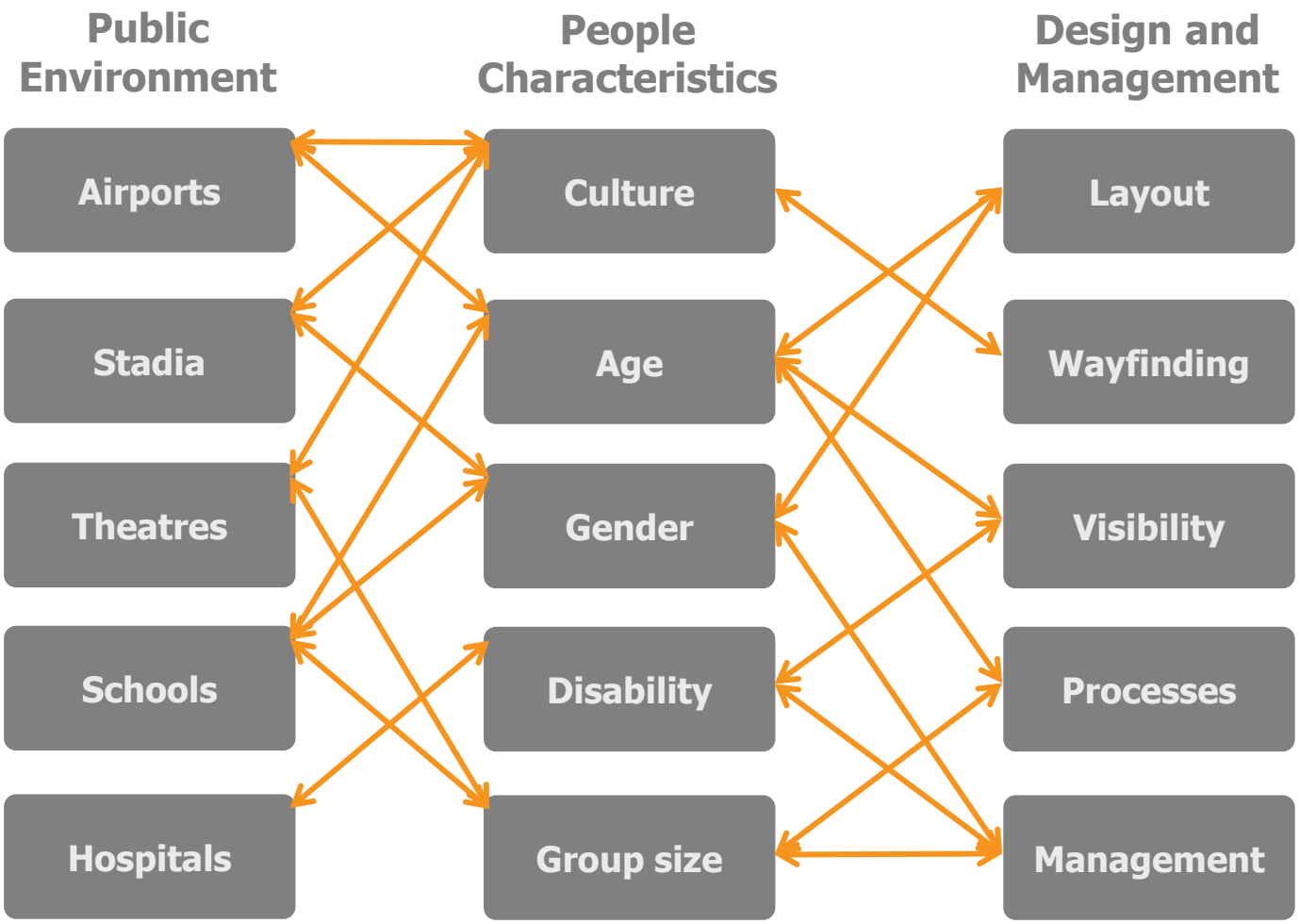
Solving crowd flow problems



Widening corridors to solve congestion problems - is like loosening your belt to cure obesity!

Can you predict human behaviour?

Can you model crowd flow?



Some counter-intuitive facts – escalator throughputs

Riding or **Walking**, which is more efficient?

A

Both lanes riding

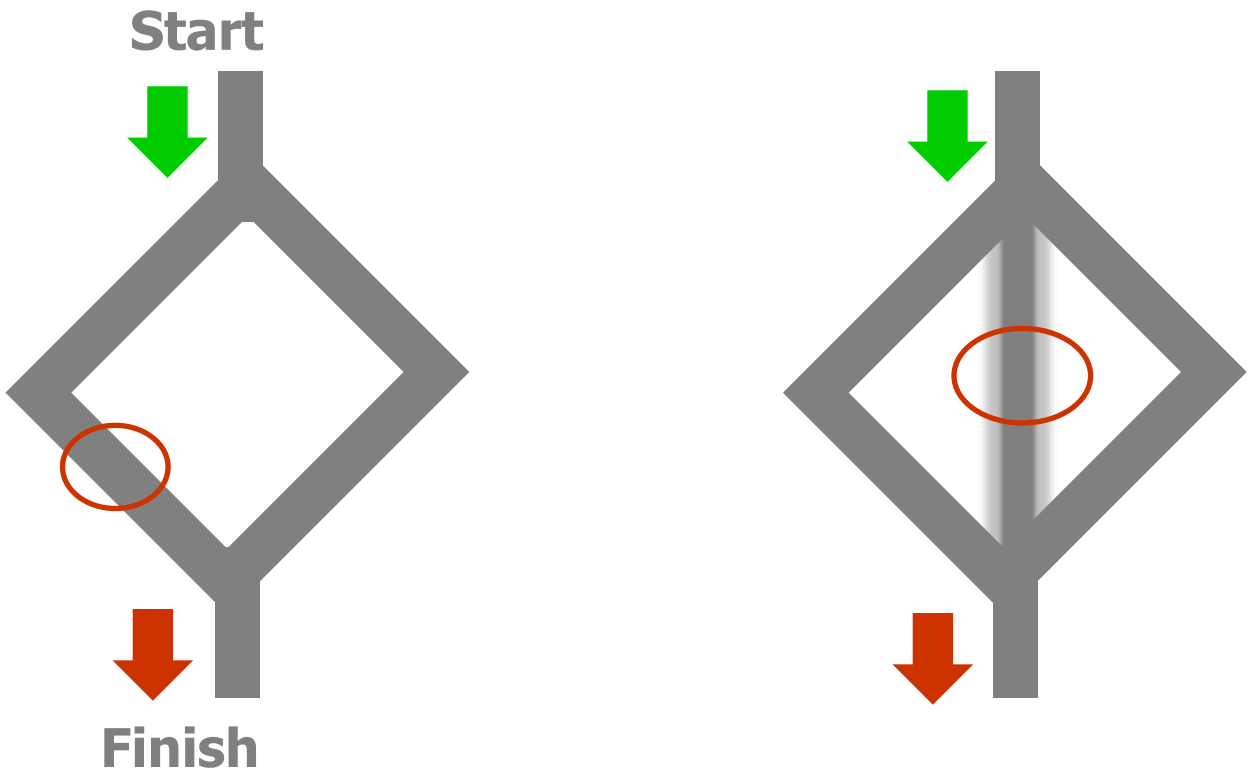
B

One lane walking

A < B ?

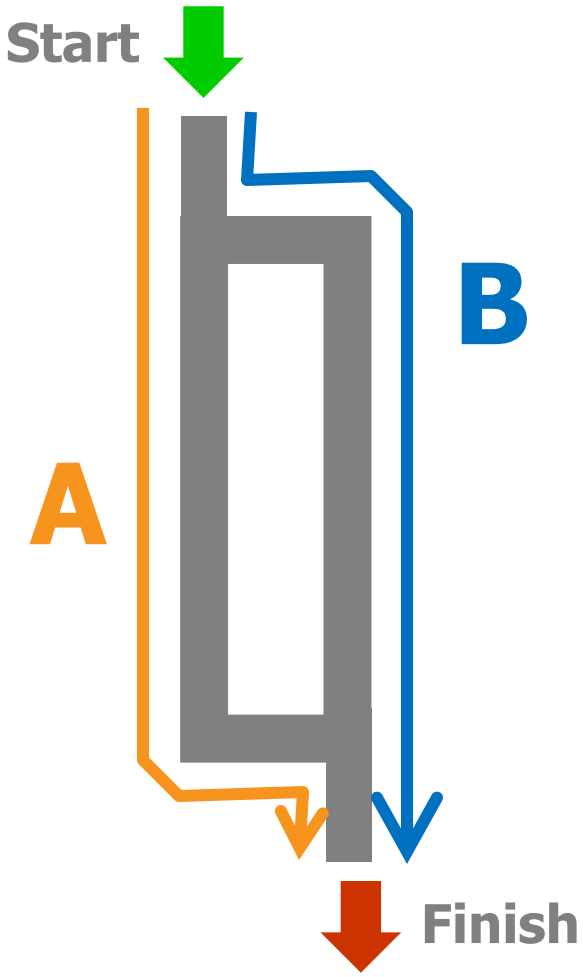
Some counter-intuitive facts – Braess's Paradox

Add route to reduce congestion?



Some counter-intuitive facts – shortest route?

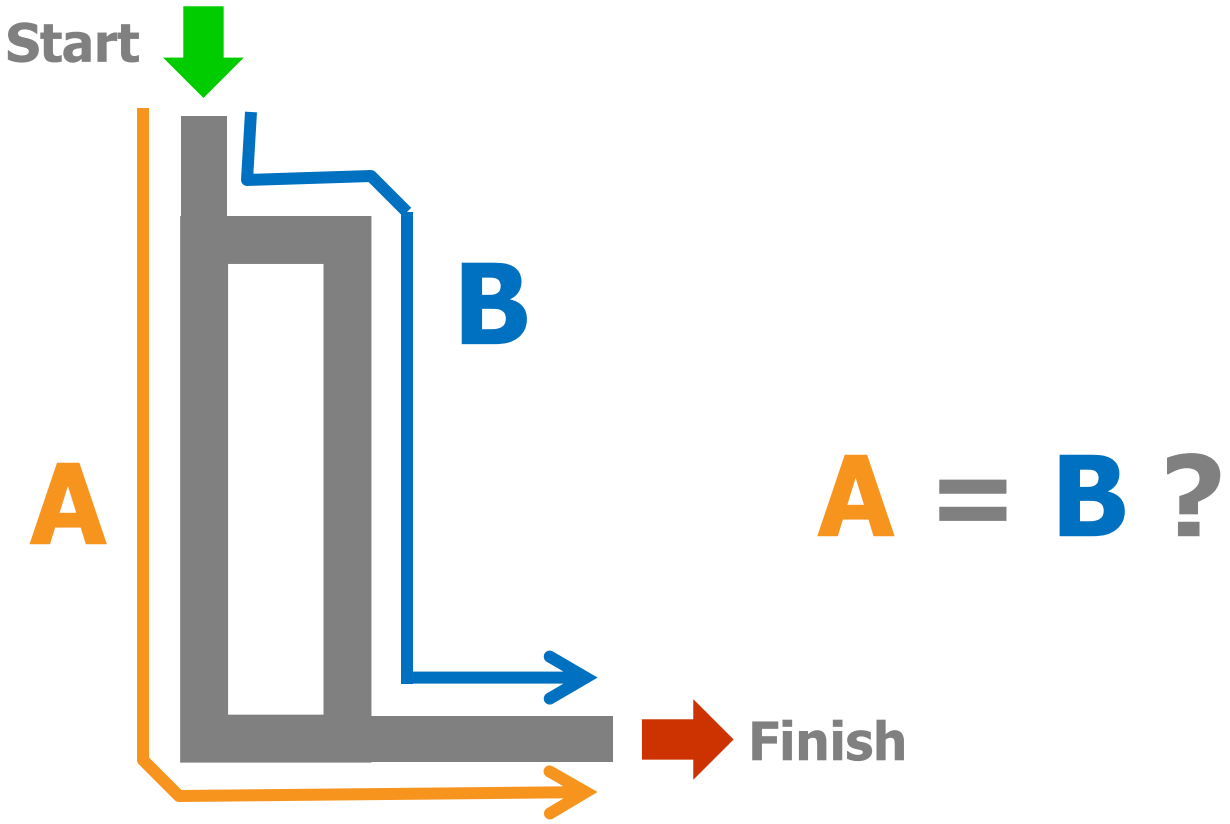
Do people take shortest route?



A = B ?

