Urban Computer Models
The Basis for Urban Analytics

Michael Batty

m.batty@ucl.ac.uk
@jmichaelbatty

http://www.complexCity.info/
http://www.spatialcomplexity.info/

Saturday, 22 June 2019

The lecture is in three parts

- Smart Cities: Definitions, History, Big Data
- Ideas About How Computers are Being Embedded in Cities, in particular networks and transit
- Urban Computer Models: The Basis for Urban Analytics

Urban Computer Models: The Basis for Urban Analytics

- Land Use Transportation Interaction (LUTI) Models: A Little Bit of History
- Our London Models: SIMULACRA: ARCADIA and SCALE Projects
- Requirements: The Model Design: Flows:
- The Visual Template: The Desktop Model
- Building a Web-Based Model Interface
- The QUANT Model: For Very Large Areas

Land Use Transportation Interaction (LUTI) Models: A Little Bit of History

- Early models: CATS 1955: The 1960s Models
- Largeness, remoteness from users, crude representation, limits on computation, poor links to policy
- Lack of understanding of model outcomes
- Statics versus dynamics – semi-dynamic models but most operational models predicated in terms of equilibrium and as we have seen, the most developed are structured in terms of a dynamic equilibrium
- Disaggregation of sectoral activities
- Many aggregates treated as agents, many zones

- Alter and aggregate the zoning system quickly and easily, on the fly almost
- Alter by adding and deleting different model sectors, so for example running a model based on simply the retailing and other employment sectors without the residential and so on
- Subjecting the model to various kinds of physical constraints, at will and according to external policies
- Extending all sectors to not only predict endogenous activities but to also be subject to exogenous inputs of the same
- To interface the models easily and quickly with other sectoral models, particularly demographic and possibly more established transport models

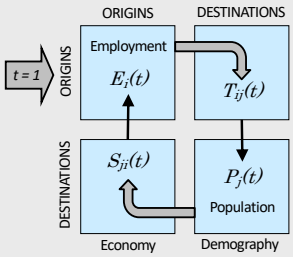
Our London Models: SIMULACRA: ARCADIA and SCALE Projects

- SIMULACRA is a generic set of models that we are building for a series of projects, first the ARCADIA project that is an extension of Tyndall, and then for another EPSRC Project called SCALE which deals with energy change in large cities
- We are very keen on building a model framework in which we can develop many different variants, easily and quickly. Visualisation is critical, so is scale, so it speed
- I think we are now in a position in this field where we can and should develop lots of variants, which test the robustness of any approach

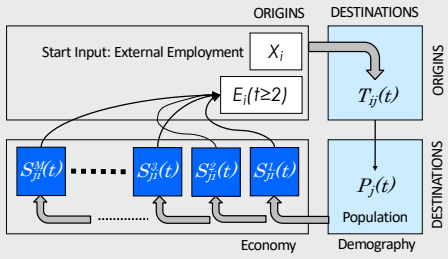
Requirements:

- Alter and aggregate the zoning system quickly and easily, on the fly almost
- Alter by adding and deleting different model sectors, so for example running a model based on simply the retailing and other employment sectors without the residential and so on
- Subjecting the model to various kinds of physical constraints, at will, according to external policies
- Extending all sectors to not only predict endogenous activities but to also be subject to exogenous inputs of the same
- To interface the models easily and quickly with other sectoral models

Let me give you a quick tutorial on their structure:

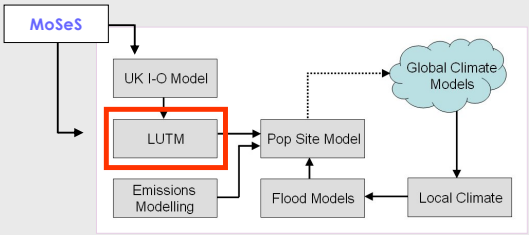


We can expand this structure into multiple sectors. Several LUTi models have done this – e.g. the Cambridge (UK) input-output LUTi

