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Global Change, Adaptation and Risk Management

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The Chinese University of Hong Kong

Modelling and Predicting Crowding and Congestion:

in Small Spaces in Large Cities

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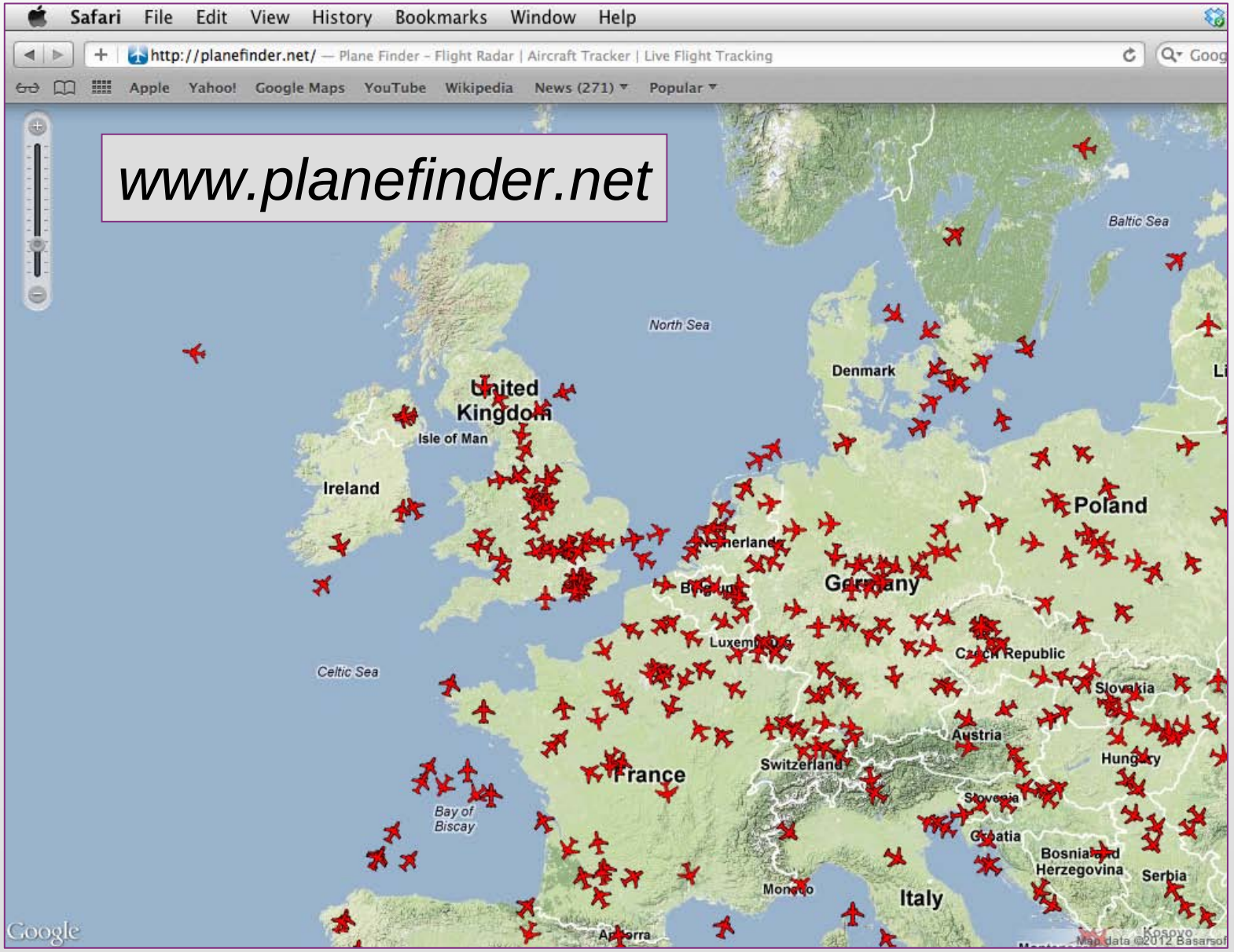
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An Outline

- Classifying Extreme Events in Cities
- Some Examples: Transport Networks and Flows
- Exemplar 1: Public Bike Schemes: Local Routing
- Exemplar 2: London's Public Transport System
- Building Models of Crowds and Congestion
- Exemplar 3: Notting Hill and Covent Garden
- Next Steps

Classifying Extreme Events in Cities

Extreme events take place over short periods of time and are usually confined to relatively small places

Not always: long term changes in climate, for example, flooding often takes place over tens of years, although we slowly accommodate to these events – through adaptation, mitigation

The events I am dealing with today are much smaller scale – they relate to the city's routine functioning – which is something we live with daily

The events we are speaking of tend are in hours & days

The image of the city is thus a of machine and the notion of an extreme event is, E. M. Forster's hallowed words when "The machine stops"

There are countless ways in which this can happen and our flow analogy underpins many of these – the heart stops when the arteries clog, the brain seizes up when the nervous system is shocked, and so on

In large cities, these events can be caused spontaneously through simply pumping more and more activity into the system – people – or it can take place in a planned way through direct interference – through terrorism for example, i.e. 7/7

It can also take place through spontaneous infection such as the spreading of a disease on the network itself

So networks and flows are really key to a classification of such events

To summarise: these kinds of events are caused by

- ***capacity limits***
- ***direct intervention & interference with the function***
- ***diffusion effects***

Or all of these when effects cascade across networks

Some Examples: Transport Networks and Flows

Let me show you some systems taken from our work in London where we are measuring flows and where we are thinking about these kinds of events

I should also make the point that we are only just beginning to get to grips with these issues because of the emergence of Big Data – from sensed data – from devices that let us collect very large volumes of data routinely and remotely

This is a sea change in what we can do. I will digress slightly to make this point with respect to GIS

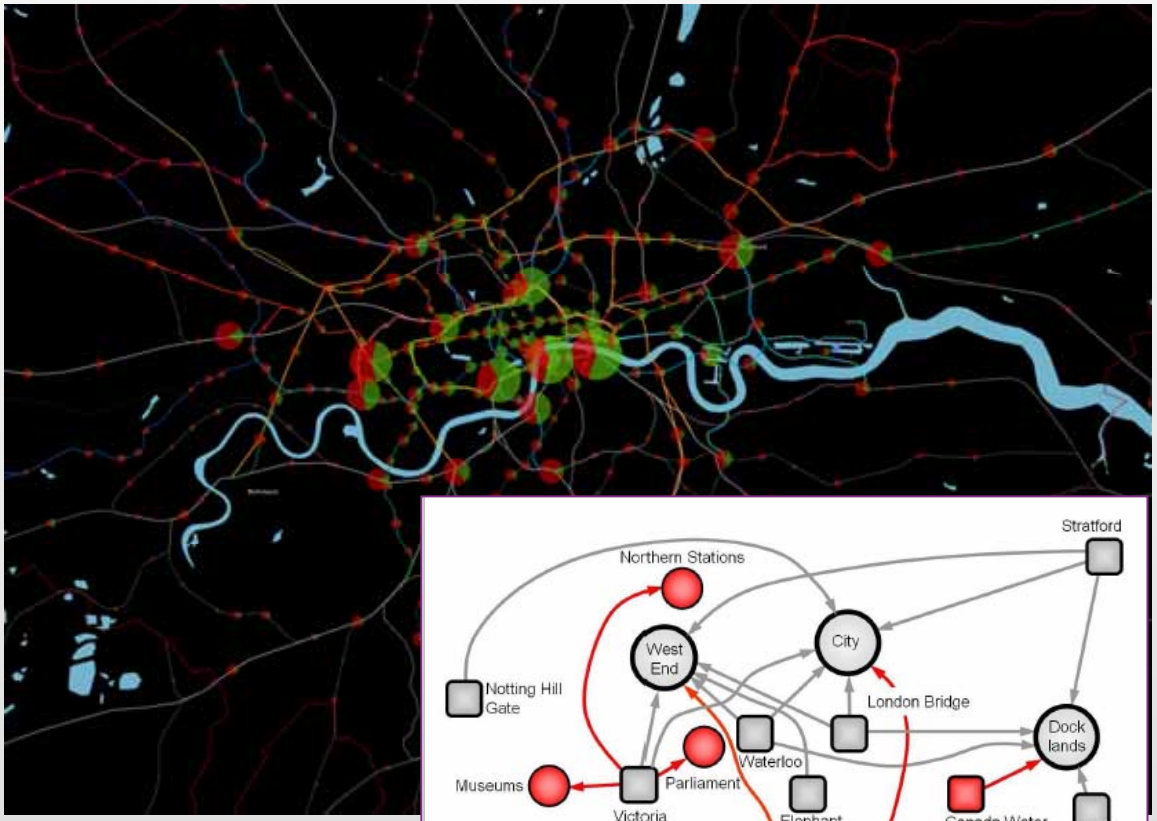
The last 10 or 15 years has seen us move from dealing mainly with strategic issues in cities to dealing with the more routine

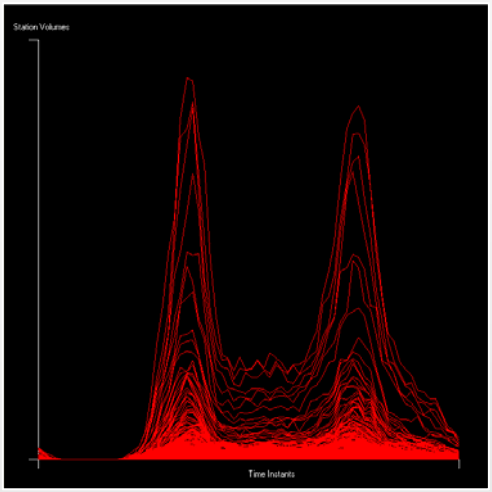
There has been a change in focus from aggregate to disaggregate

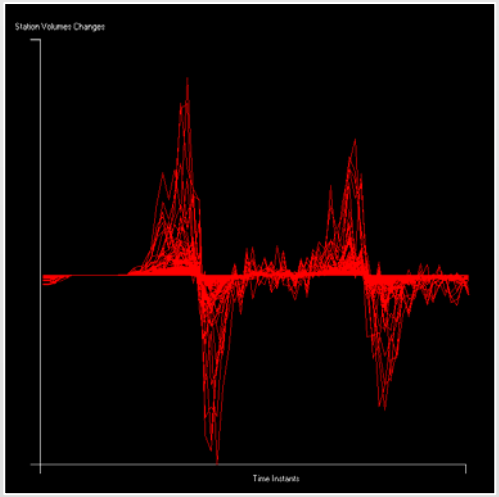
This has come through a sea change in the way we think about human systems but it has also come from all pervasive computing, from the beginnings of very local sensing