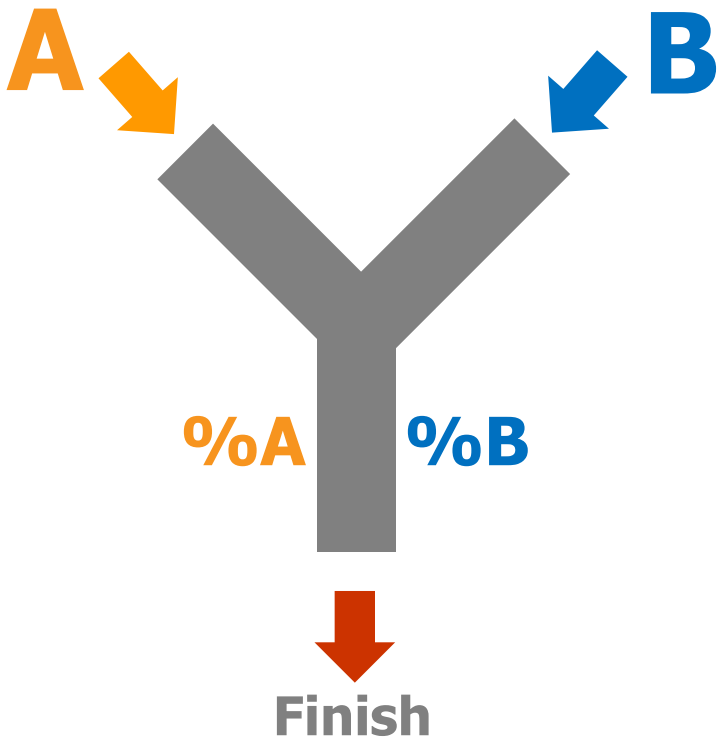
Some counter-intuitive facts – shortest route?

Do people take shortest route?



Some counter-intuitive facts – Merging of flows?

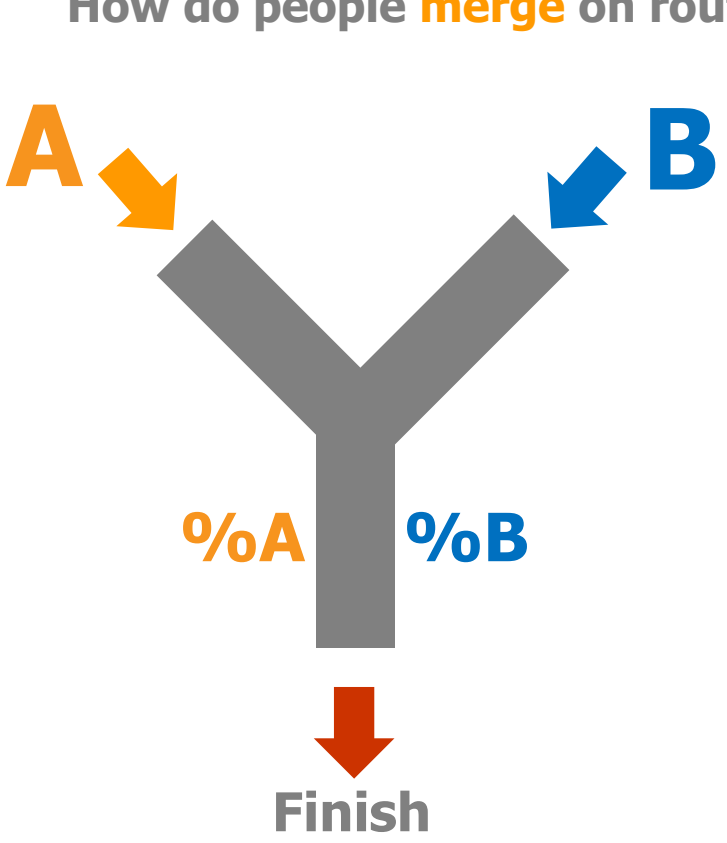
How do people merge on route?

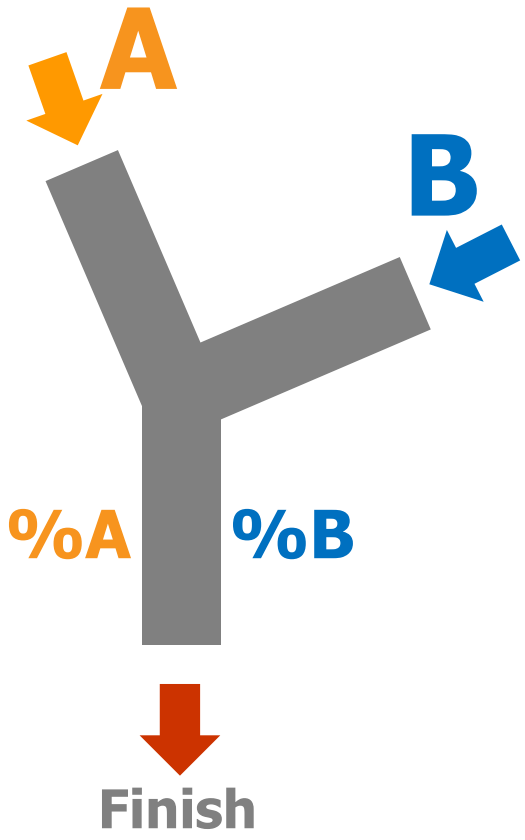


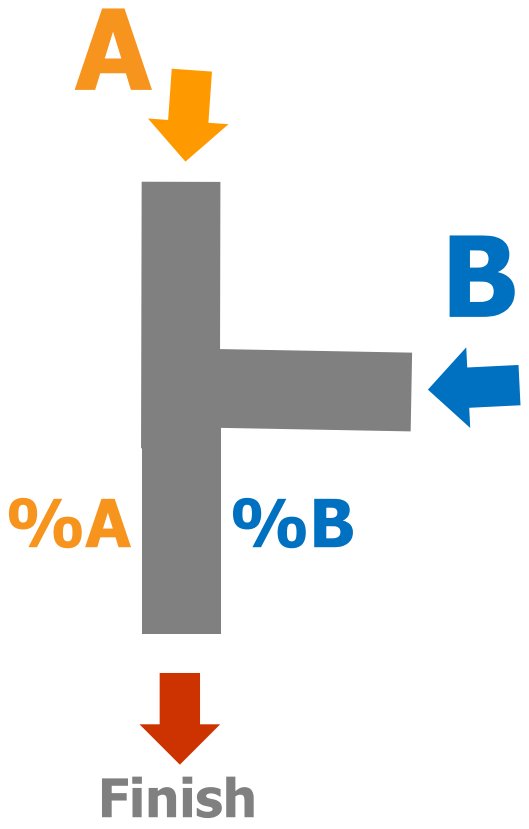
%A = %B ? (50-50 merging?)

Some counter-intuitive facts – Merging of flows?

How do people merge on route?



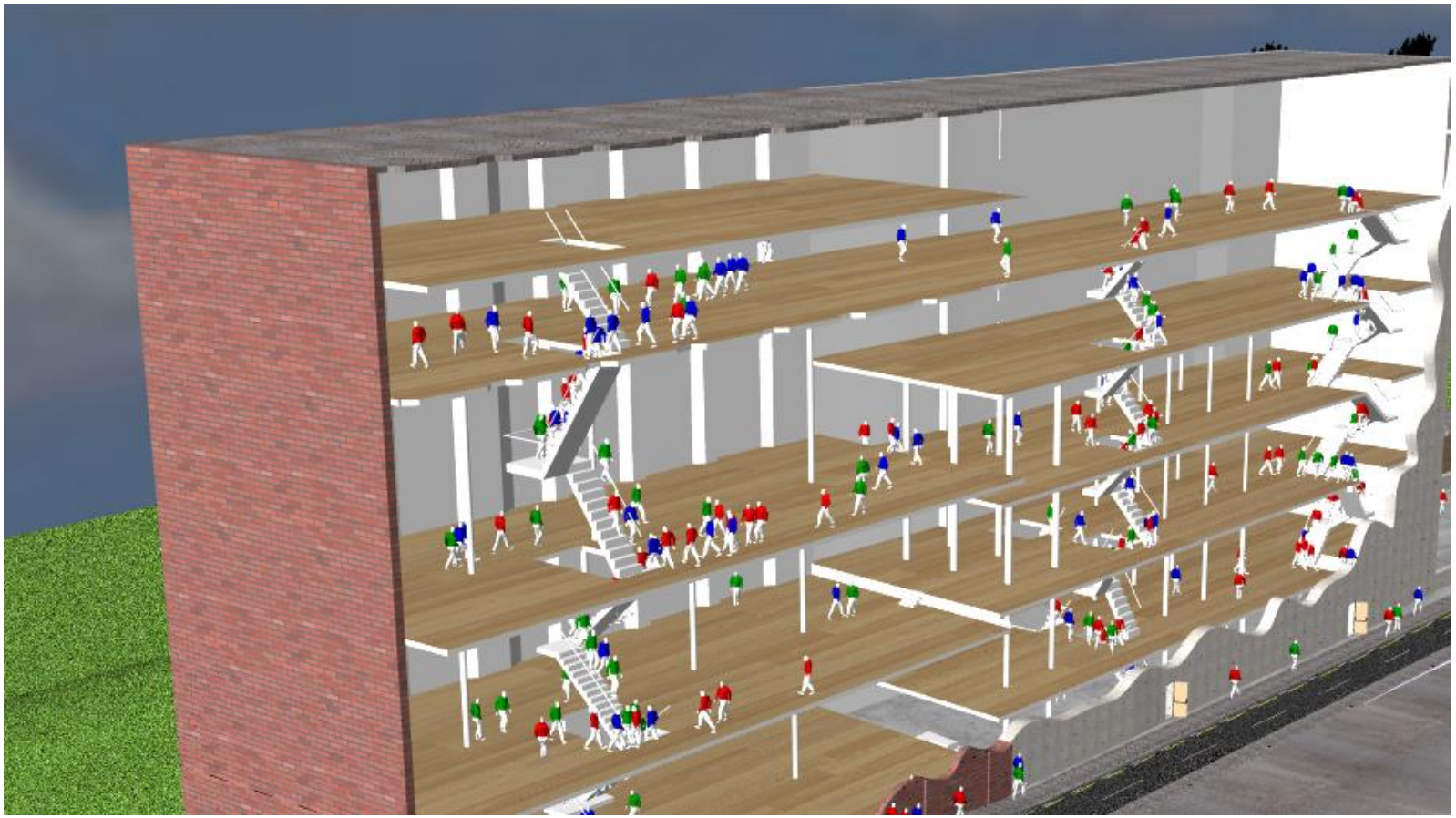




%A = %B ? (50-50 merging?)