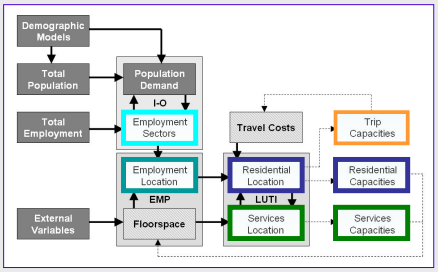


Integrated Assessment

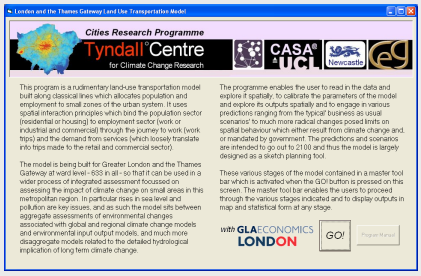
So let me pull these together in my first example

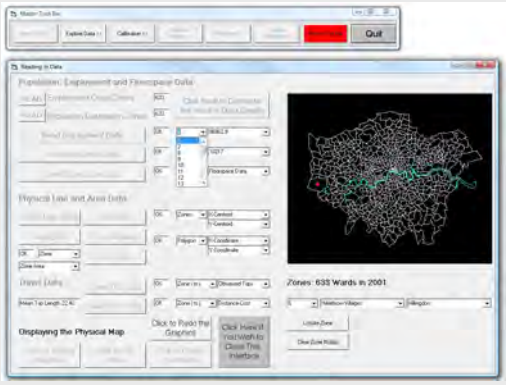


The Structure of the Land Use Transport Model

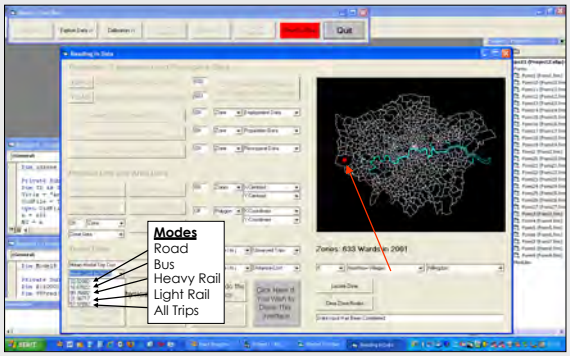


To give a flavour of the model, I will show some screen shots first



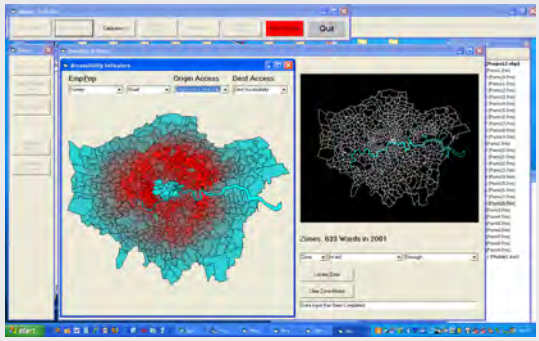


Urban Computer Models: The Basis for Urban Analytics

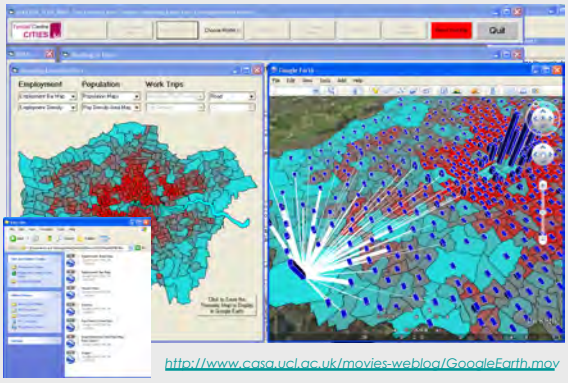


Road: 38%; Bus: 12%: Heavy Rail: 12%: Light Rail 19%; Other (Walk, Bike): 19%