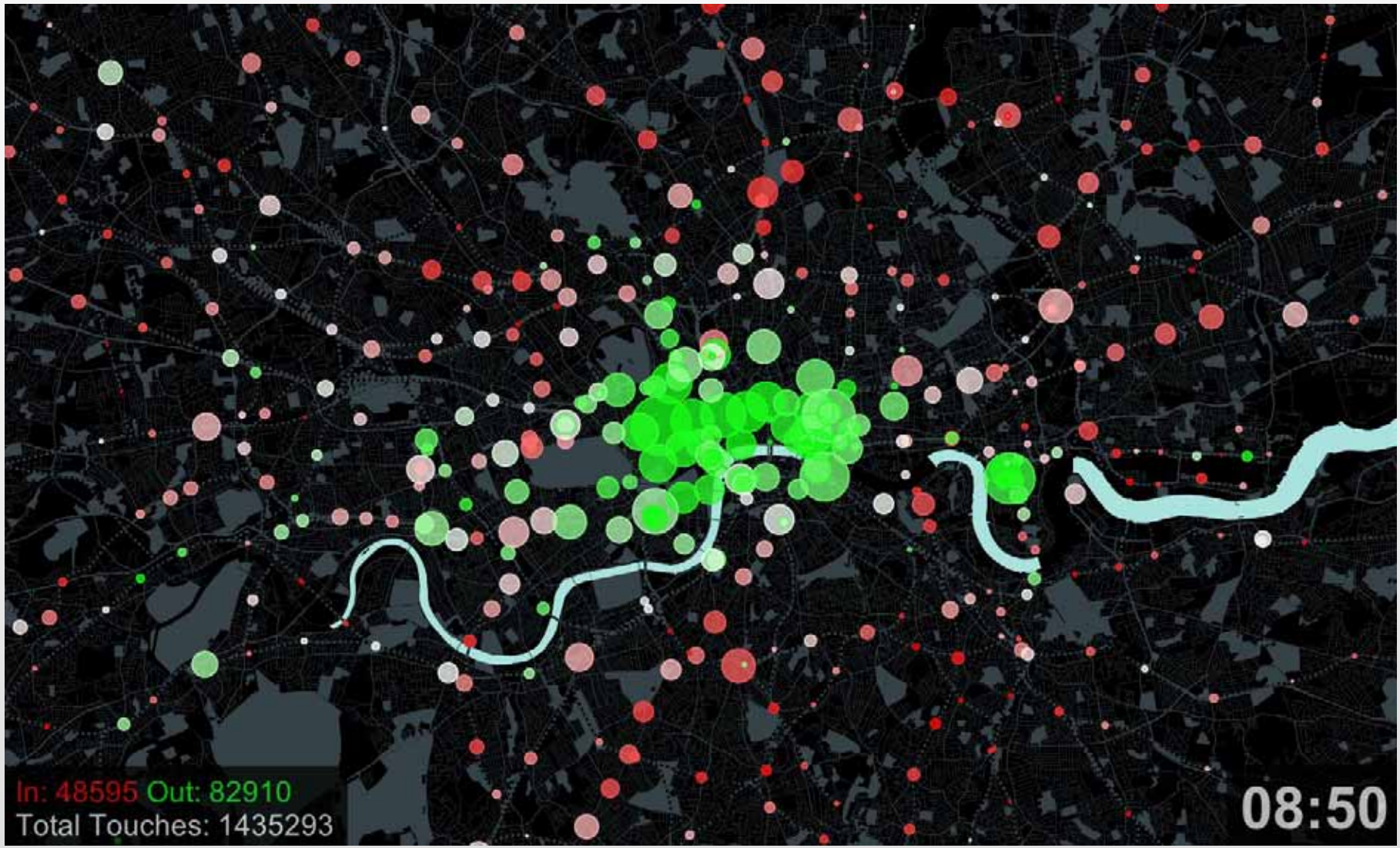
Think about the use of swipe card to get into rooms, credit cards everywhere and so – this is Big Data and so with GIS – GIS is downscaling to small spaces

Ok some more examples that make the point ; first our Oyster Card Data – interpreting urban structure, multitrips, etc.





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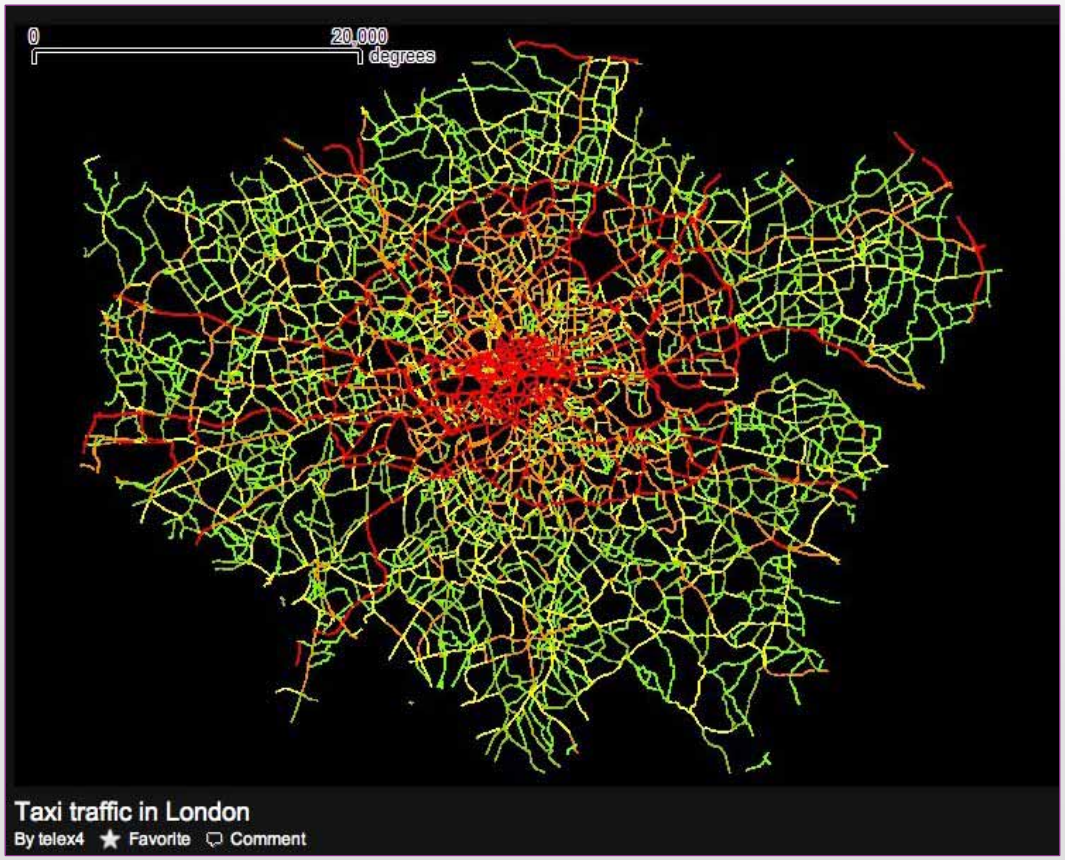
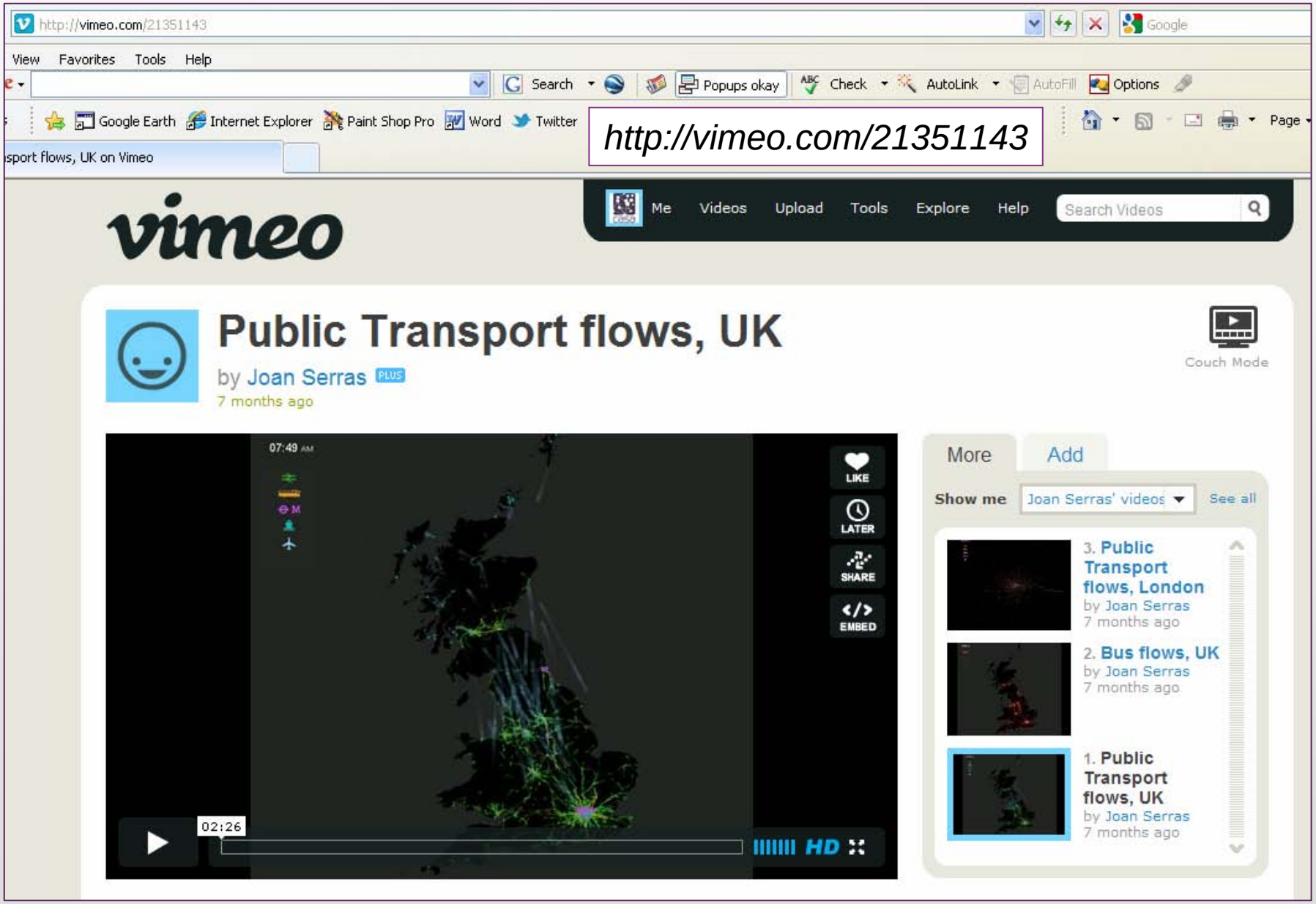
Public Transport Vehicle (not People) Flows from Timetable and OS Streetline Data by Joan Serras (CASA)