Some counter-intuitive facts – Merging on stairs

Deference behaviour on stairs

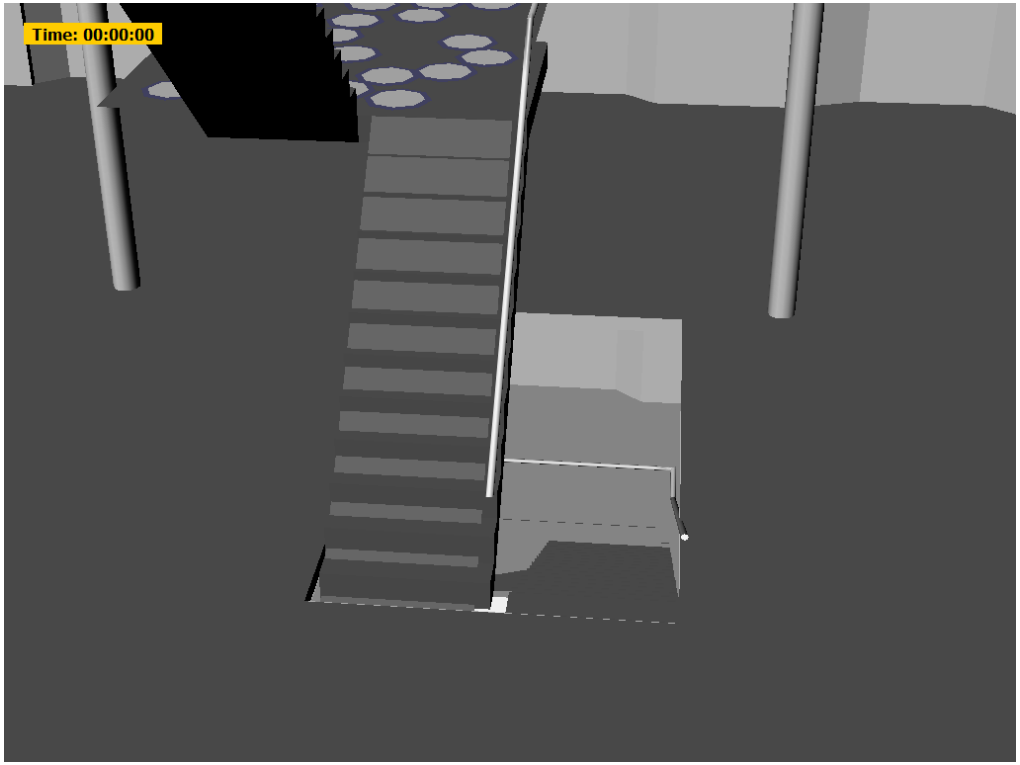


Buro Happold HQ building

Some counter-intuitive facts – Merging on stairs

Buro Happold HQ building
Stair merging experiment

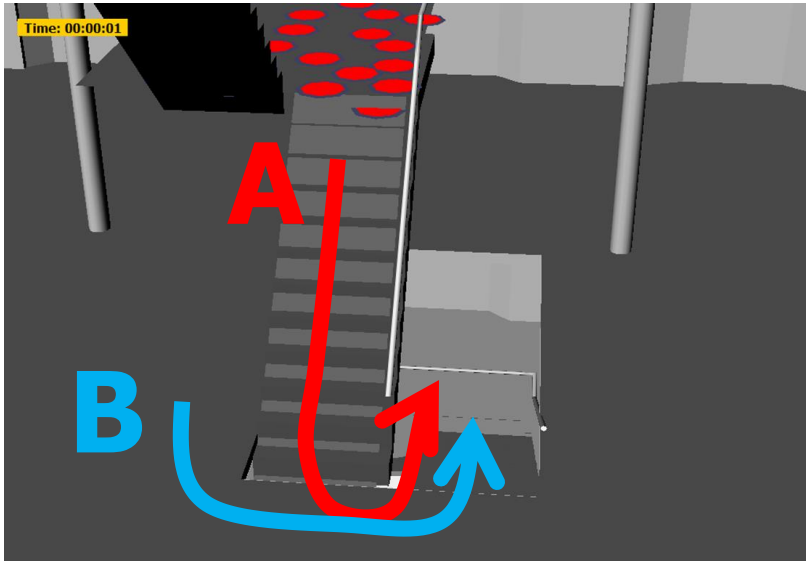
Merging behaviour at stairs



Previous research suggests that people in stairs may **defer** to people joining from floors.

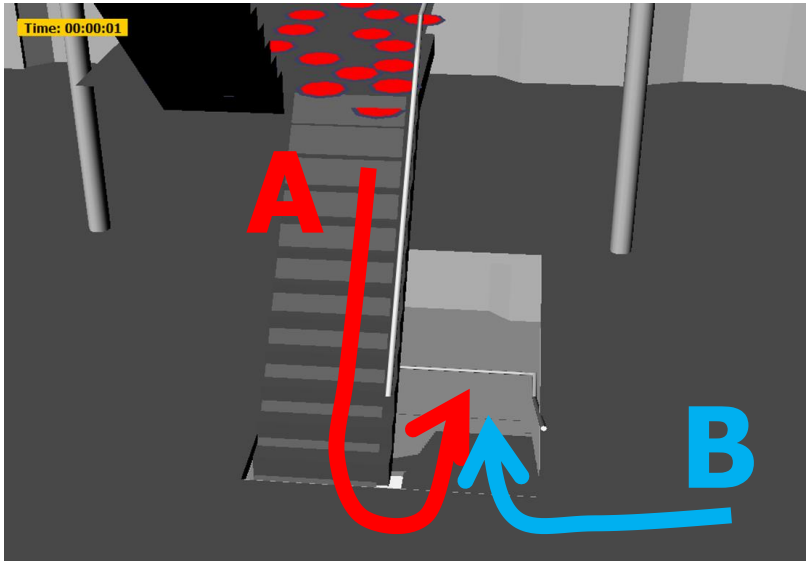
- Deference can put people on higher floors at **risk**.
- There's a limited amount of experimental **data**.
- It is hard to simulate deference or test the **sensitivity**.

Some counter-intuitive facts – Merging on stairs



I

In-line merge

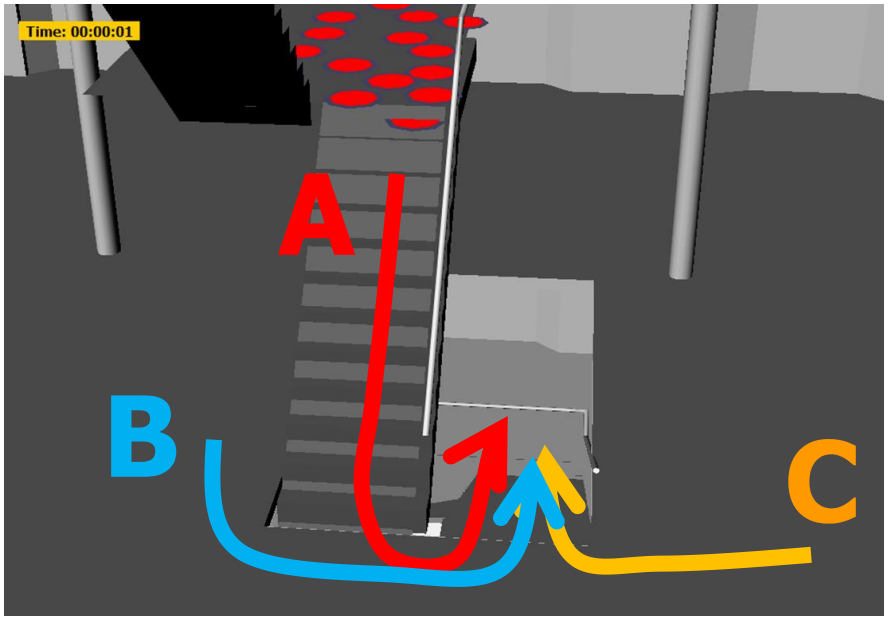


II

Opposing merge

%A = %B ? (50-50 merging?)

Some counter-intuitive facts – Merging on stairs



III

3-way merge

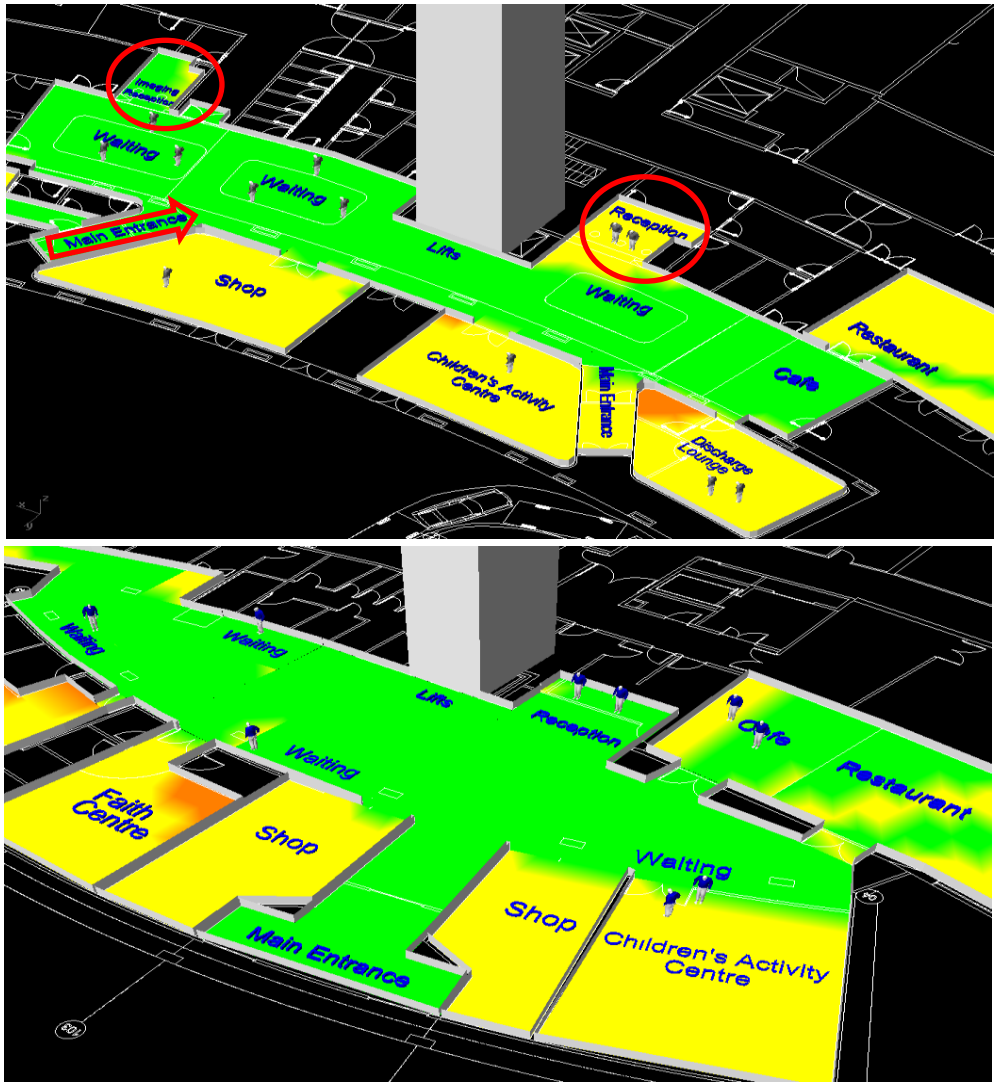
%A = %B = %C?

(equal merging?)

%A + %B = %C?

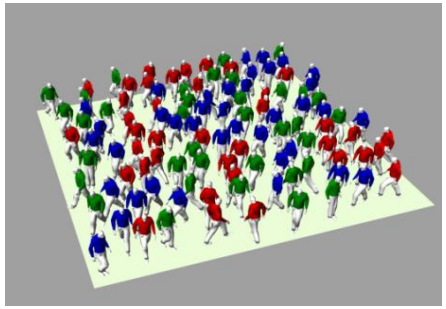
(50-50 merging?)

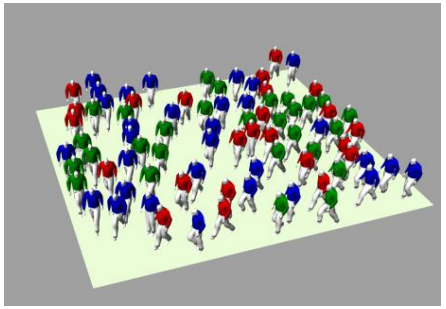
How does geometry affect people movement?



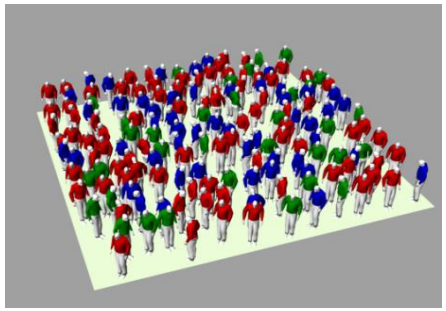
Level of Service Description

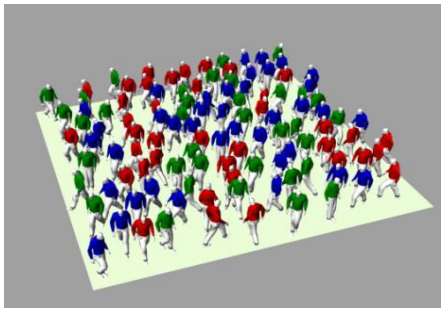
Level of service B (0.93 -1.21m^2/person):
"Space is provided for standing and restricted circulation through the queuing area without disturbing others" – Fruin.



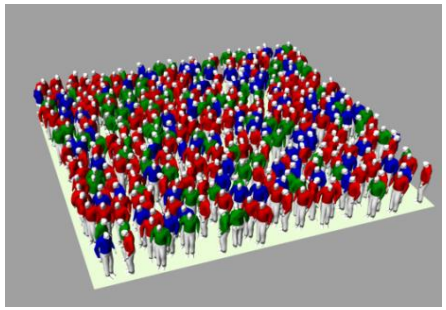


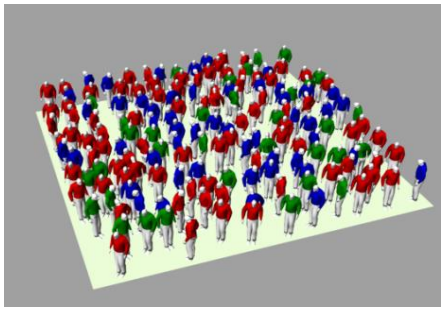
Level of service C (0.65 – 0.93m^2/person):
"Space is provided for standing and restricted circulation through the queuing area by disturbing others" – Fruin.