Urban Computer Models: The Basis for Urban Analytics

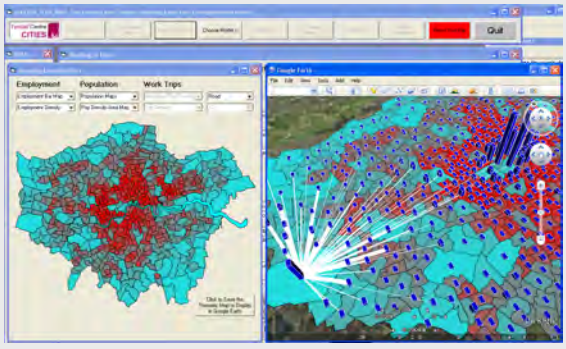


Urban Computer Models: The Basis for Urban Analytics



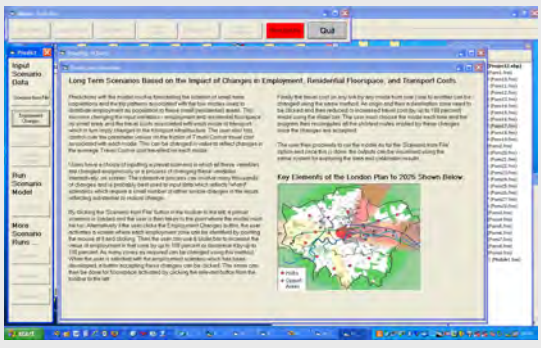
http://www.casa.ucl.ac.uk/movies-weblog/GoogleEarth.mov

Urban Computer Models: The Basis for Urban Analytics

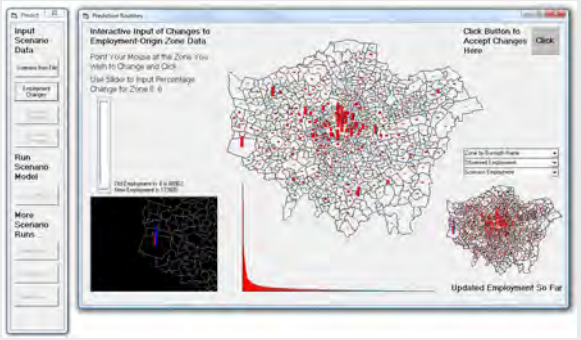


Exporting data and predictions to external software on the fly

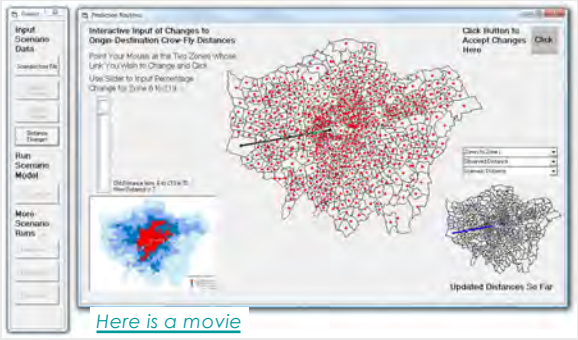
Urban Computer Models: The Basis for Urban Analytics