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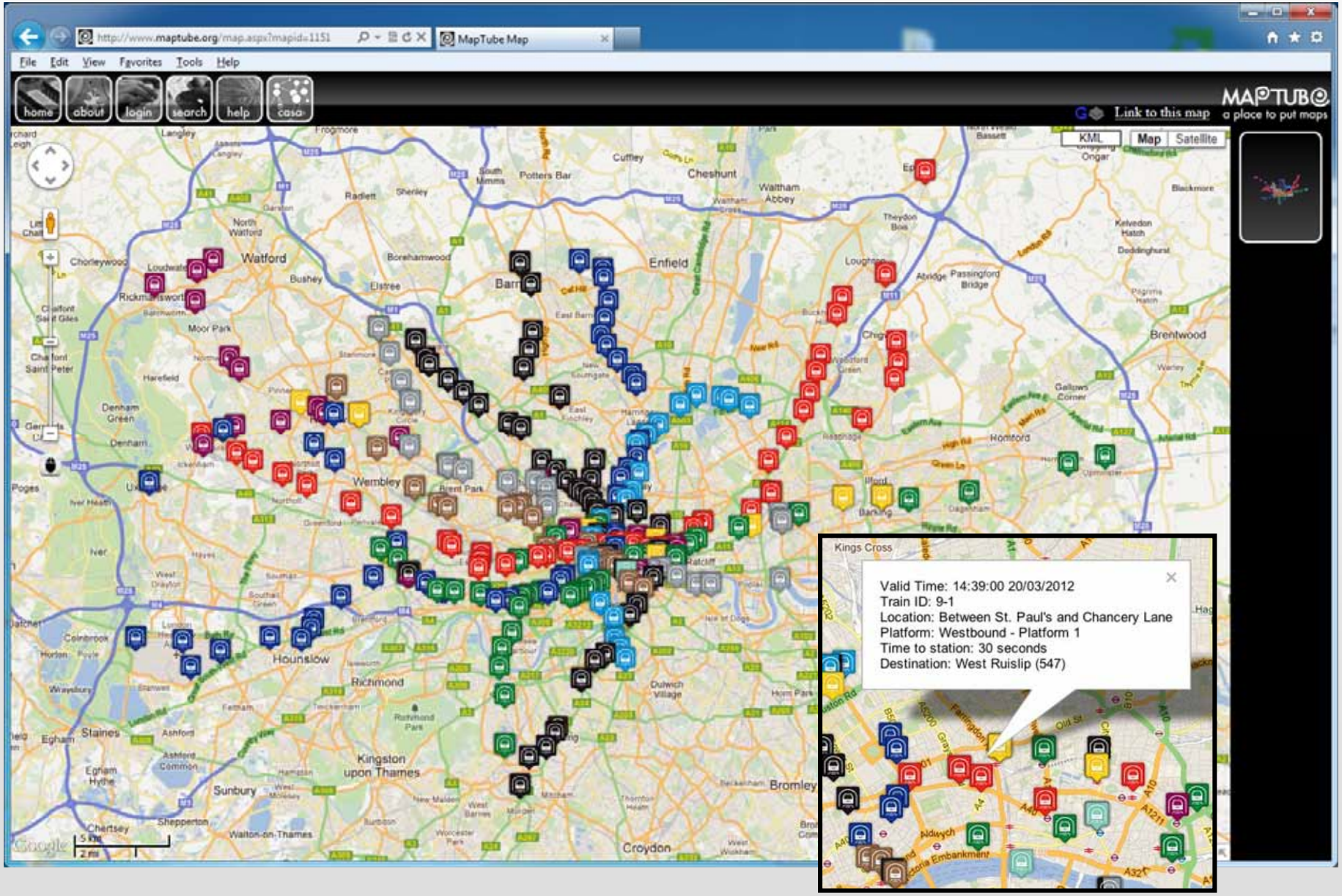
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Kings Cross
Valid Time: 14:39:00 20/03/2012
Train ID: 9-1
Location: Between St. Paul's and Chancery Lane
Platform: Westbound - Platform 1
Time to station: 30 seconds
Destination: West Ruislip (547)
Watford
Enfield
Wembley
Hounslow
Richmond
Kingston upon Thames
Croydon
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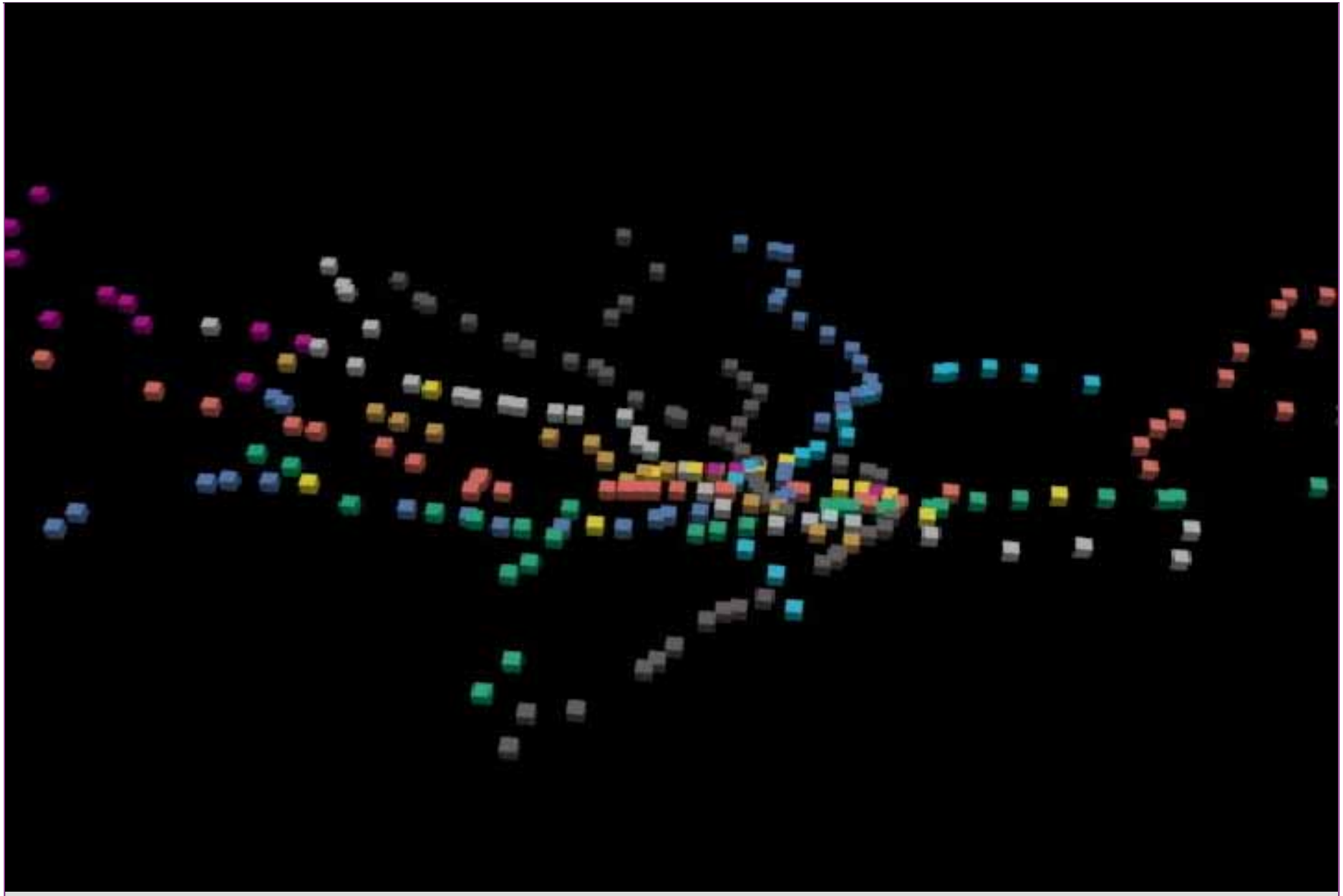
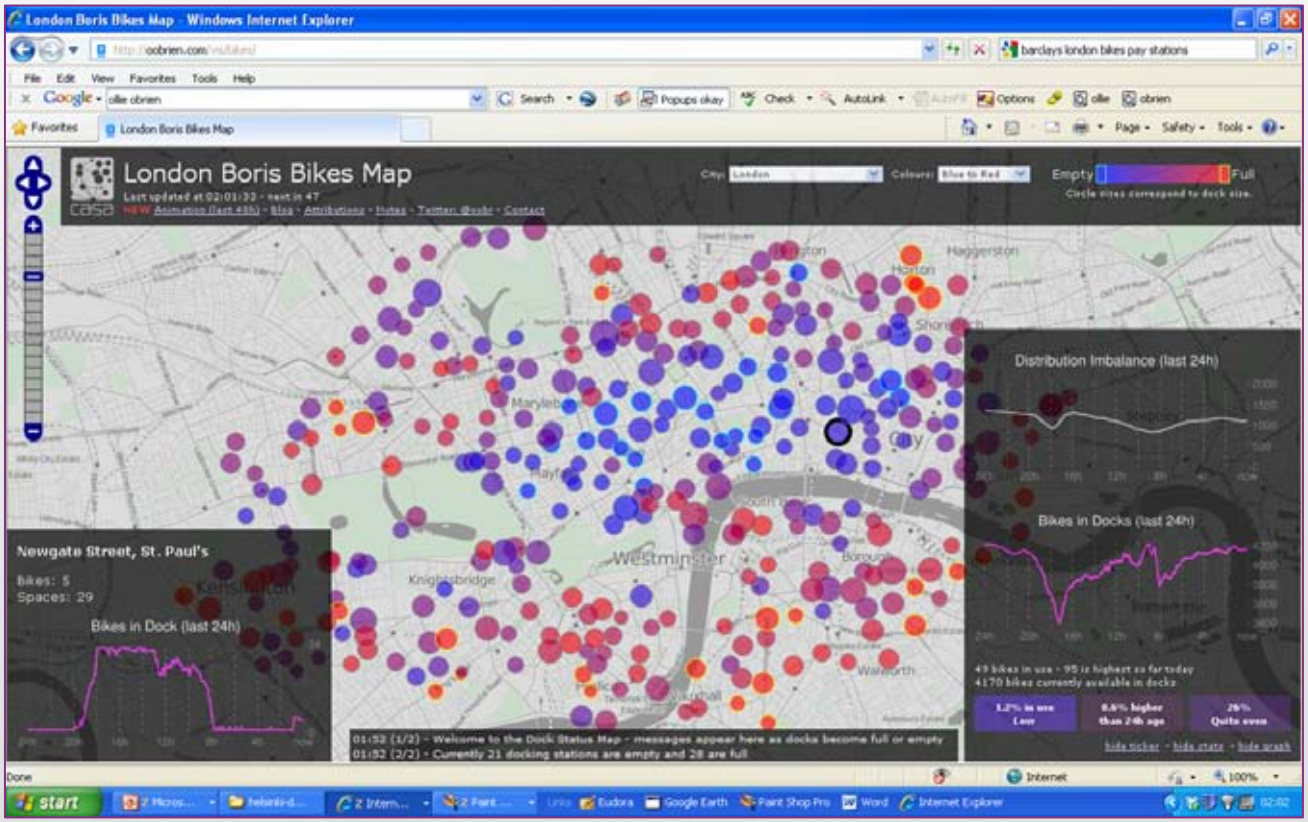