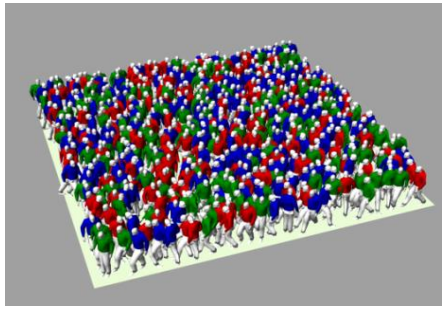


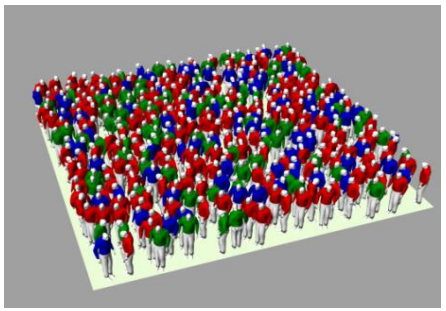
Level of service D (0.28 –0.65m^2/person):
"Circulation through the queuing area is severely restricted, and forward movement is only possible as a group" – Fruin.





Level of service E (0.19 – 0.28m^2/person):
"Space is provided for standing but personal contact with others is unavoidable. Circulation within the queuing area is not possible." – Fruin.

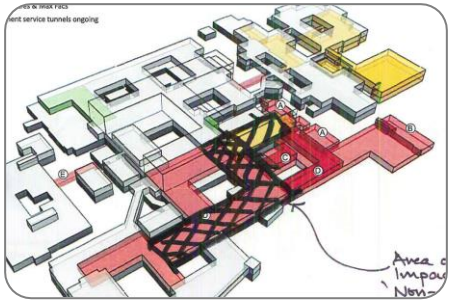




Modelling approach, tools and techniques

Evidenced based modelling

Optimise this…



Facility **Design**

Operational **Management**

People **Activities** and Behaviour

To maximise this…

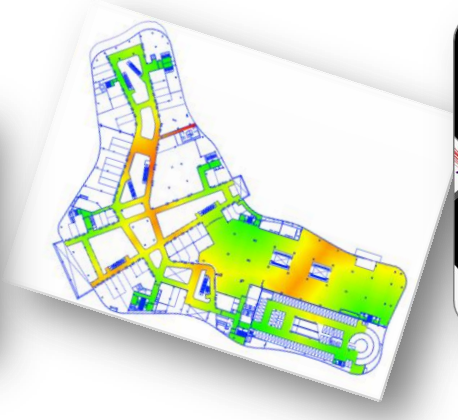
Experience

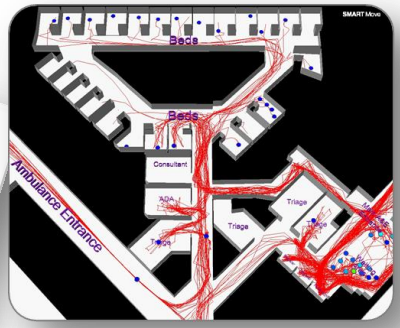
Cost savings

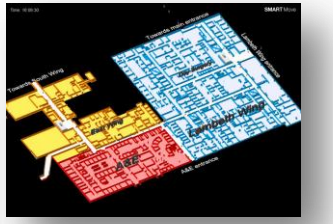
Revenues

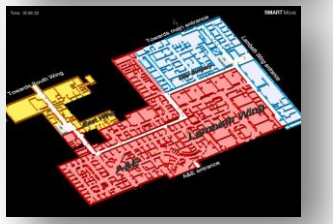
SMART Move

Our approach

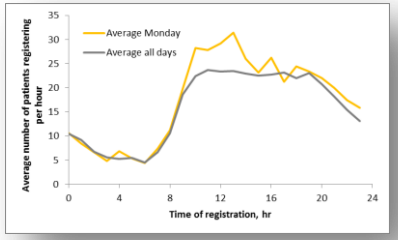


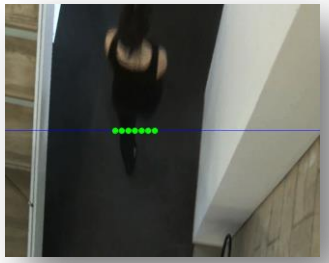


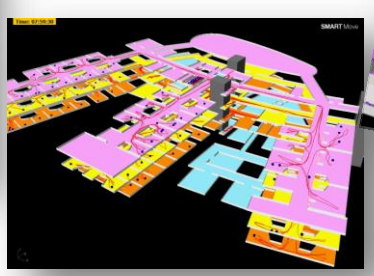


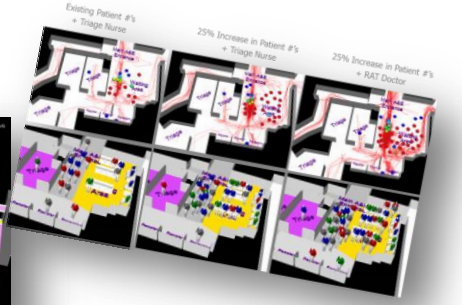


Identify **scenarios** → Gather **data** → **Analyse** data → **Model** performance → **Test** options

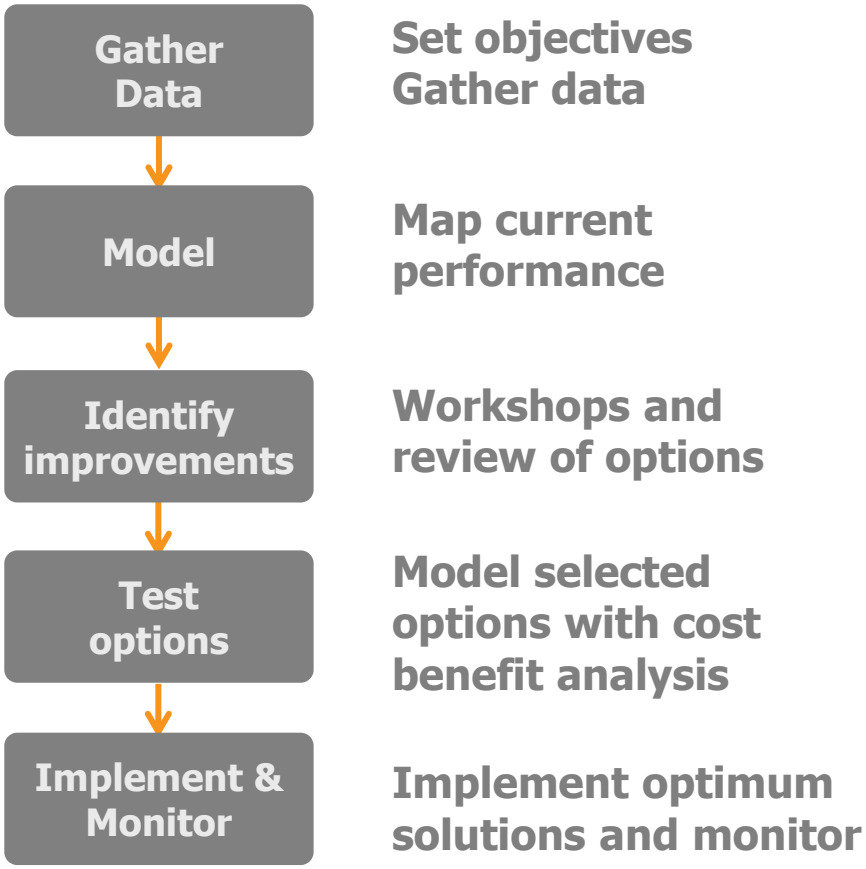




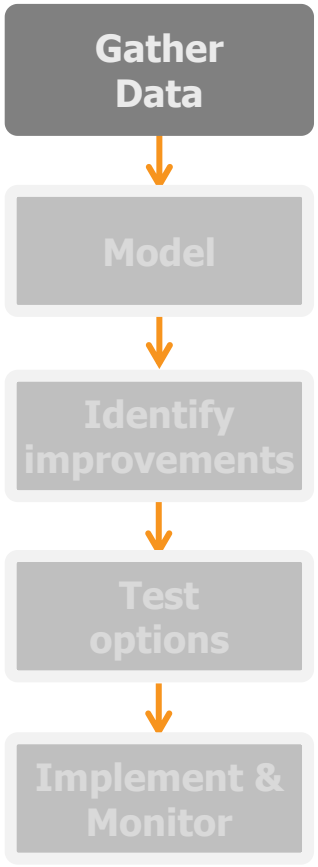


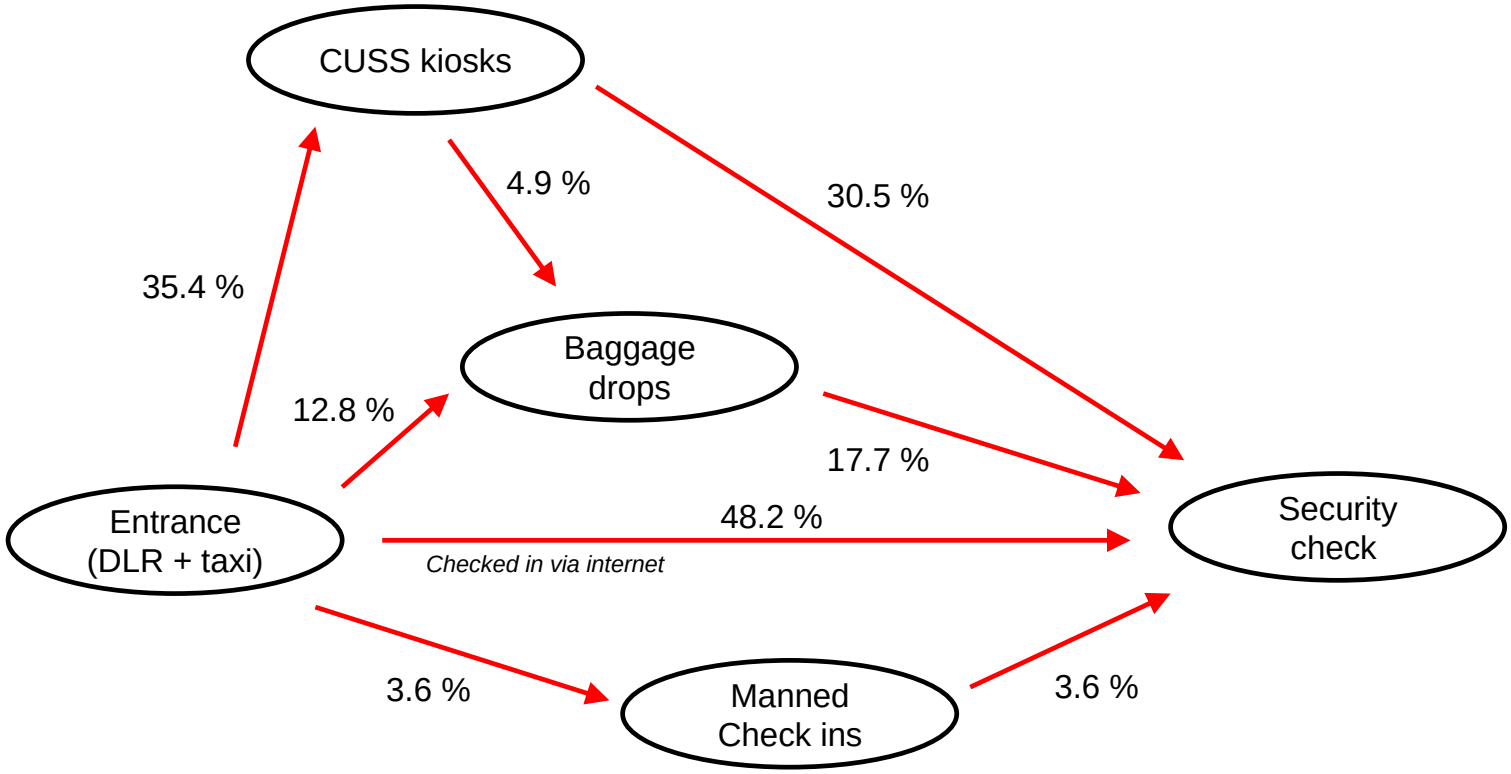


The 'Modelling' process



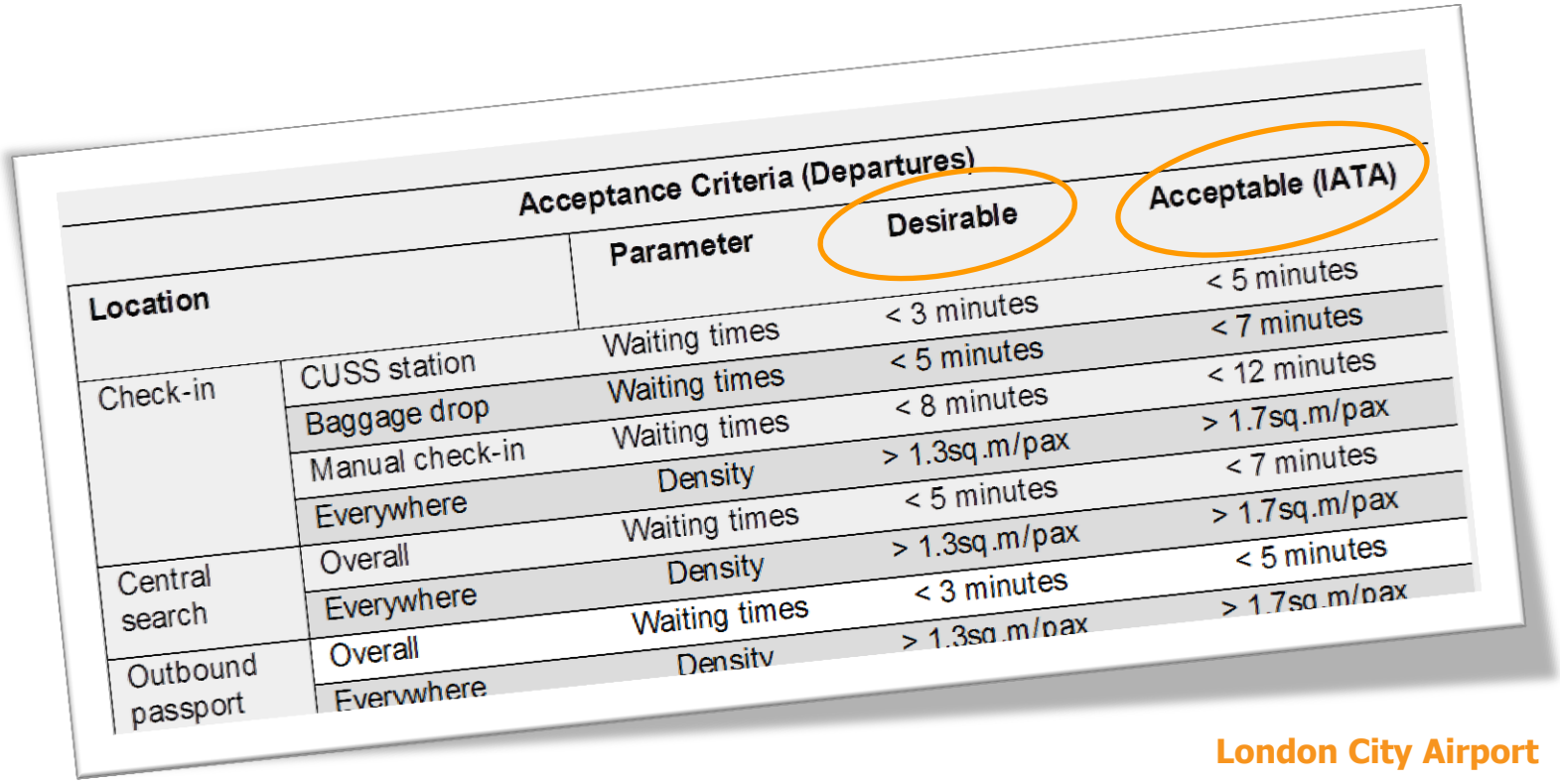
Data gathering: flow patterns





Data gathering: flow patterns

- Gather Data
- Model
- Identify improvements
- Test options
- Implement & Monitor

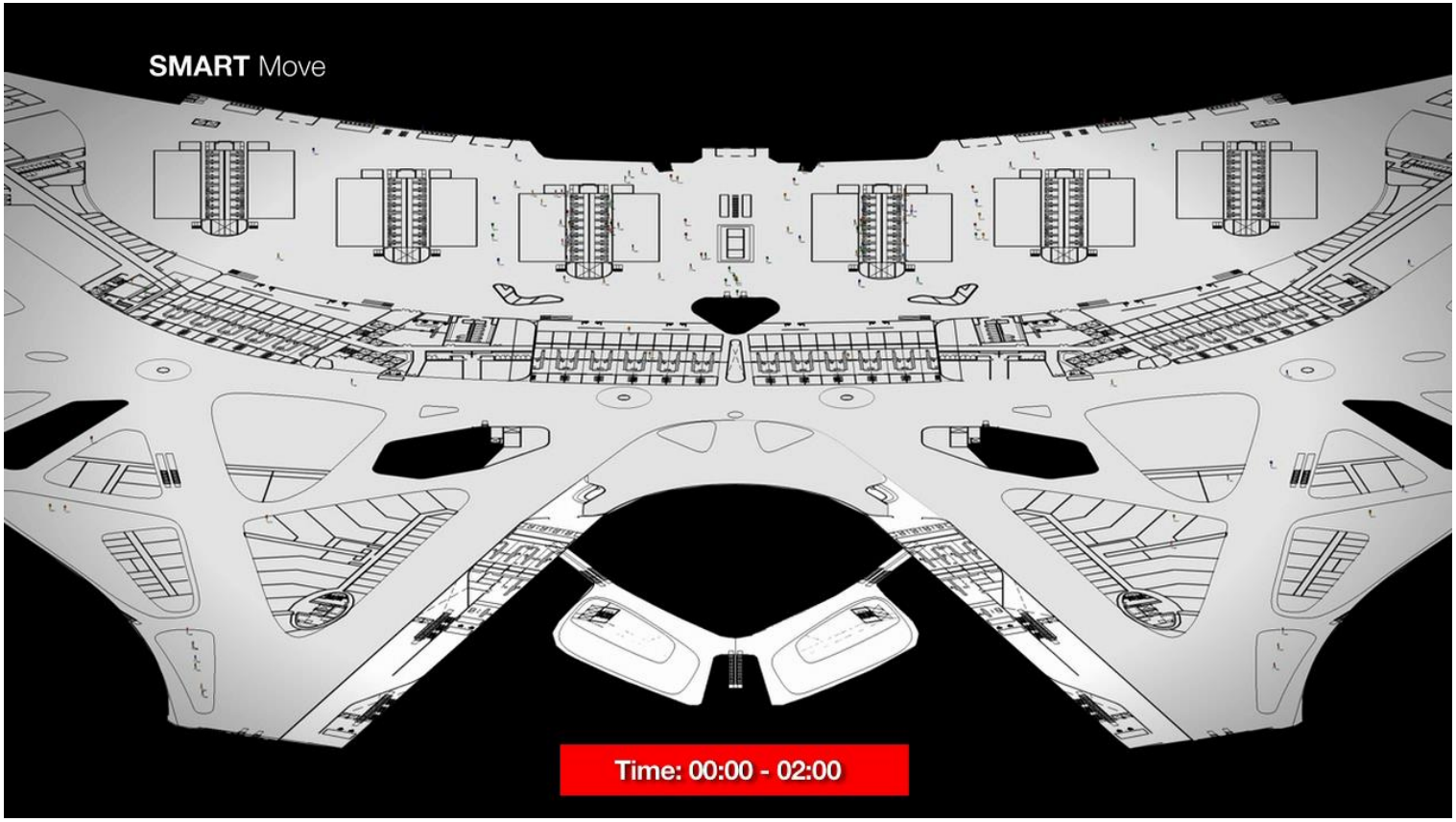


Location		Acceptance Criteria (Departures) Parameter	Desirable	Acceptable (IATA)
Check-in	CUSS station	Waiting times	< 3 minutes	< 5 minutes
	Baggage drop	Waiting times	< 5 minutes	< 7 minutes
	Manual check-in	Waiting times	< 8 minutes	< 12 minutes
	Everywhere	Density	> 1.3sq.m/pax	> 1.7sq.m/pax
Central search	Overall	Waiting times	< 5 minutes	< 7 minutes
	Everywhere	Density	> 1.3sq.m/pax	> 1.7sq.m/pax
Outbound passport	Overall	Waiting times	< 3 minutes	< 5 minutes
	Everywhere	Density	> 1.3sq.m/pax	> 1.7sq.m/pax

London City Airport
pax flow cceptance criteria

Simulations – in-house software SMART Move

- Gather Data
- **Model**
- Identify improvements
- Test options
- Implement & Monitor