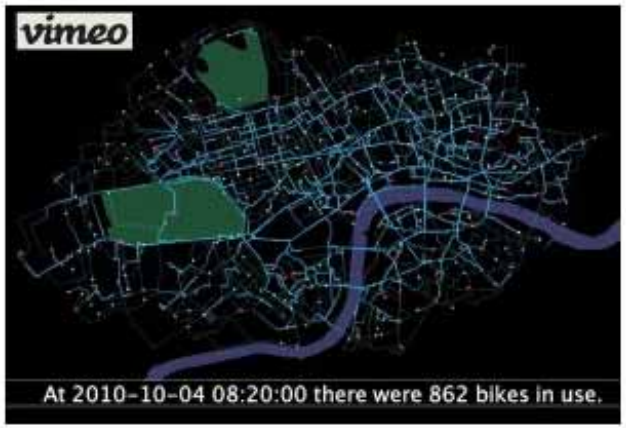
Exemplar 1: Public Bike Schemes: Local Routing

There are now public bikes schemes in many cities – one of our guys in CASA Ollie o'brien has classified these and has routine online data on these for many example. Our main example is London in fact where all the data from the very beginning of the scheme is available – several million records

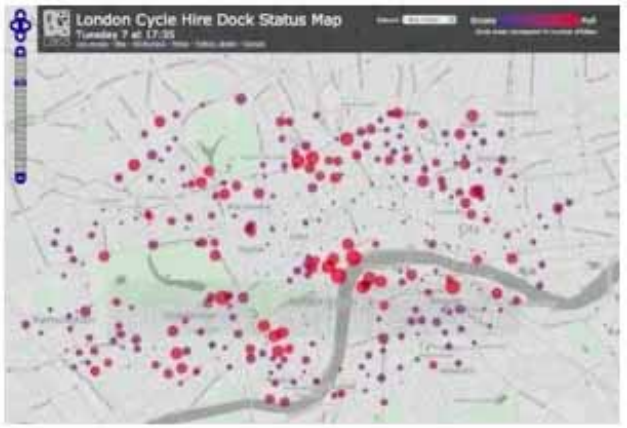
And we are just beginning to analyse this – so far we have not seen this examples in terms of crowds of congestion but doubtless the interaction of bikes with other traffic is an enormous issue in terms of extreme events

Our Bikes Project: Bikes Data – 4200 bikes, started Nov 2010, all the data– everything – all trips, all times, all stations/docks





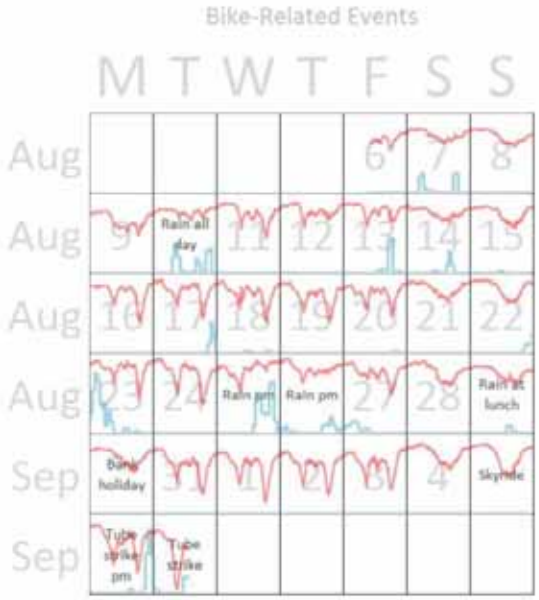
Animations of Public Bike Movements



Animations of Changes in the Bike Nodes: Docking

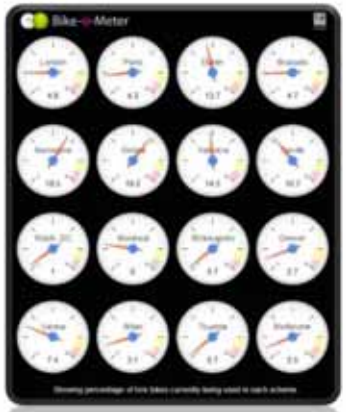
More Analysis

- **London**
- Graph shows number of bikes available to hire
- Effect of rain
  - Using the CASA weather station
- Effect of the tube strikes

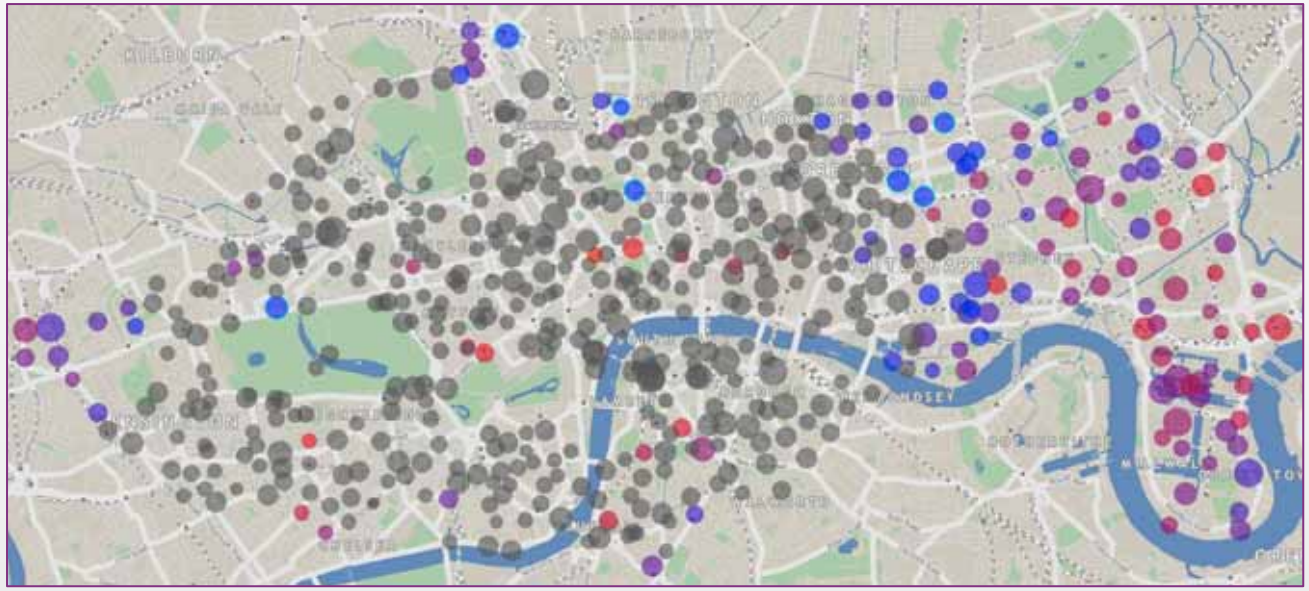


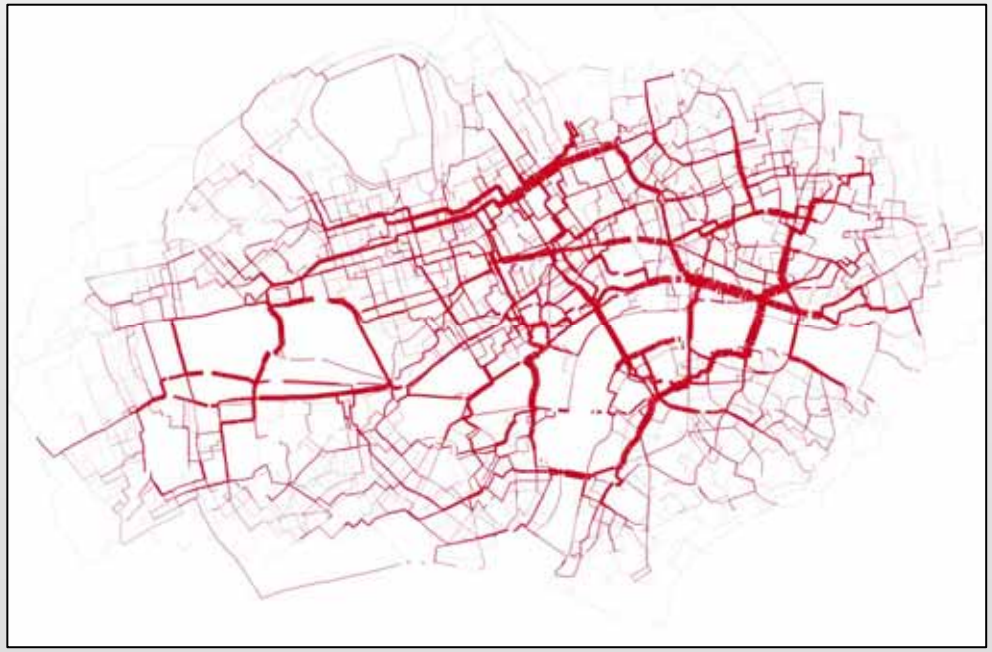
Bike-o-Meter
casa.ucl.ac.uk/bom

- Tweet-o-Meter for bikes
  - Steven Gray (@frogo)
  - Using Google Gauges
- See the real life Tweet-o-Meters at the new British Library "Growing Knowledge" exhibition
  - Should be easy to hack to show the Bike-o-Meters instead ☺




Barclays Cycle Hire
extends east
from 8 March





Exemplar 2: London's Public Transport System

We are hard at work with our Big Bata set on London's public transport system. Let me emphasise yet again that we are talking here of 7-8 million swipes/trips, crudely – 40 million a week, 200 million a month, 2.4 billion a year, more than 10 billion in five years ….