Day in life simulation of an airport

Simulations – in-house software SMART Move

Gather Data

↓

Model

↓

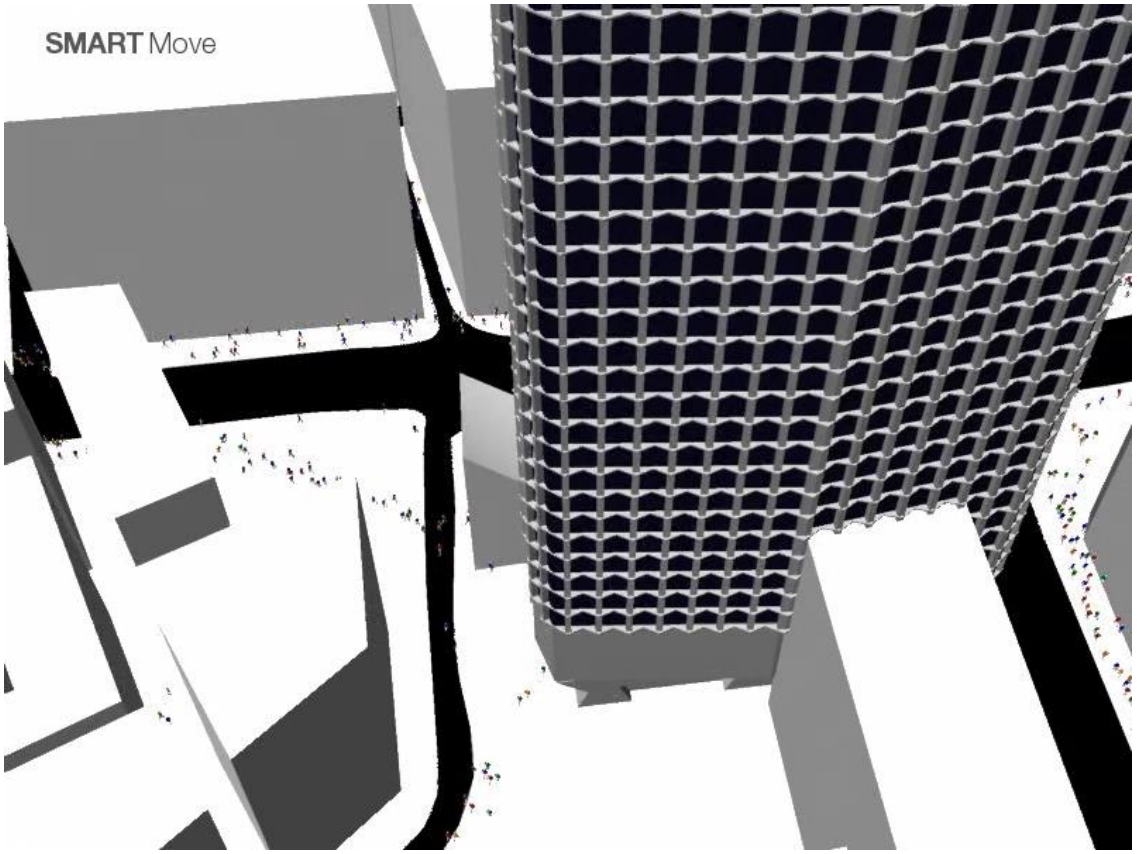
Identify improvements

↓

Test options

↓

Implement & Monitor



St Giles Circus, London

Visual mapping of performance

Observe

↓

Model

↓

Identify improvements

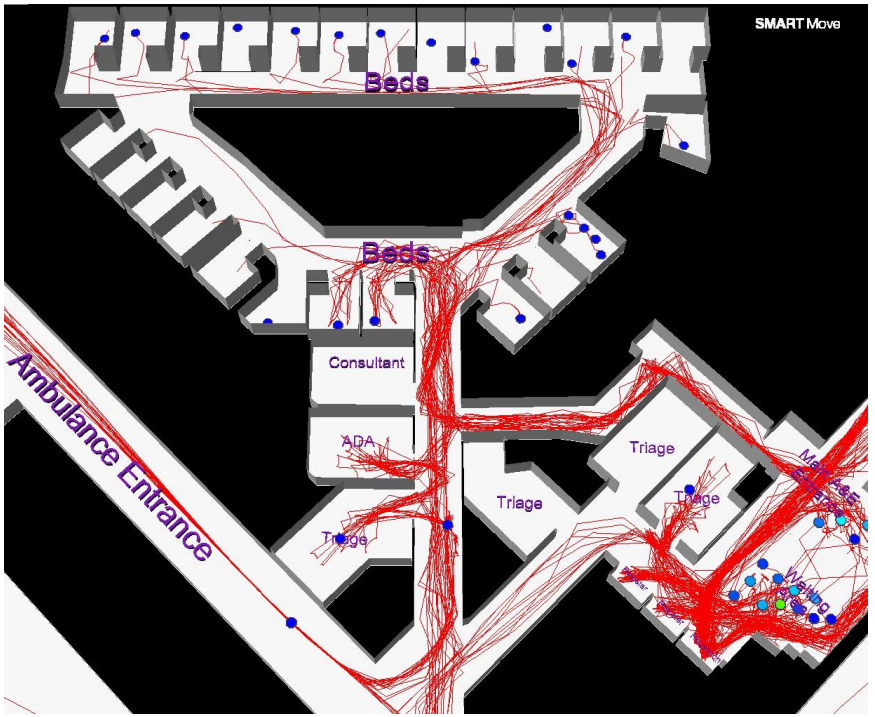
↓

Test options

↓

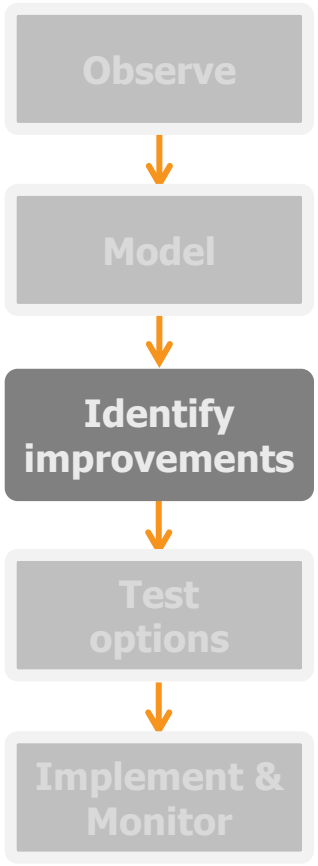
Implement & Monitor

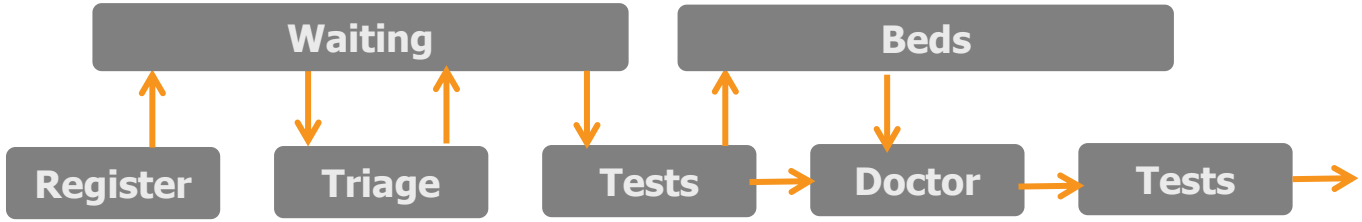
Simulation of Ambulance Entrance/Triage and Major Beds



- Journey times
- Travel distances
- Waiting times
- Densities
- Conflicts
- Interactions
- Flowrates
- (bespoke)…

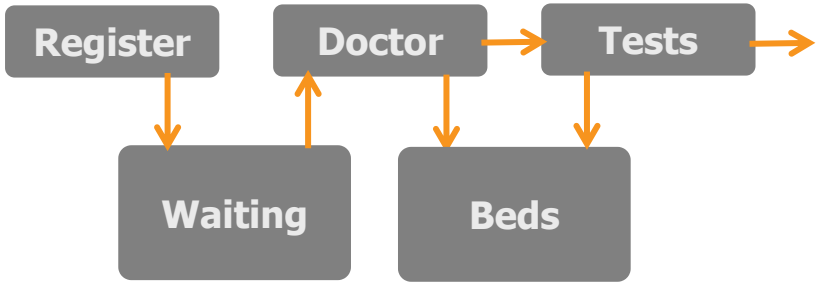
Identify alternatives – spaces, processes and processes





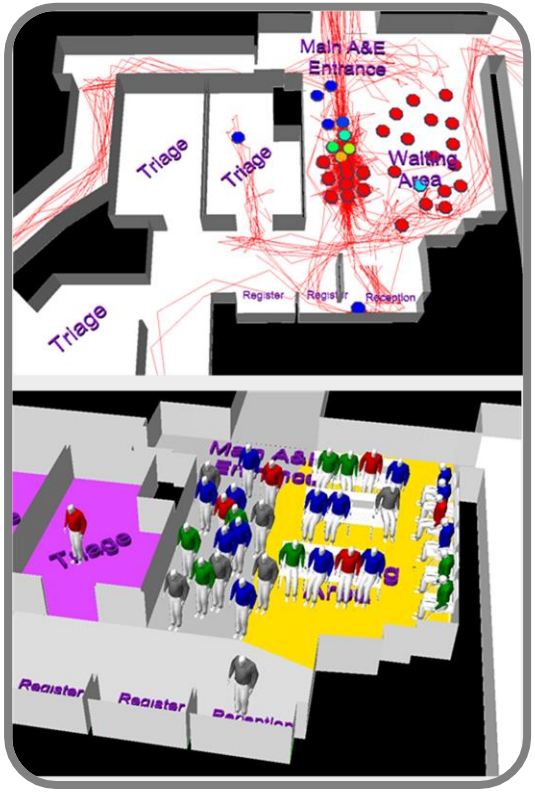
Triage process

RAT process

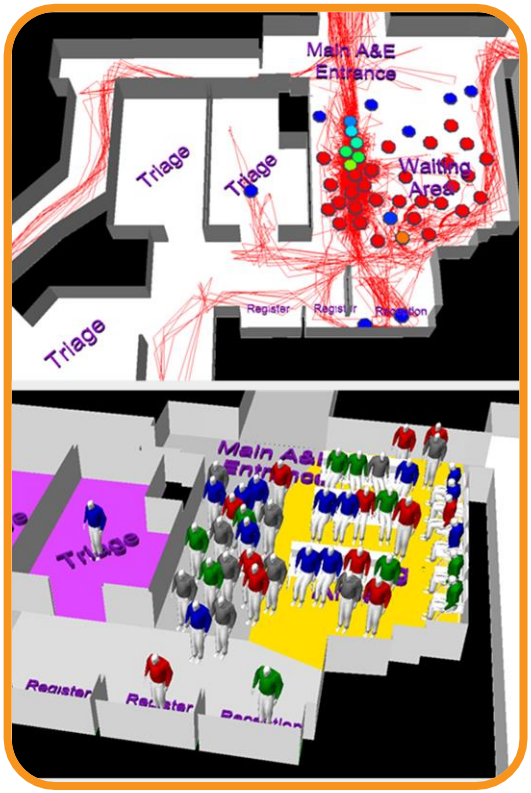


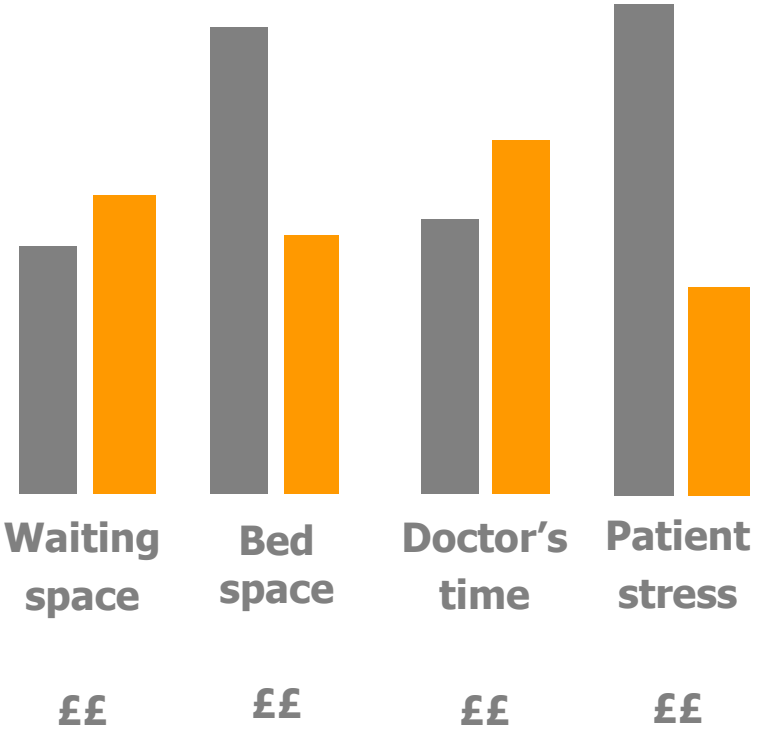
Queen's Hospital A&E department optimisation

Current Process



Proposed Process

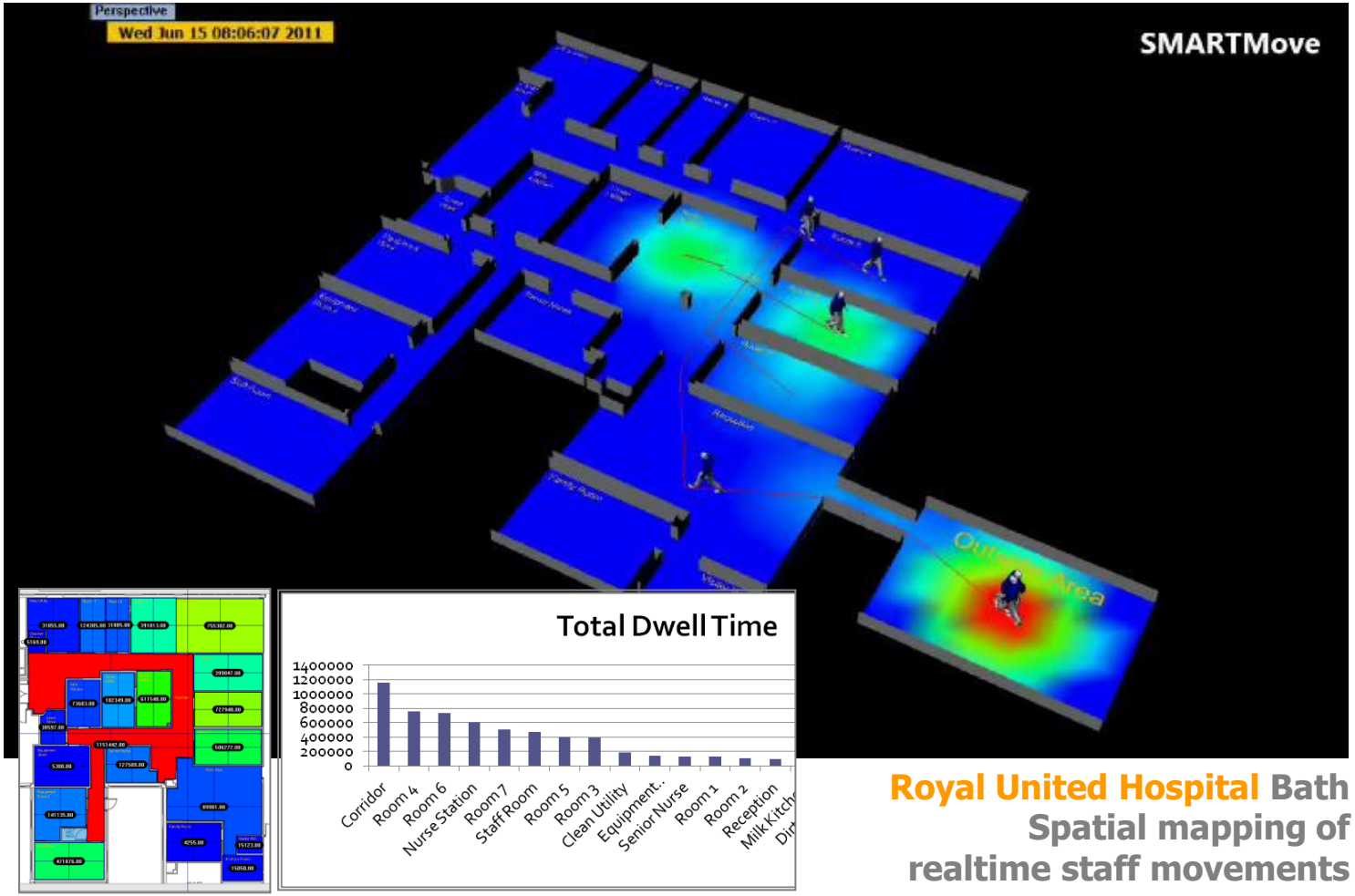




Queens Hospital Romford: Comparison of TRIAGE and RAT processes in terms of space requirement, staff utilisation, and patient experience.