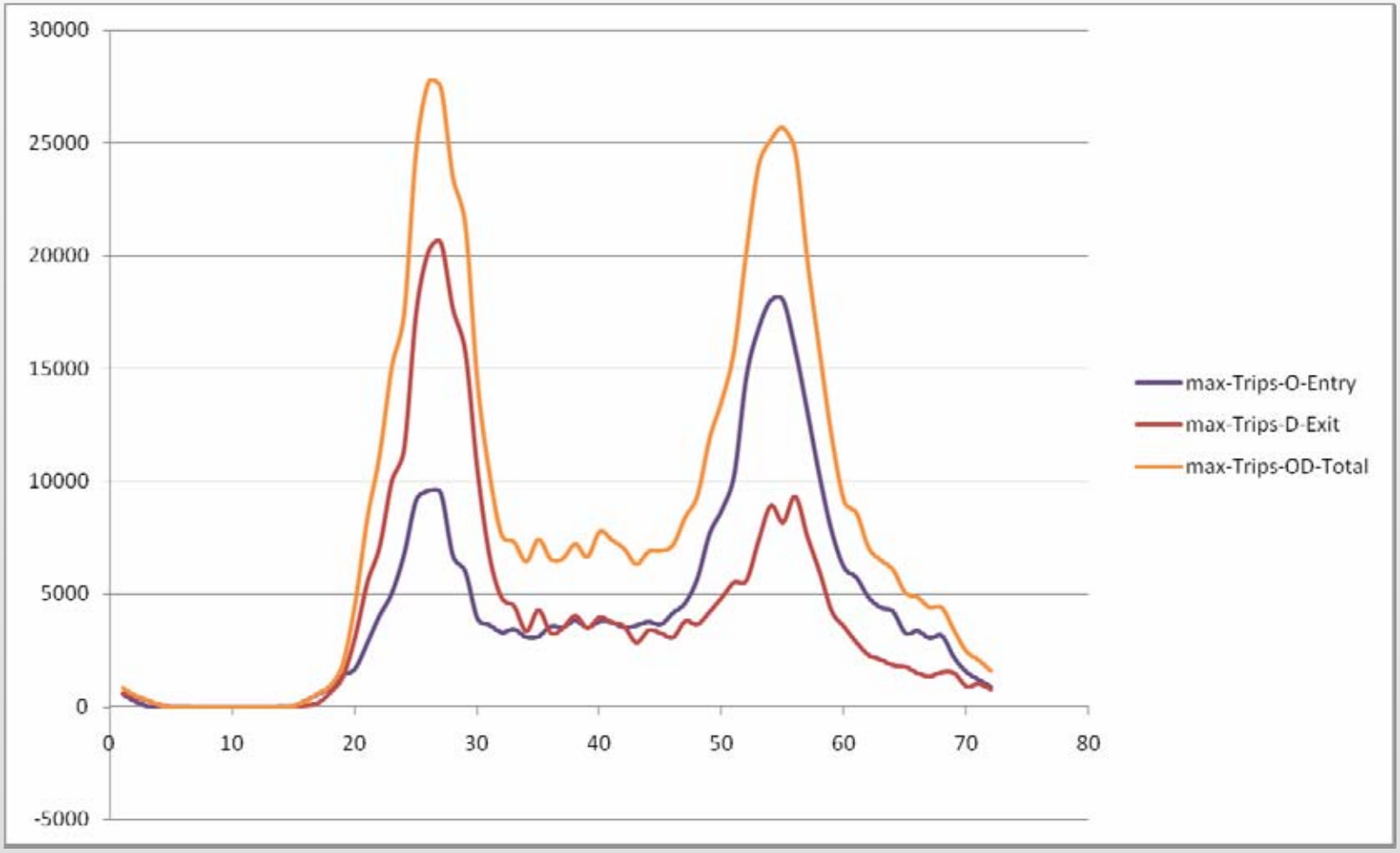
As E. M. Forster in his short story of 1909 implies, this will only end when we or something switches off the machine … the implications of data for ever are interesting. We can mine this data a million ways but there are issues. Let me give you a sense of what we are doing.

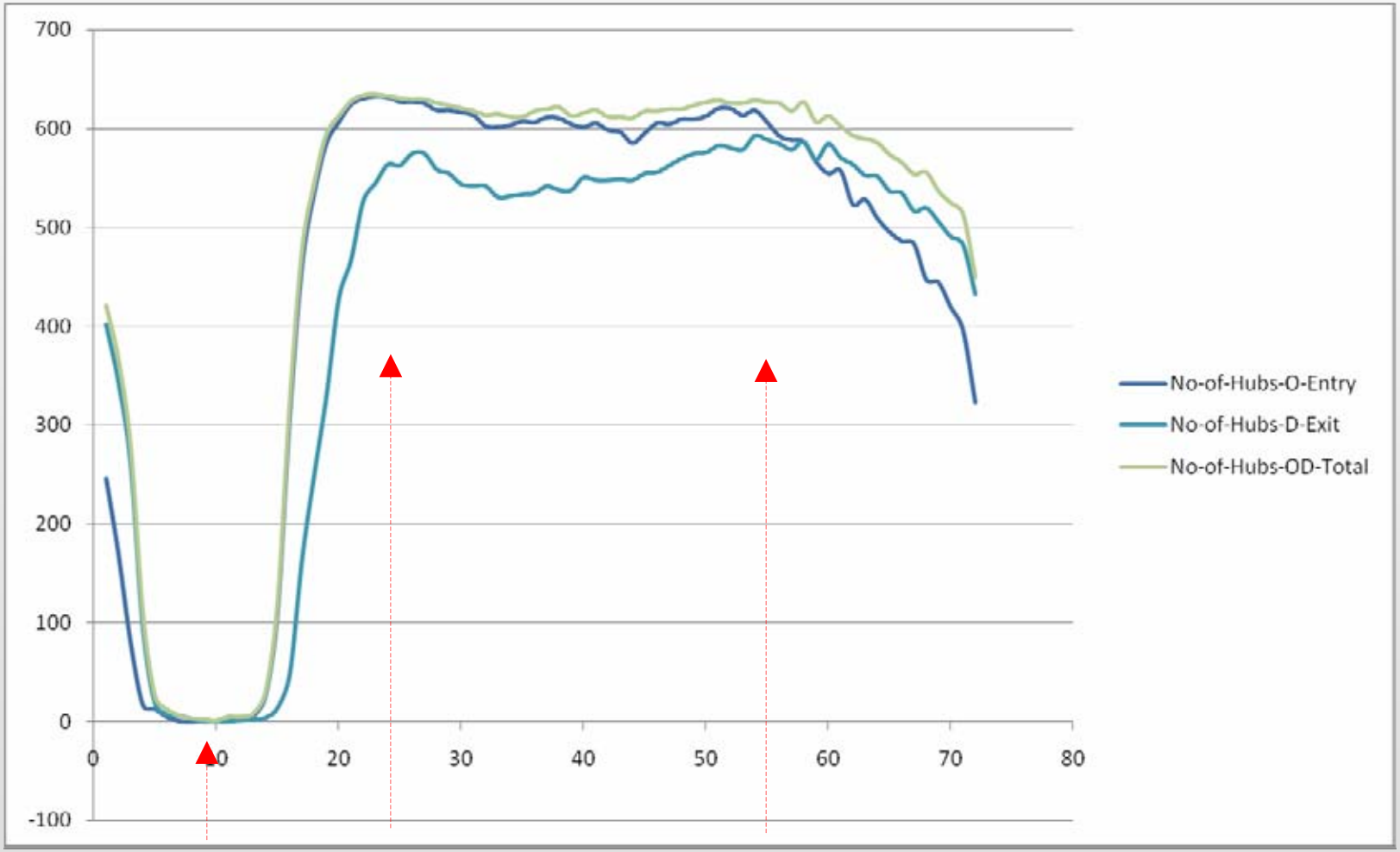
We can examine origins volumes, destination volumes separately and we are doing but here we will simply add these together as total volumes – in this sense they will not have meaning any longer as trips

	A	B	C
1	1	London-Bridge	599568
2	2	Victoria	502127
3	3	Waterloo	486861
4	4	Liverpool-Street	437658
5	5	Kings-Cross	395919
6	6	Shepherd's-Bush	346027
7	7	Hammersmith	274623
8	8	Wimbledon	198913
9	9	Paddington	196067
10	10	Vauxhall	180411
11	11	Stratford	177964
12	12	Oxford-Circus	150704
13	13	Charing-Cross	149290
14	14	Ealing-Broadway	139911
15	15	Euston	138394
16	16	Canary-Wharf	132206
17	17	Barking	112842
18	18	Balham	111090
19	19	Brixton	108814
20	20	London-Terminals	93026