Live dashboard to monitor performance

- Observe
- Model
- Identify improvements
- Test options
- Implement & Monitor



Royal United Hospital Bath
Spatial mapping of realtime staff movements

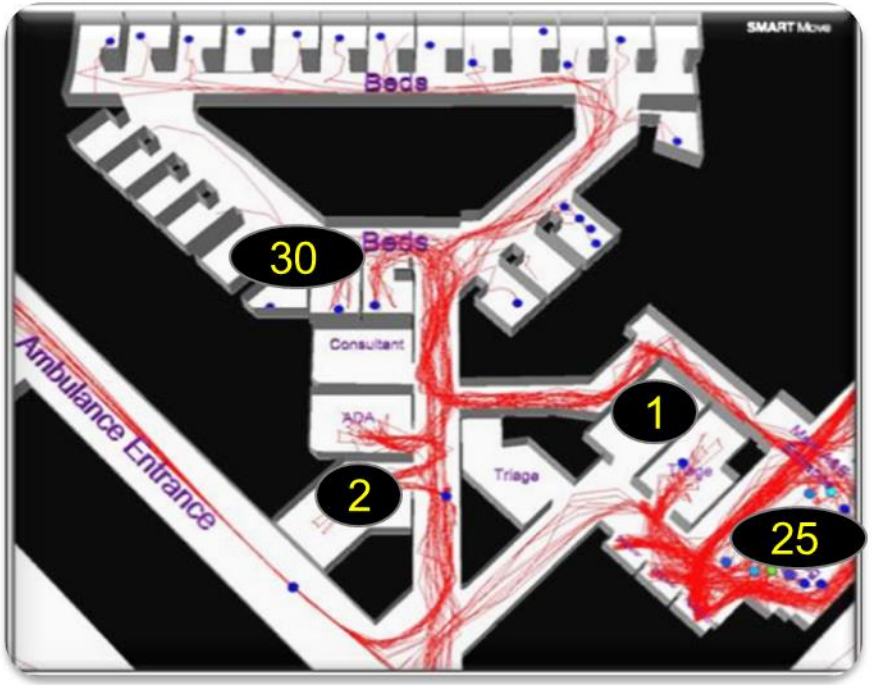
SMART Viewer

Spatial view | Process view | Patient view | All Patients

Summary

Occupancy
150

Average time in A&E
2hr 10min



Parameters

- ✓ Occupancy
- ❑ Utilisation
- ❑ Density
- ❑ Waiting time
- ❑ Time in A&E

Timescale

Cumulative

< Past

Past day | Past hr | Now | Next hr | Next day

Future >

SMART Viewer

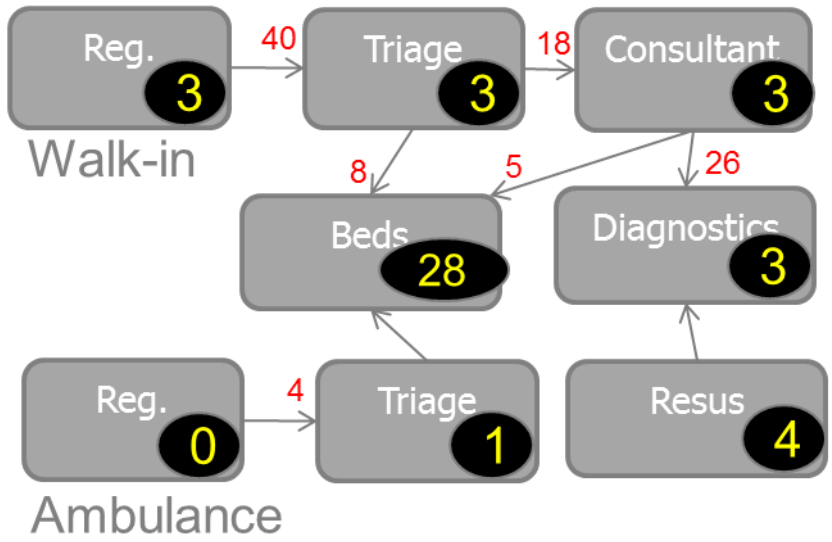
Spatial view | **Process view** | Patient view | All Patients

Summary

Processing
49

Waiting
101

Process maps



Parameters

- ✓ # being processed
- ❑ # waiting
- ❑ Average time
- ❑ Utilisation
- ❑ # staff

Timescale

Cumulative

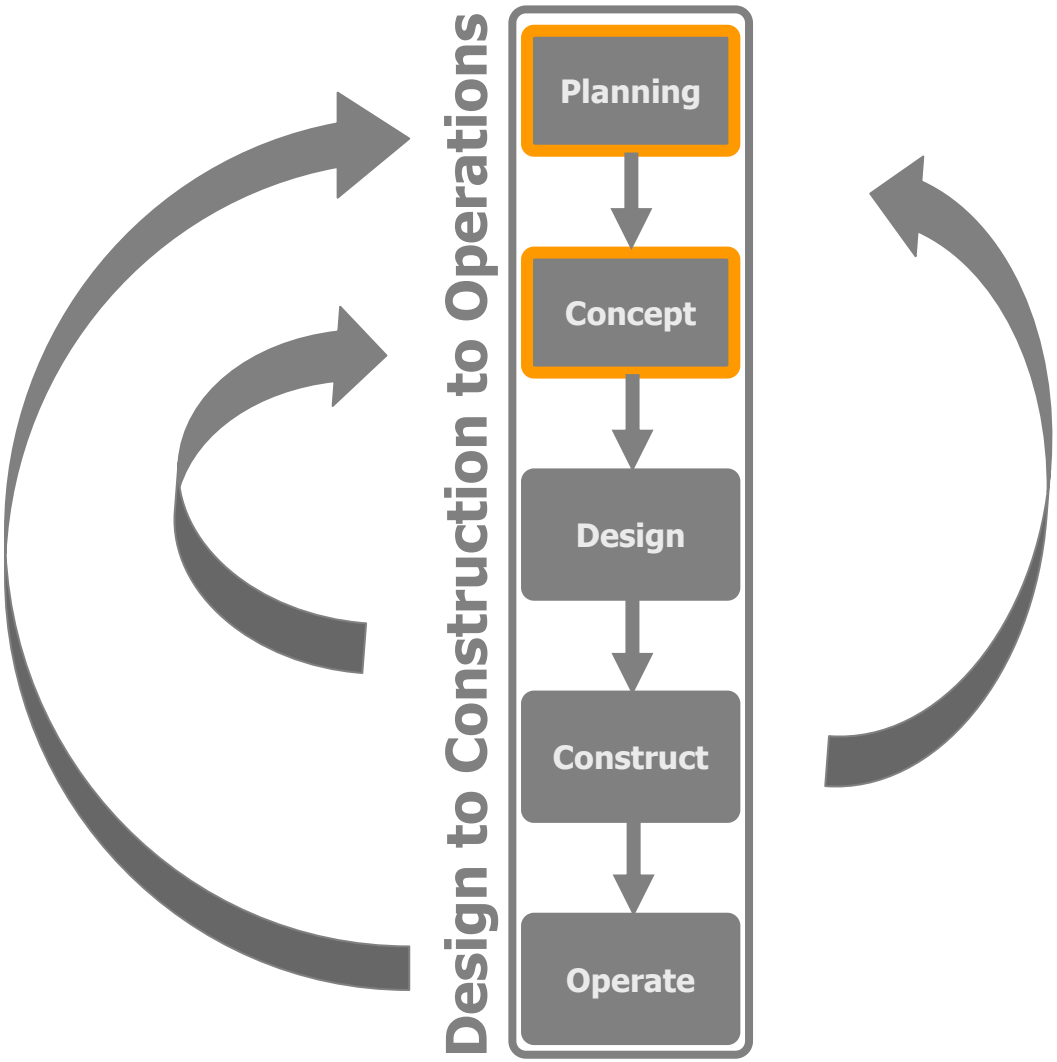
< Past

Past day | Past hr | Now | Next hr | Next day

Future >

Innovations in crowd flow and future trends

Rapid iterations for conceptual design and planning



Rapid iterations for conceptual design and planning

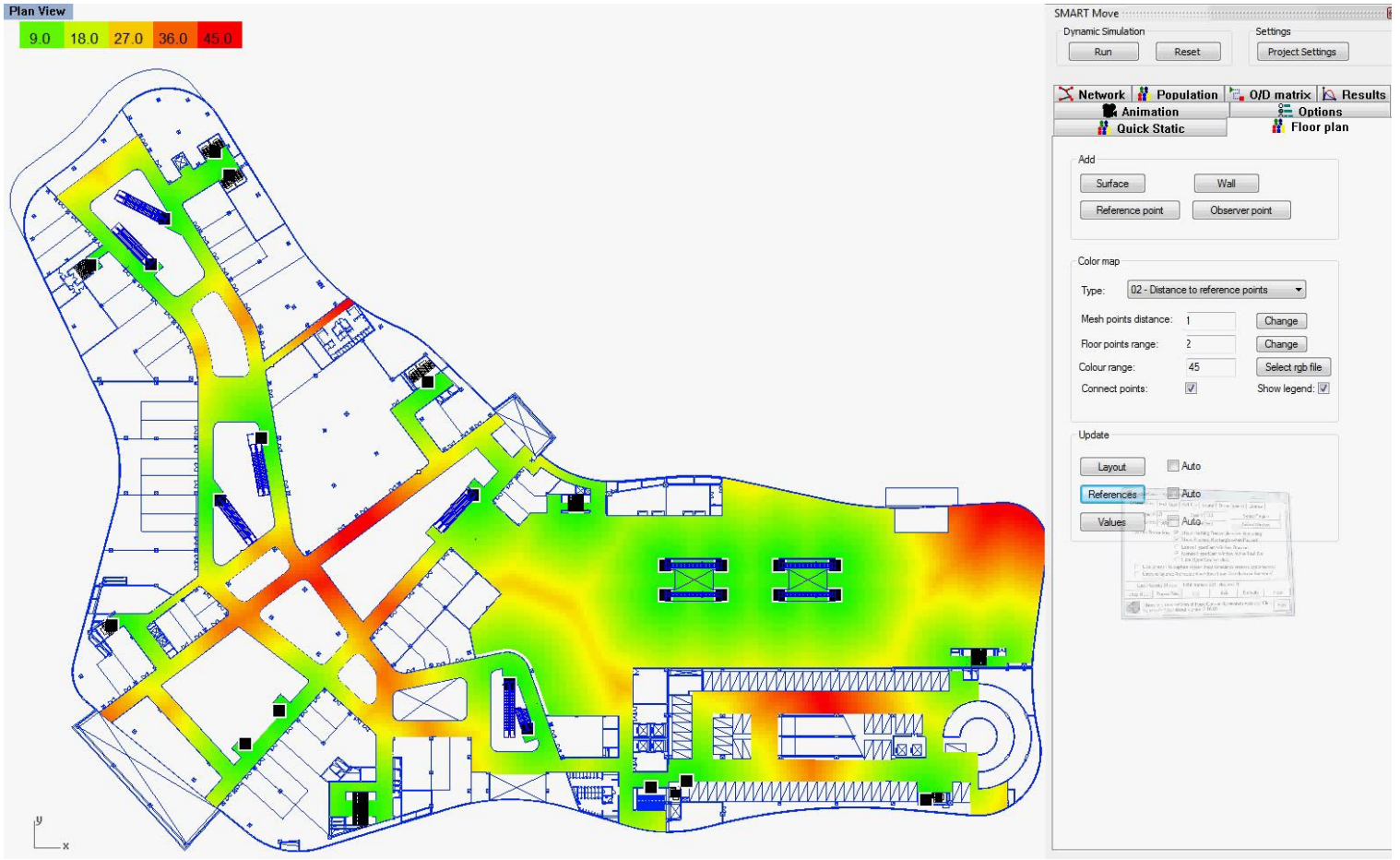
Observe

Model

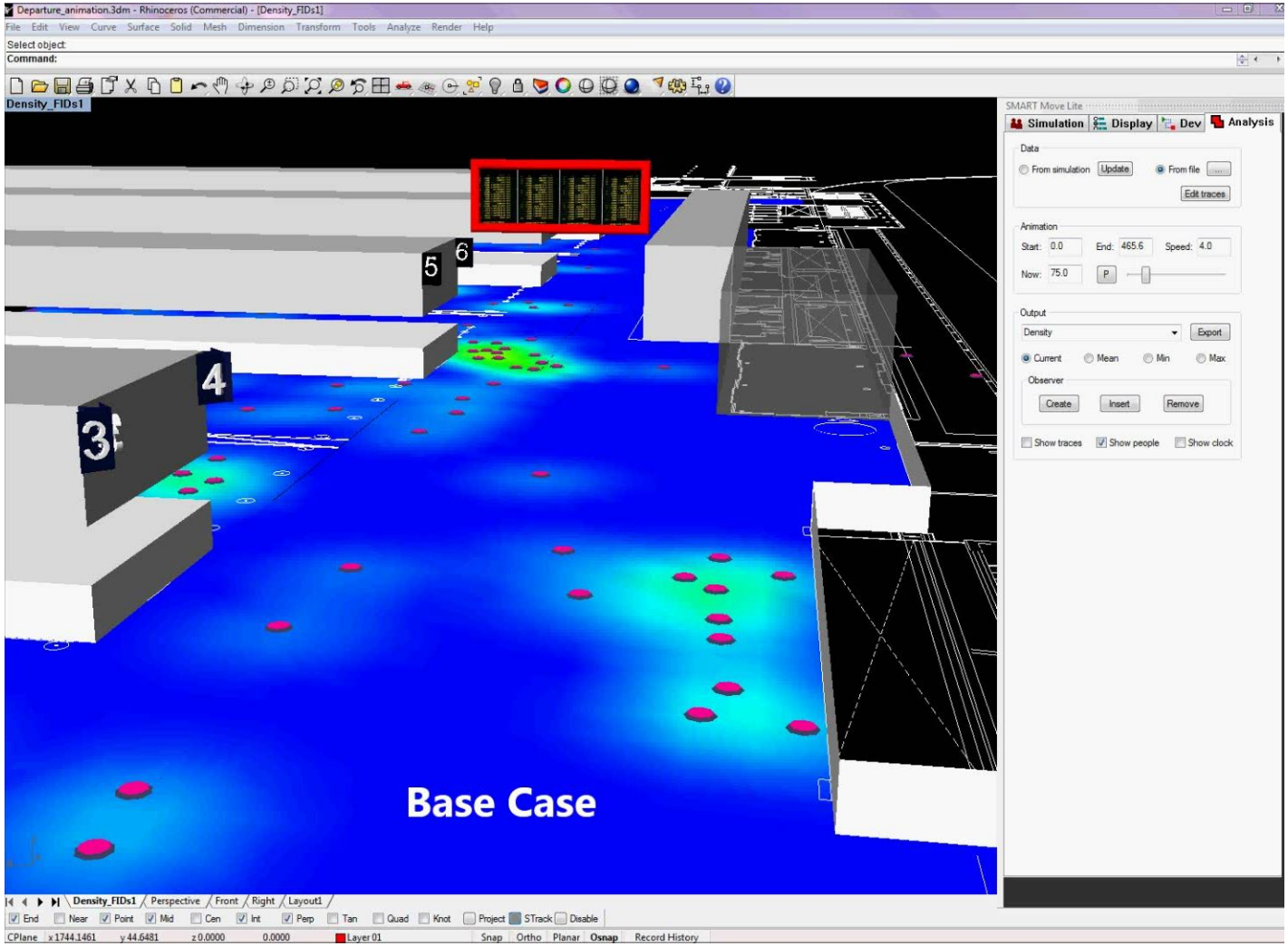
Identify improvements

Test options

Implement & Monitor



SMART Spaces



Widening corridors to solve congestion problems -
is like loosening your belt to cure obesity!

~~Dynamic~~ Realtime modelling

Widening corridors to solve **congestion** problems -
is like **loosening** your belt to cure **obesity**!

Rapid iterations for conceptual design and planning

Observe

↓

Model

↓

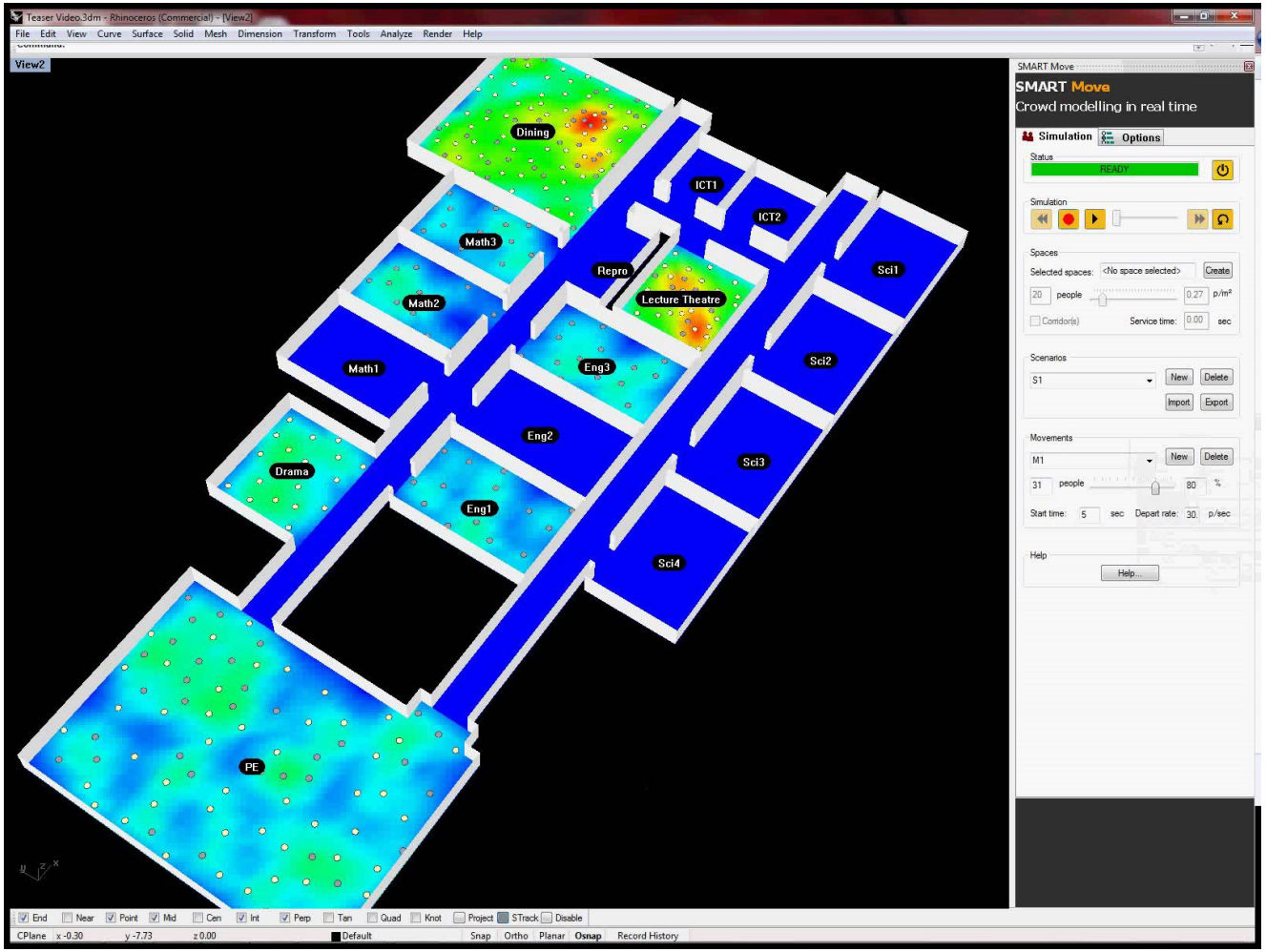
Identify improvements

↓

Test options

↓

Implement & Monitor



SMART Move

Optimising the orientation and queuing space in a museum

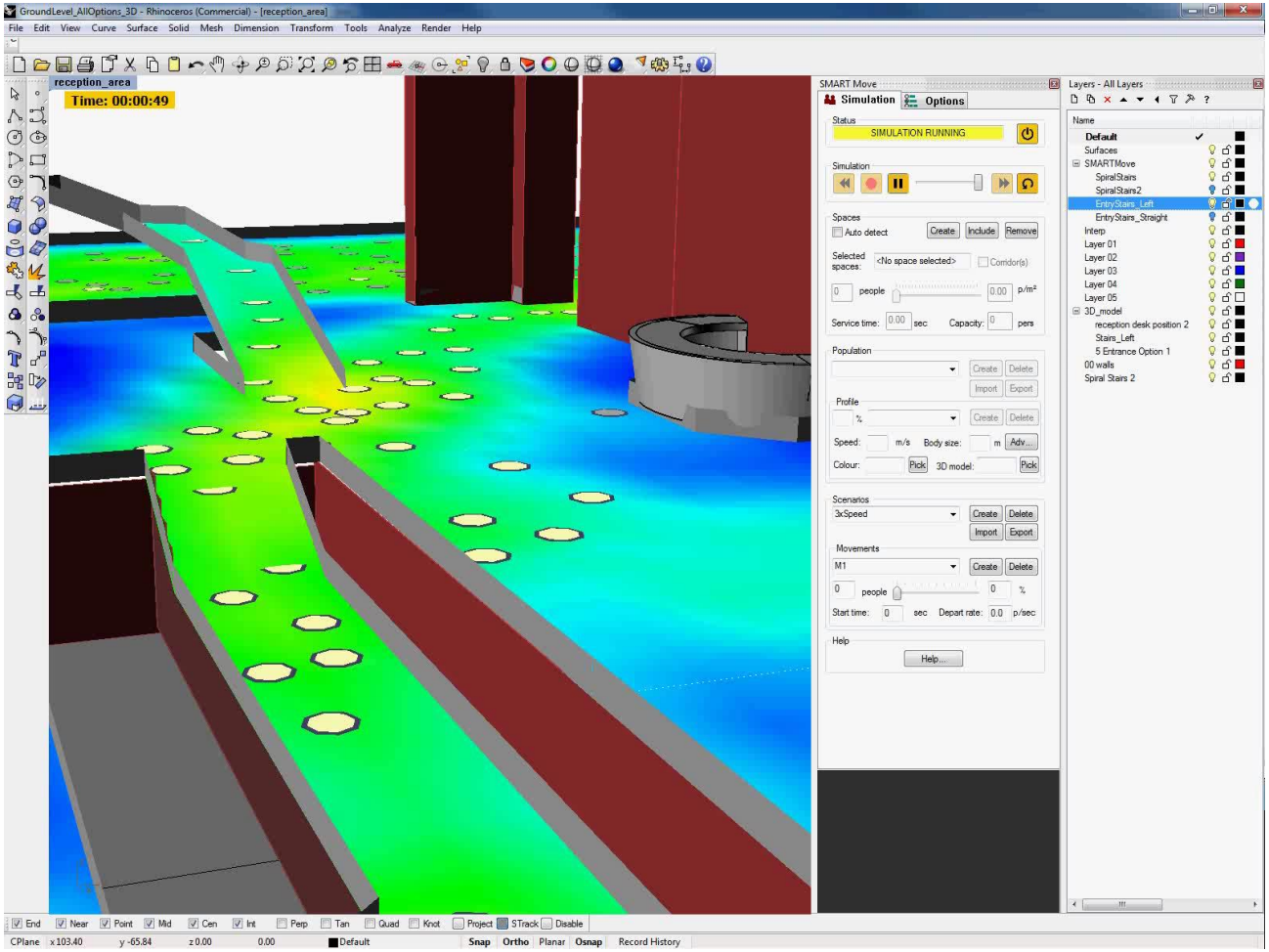
Observe

Model

Identify improvements

Test options

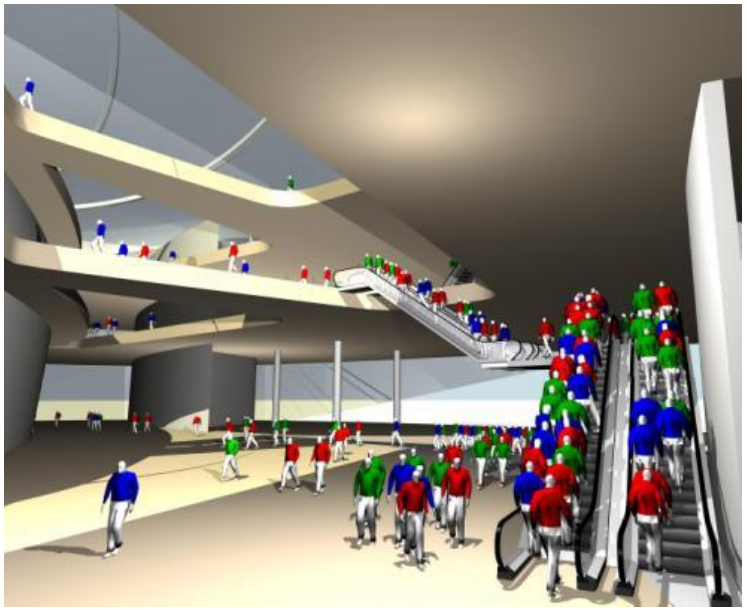
Implement & Monitor



SMART Move

SMART Space

Optimising the Interface between People and Places



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