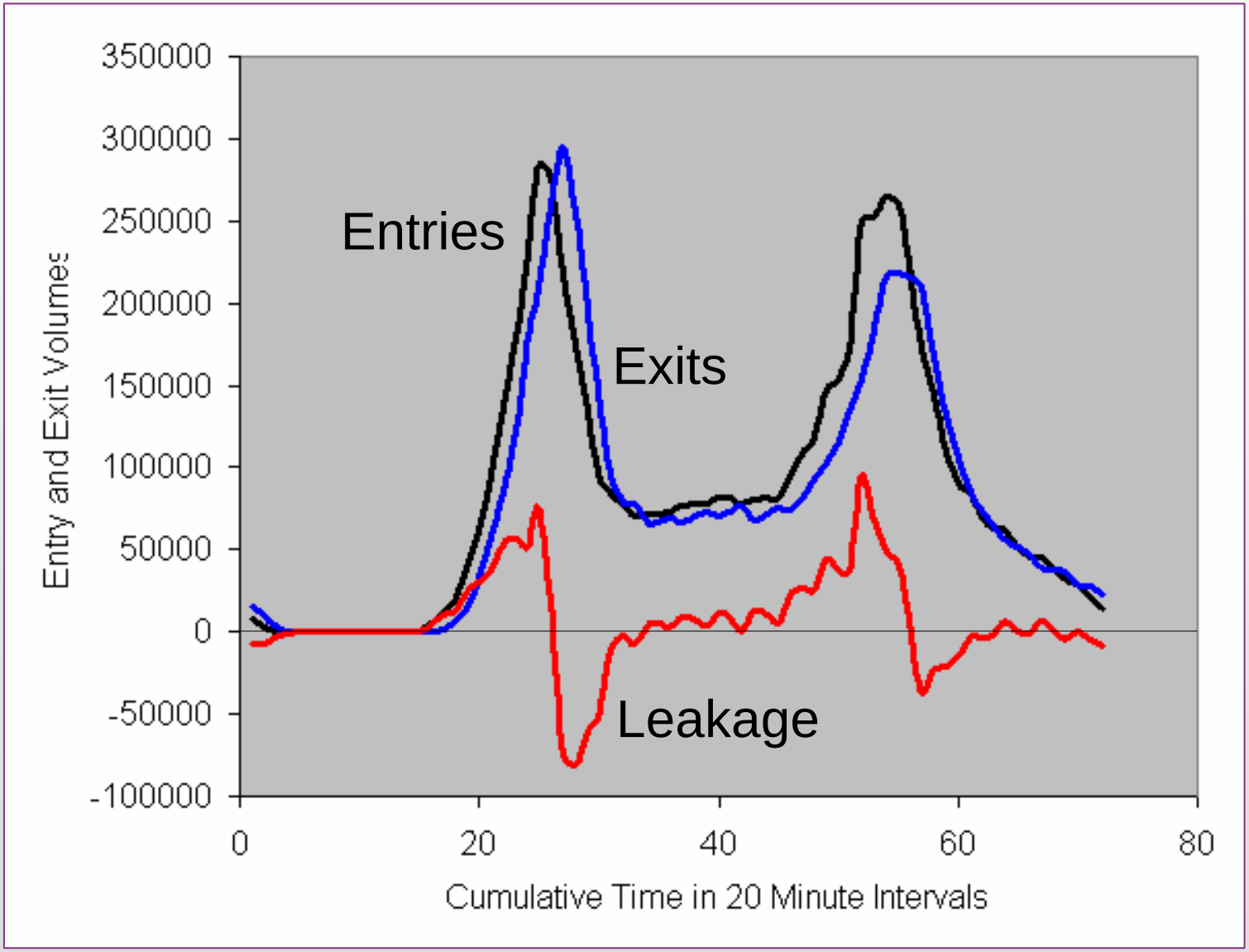
We will now examine the profiles of behaviour during the 24 hour day to provide some sense of the problem

Examining the Dynamics of the Hub Volumes





Night am peak pm peak


350000
300000
250000
200000
150000
100000
50000
0
-50000
-100000
Entry and Exit Volumes
Entries
Exits
Leakage
0
20
40
60
80
Cumulative Time in 20 Minute Intervals

We will look at various comparisons between hub volumes as ordered from largest to smallest. We show these as counter-cumulative frequencies which are rank size plots.

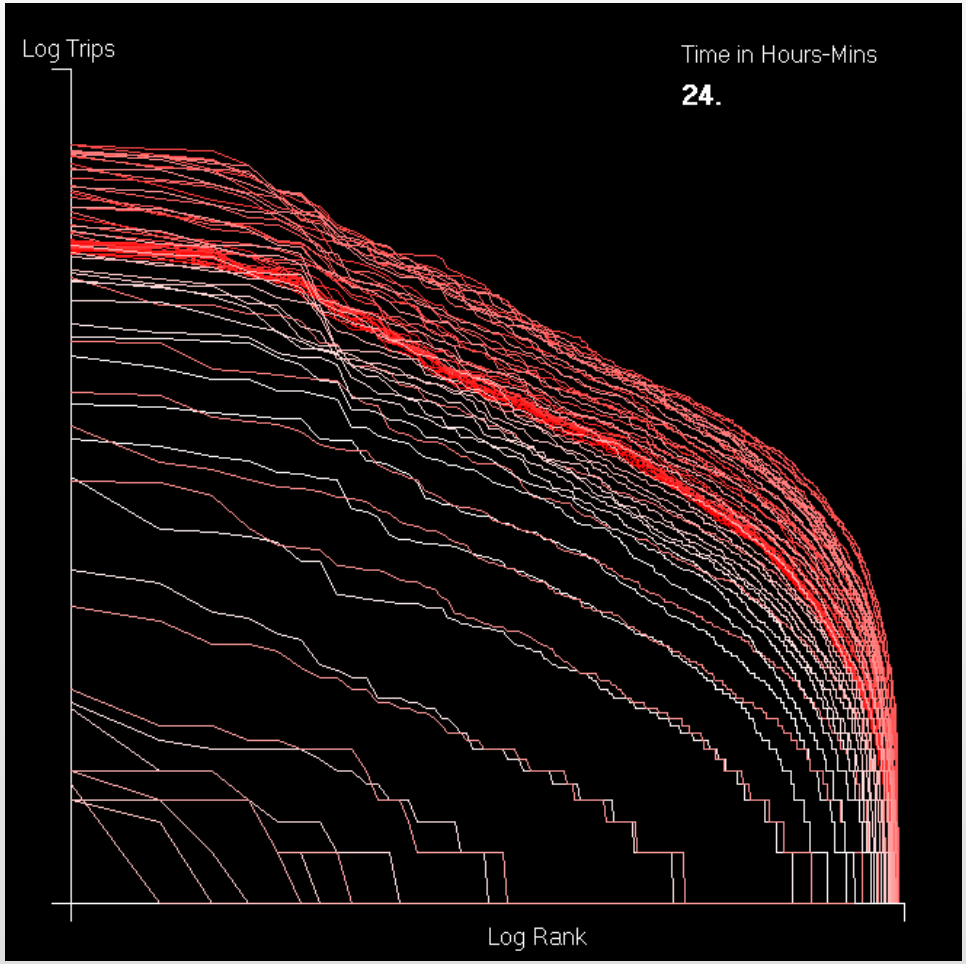
We add swipe in to swipe outs. Because of their right skewness, we plot them on log log scales which if they follow power laws – which they don't for obvious constraints on their scaling – would appear as straight lines.

Here is the scaling

All Hub Volumes Ordered as Rank Size Profiles

$$O_i(t) + D_i(t) = \sum_j F_{ij}(t) + \sum_j F_{ji}(t)$$

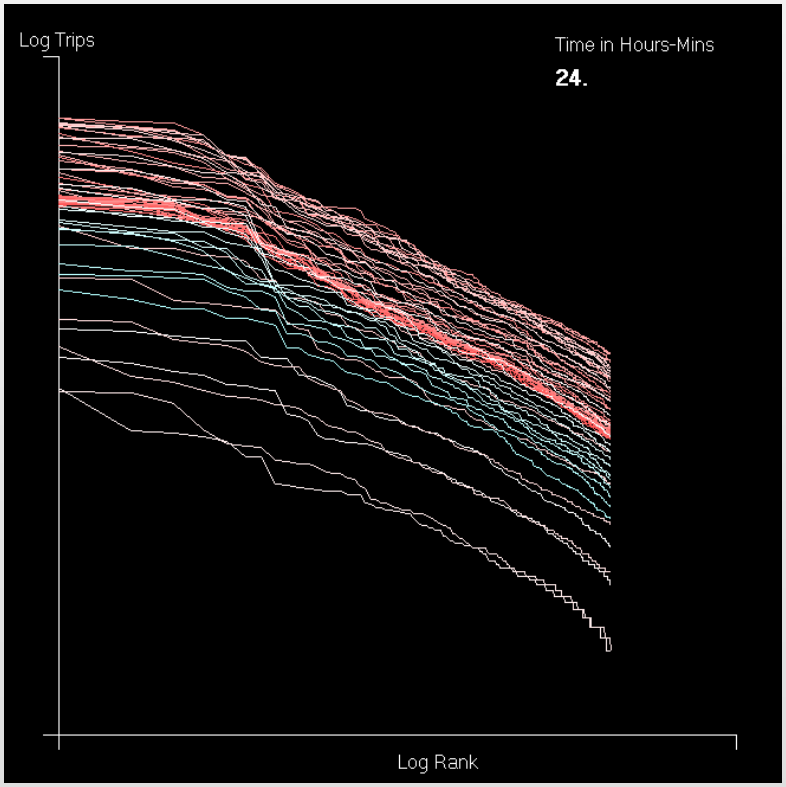
Let me load the program and run it as it is quite short and fast and gives you an idea of the dynamics



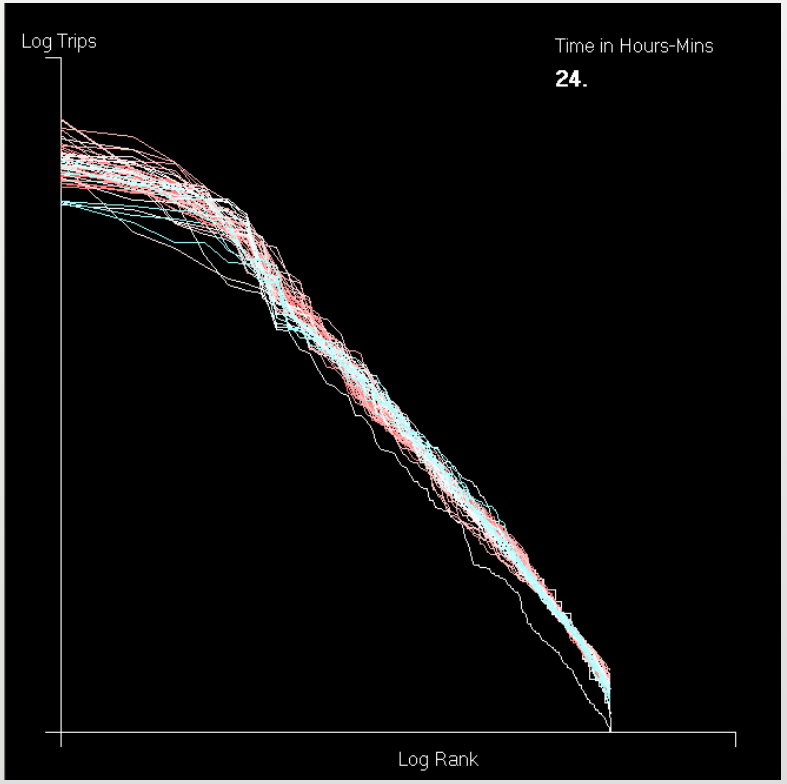
$R_i(t)$

We have a major problem as all hubs are not always active. To make good comparisons, we need to compare like with like – nos of hubs & volumes

Reduced to Top 200

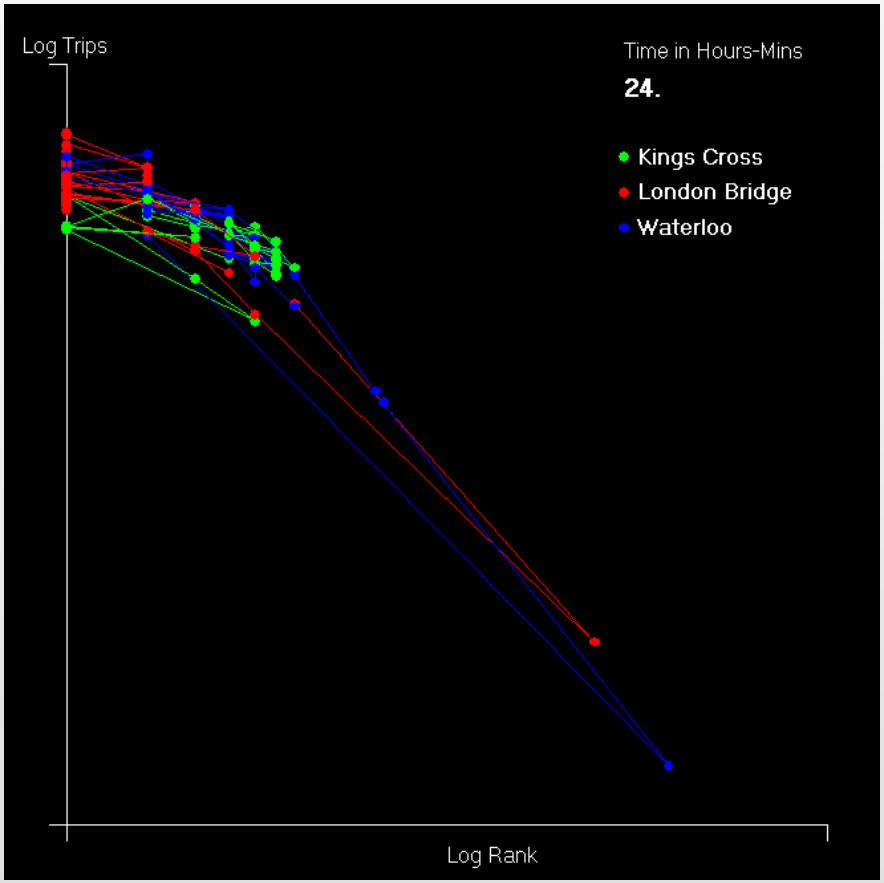


Collapsed/Standardised



The Dynamics: Examining Individual Hubs: Trajectories

Here we show the movement in the hub volumes and ranks in the direction of the lines and dots



This gives you a sense of a tiny little bit of our data mining

Building Models of Crowds and Congestion

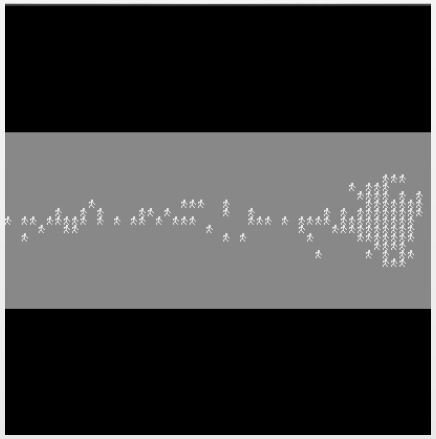
Our models of crowds tend to be rather simple – they are based on how people are attracted to a place or event which is encoded usually in the environment

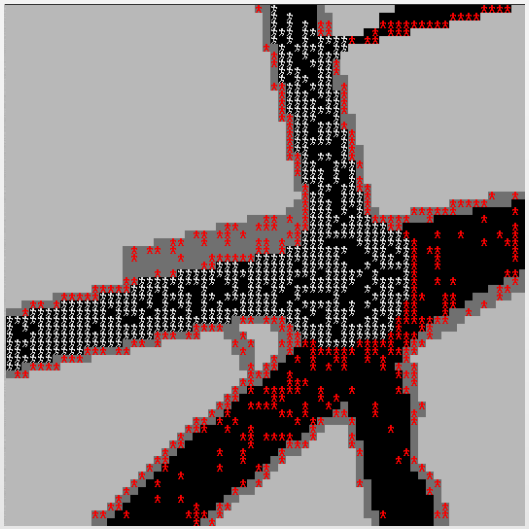
Then how they avoid obstacles which may be other people as well as physical obstacles like buildings

Then how they interact, are attracted, flock and crowd together

And then how they diffuse. The social forces model due to Dirk Helbing is as good a version of this as there is and in essence, all ABM of crowds tend to be this.

There is some randomness in essence which is moderated by the rules that we have just stated

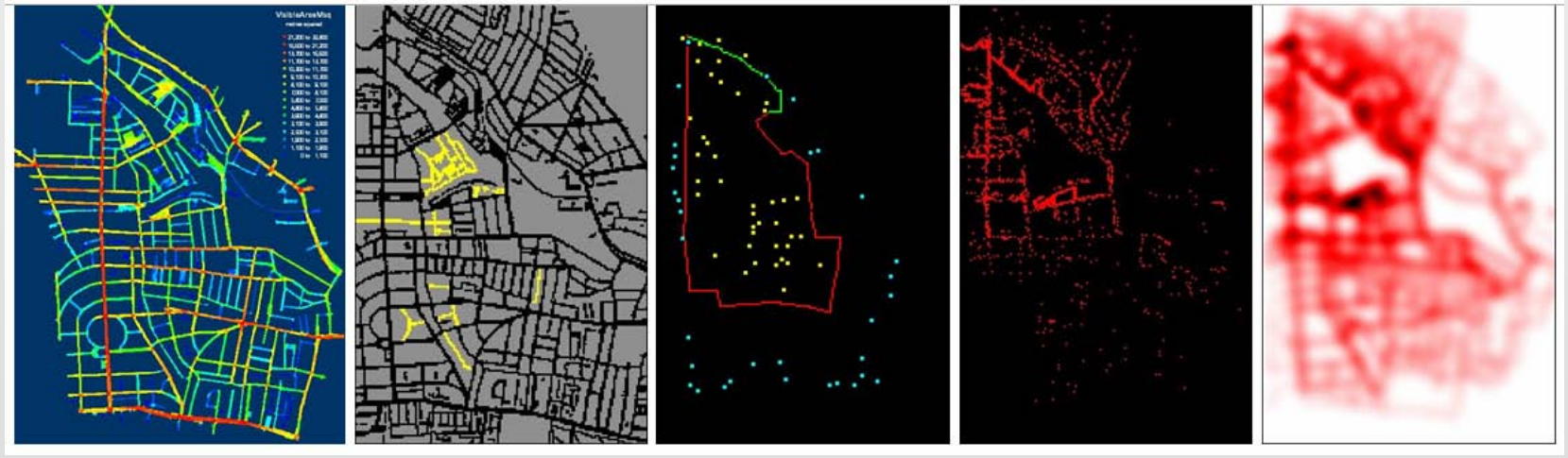




Let me quickly show some examples

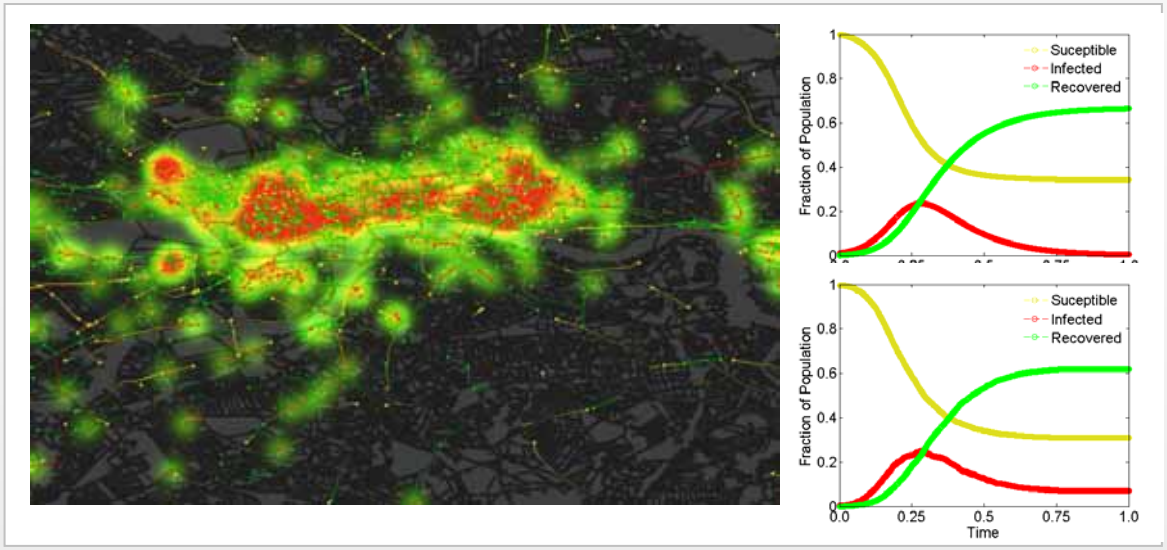
Exemplar 3: Notting Hill and Covent Garden

In a different tradition but one which is rapidly converging with our interests in sensing and networks, we have developed a number of pedestrian models, first for the Notting Hill Carnival, and then for many town centres



We are now working on fine scale models which are mirror diffusion and spread in situations ranging from epidemics to evacuation and shopping.

We have a simple model of epidemics on networks in London and we are looking at evacuations of major shopping centres such as Covent Garden (right)



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Dr Anders Johansson

Senior Lecturer in Systems Engineering, Systems Centre
Department of Civil Engineering,
University of Bristol

Honorary Senior Research Associate, Centre for Advanced Spatial Analysis (CASA),
University College London (UCL)

BBC

Crowd experiment and live crowd analytics in London:
Bang Goes the Theory - Series 6 - Episode 4 [www]

THE LANCET Mass Gathering Medicine

New papers on **Mass Gatherings Health** in the ***Lancet Infectious Diseases***

Johansson, A., Batty, M., Hayashi, K., Albar, O., Memish, Z., and Marcozzi, D. (2012) **Crowd and environmental management during mass gatherings** [www]

Steffen, R., Bouchama, A., Johansson, A., Dvorak, J., Isla, N., Smallwood, C., and Memish, Z. A. (2012) **Non-communicable health risks during mass gatherings** [www]

Khan, K., McNabb, S., Memish, Z., Eckhardt, R., Hu, W., Kossowsky, D., Sears, J., Arino, J., Johansson, A., Barbeschi, M., McCloskey, B., Henry, B., Cetron, M., and Brownstein, J. S. (2012) **Infectious disease surveillance and modelling across geographic frontiers and scientific specialties** [www]

Press
Press release: [www] MyScience: [www] Guardian: [www] BBC:

Next Steps

Well of course with all these examples we can throw spanners in the works and watch what happens.

We are getting the Oyster Card data from TfL for over the Olympics period – and at least we will be able to retrofit our models of how the system breaks down !

It would be nice to get the Octopus card data for HK

But the real challenges are a) *building models which match these new data* and b) *exploring coupled networks – how network effects cascade*. I leave you with these and here are some resources.

Let me finish by listing some resources: first recent papers which are related to this

Comber, A., Brunsdon, C., ***Batty, M., Hudson-Smith., A., Neuhaus. F., , and Gray, S.*** (2012) Exploring Geographies in Social Media: A Comparative Analysis of Methods for Detecting Networked Communities in Twitter Data, submitted to **Social Networks**

Johansson, A, Batty, M., Hayashi, K., Al Bar, O., Marcozzi, D., and Memish, Z. A.(2012)) Crowd and Environmental Management During Mass Gatherings, **The Lancet Infectious Diseases**, doi:10.1016/S1473-3099(11)70287.

Roth C., Kang S. M., ***Batty, M.,*** and Barthelemy, M. (2011) Structure of Urban Movements: Polycentric Activity and Entangled Hierarchical Flows. **PLoS ONE 6(1):** e15923. doi:10.1371/journal.pone.0015923

C. Roth, S. M. Kang, ***M. Batty,*** and M. Barthelemy (2012) A Long-Time Limit for World Subway Networks, **Journal of the Royal Society Interface**, published online 16 May 2012; doi: 10.1098/rsif.2012.0259

Ratti C, Sobolevsky S, Calabrese F, Andris C, ***Reades J.,*** Martino, M., Claxton, R., Strogatz, S. (2010) Redrawing the Map of Great Britain from a Network of Human Interactions. **PLoS ONE 5(12):** e14248. doi:10.1371/journal.pone.0014248

Some of our blogs

A Science of Cities http://www.complexcity.info/

Spatial Complexity http://www.spatialcomplexity.info/

Big Data ToolKit http://bigdatatoolkit.org/

Digital Urban http://www.digitalurban.org/

GIS and Agent-Based Modelling http://gisagents.blogspot.com/

Simulacra http://simulacra.blogs.casa.ucl.ac.uk/

Sociable Physics http://sociablephysics.wordpress.com/

Spatial Analysis http://spatialanalysis.co.uk/

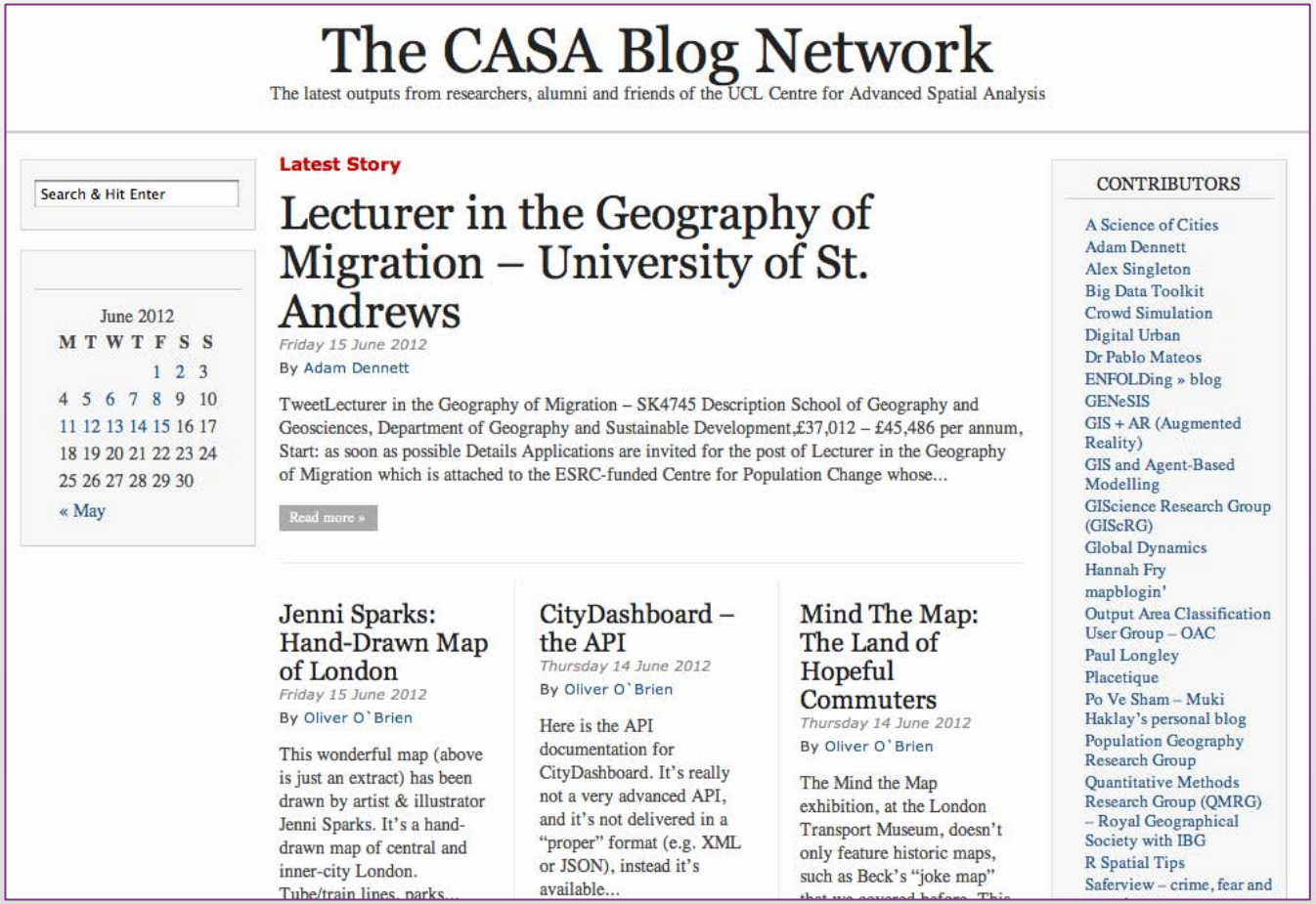
Suprageography http://oliverobrien.co.uk/

The Mapping London Blog http://mappinglondon.co.uk/

Urban Tick http://urbantick.blogspot.com/

Our blog aggregator

http://blogs.casa.ucl.ac.uk/



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« May

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Lecturer in the Geography of Migration – University of St. Andrews

Friday 15 June 2012

By Adam Dennett

TweetLecturer in the Geography of Migration – SK4745 Description School of Geography and Geosciences, Department of Geography and Sustainable Development,£37,012 – £45,486 per annum, Start: as soon as possible Details Applications are invited for the post of Lecturer in the Geography of Migration which is attached to the ESRC-funded Centre for Population Change whose...

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Jenni Sparks: Hand-Drawn Map of London

Friday 15 June 2012

By Oliver O`Brien

This wonderful map (above is just an extract) has been drawn by artist & illustrator Jenni Sparks. It's a hand-drawn map of central and inner-city London. Tube/train lines, parks...

CityDashboard – the API

Thursday 14 June 2012

By Oliver O`Brien

Here is the API documentation for CityDashboard. It's really not a very advanced API, and it's not delivered in a "proper" format (e.g. XML or JSON), instead it's available...

Mind The Map: The Land of Hopeful Commuters

Thursday 14 June 2012

By Oliver O`Brien

The Mind the Map exhibition, at the London Transport Museum, doesn't only feature historic maps, such as Beck's "joke map"

CONTRIBUTORS

A Science of Cities
Adam Dennett
Alex Singleton
Big Data Toolkit
Crowd Simulation
Digital Urban
Dr Pablo Mateos
ENFOLDing » blog
GENeSIS
GIS + AR (Augmented Reality)
GIS and Agent-Based Modelling
GIScience Research Group (GIScRG)
Global Dynamics
Hannah Fry
mapblogin'
Output Area Classification User Group – OAC
Paul Longley
Placetique
Po Ve Sham – Muki Haklay's personal blog
Population Geography Research Group
Quantitative Methods Research Group (QMRG) – Royal Geographical Society with IBG
R Spatial Tips
Saferview – crime, fear and

I will have posted this powerpoint to my blog

by the time you get to it. And this will be the latest post

http://www.complexcity.info/