Urban Computer Models: The Basis for Urban Analytics

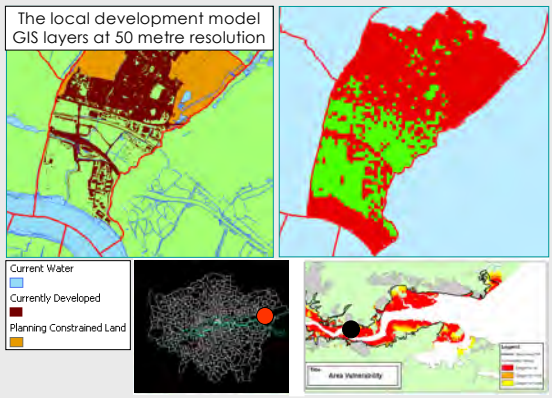


Urban Computer Models: The Basis for Urban Analytics



Here is a movie

Urban Computer Models: The Basis for Urban Analytics

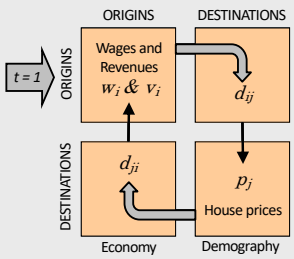


Urban Computer Models: The Basis for Urban Analytics

A Sketch for Aggregate Models: SIMULACRA

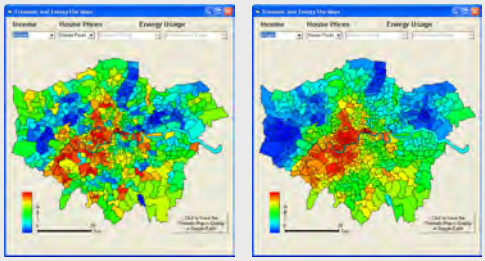
- Our current model is more disaggregate, more extensive and is really a suite of model types, it has an explicit money sector as house prices and wages are quite important
- We do not attempt to model markets – this is quite impossible in London as the market hardly follows any known theory
- We simply use transport costs, wages and prices to determine residential location

Urban Computer Models: The Basis for Urban Analytics



Urban Computer Models: The Basis for Urban Analytics

To illustrate very briefly the sort of data that we have in the money sector that is driving this variant of the model and also the residential location equations



Urban Computer Models: The Basis for Urban Analytics

with travel as a difference or variance σ^2 between these two sets of costs. Then, the system must satisfy the constraint

$$\sum_i \sum_j T_{ij}[(b_i + t_i) - (c_{ij} + \rho_j)]^2 = \sigma^2 \qquad (11)$$

The model that is generated from this constraint and which is the alternative residential location model in the current model variant is

$$T_{ij} = E_i \frac{A_j \exp(-\lambda[(b_i + t_i) - (c_{ij} + \rho_j)]^2}{\sum_j A_j \exp(-\lambda[(b_i + t_i) - (c_{ij} + \rho_j)]^2} \qquad (12)$$

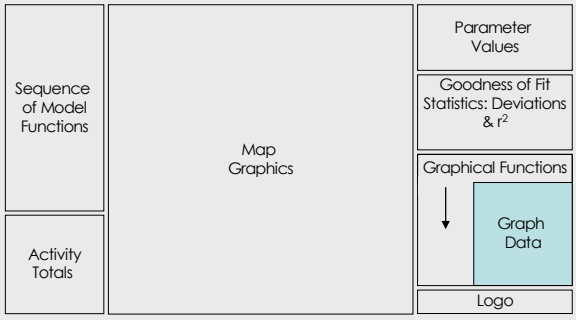
which is subject to the usual origin constraint, generating population from equation (2) with (12) replacing equation (1).

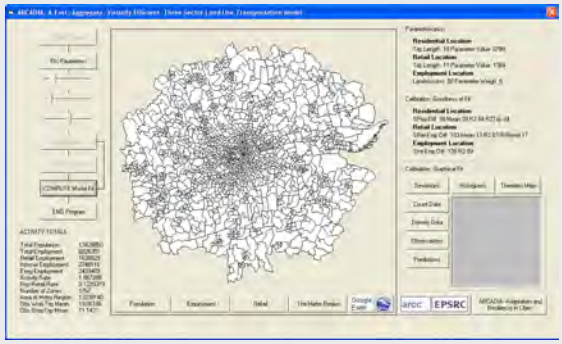


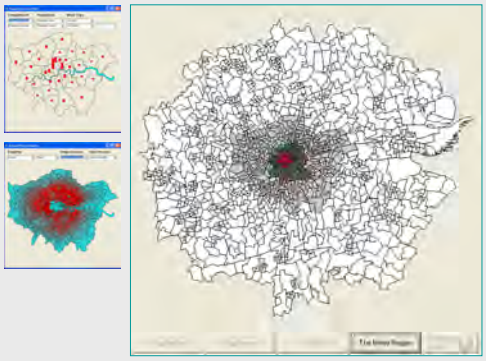
The Visual Template: The Desktop Model: Running It

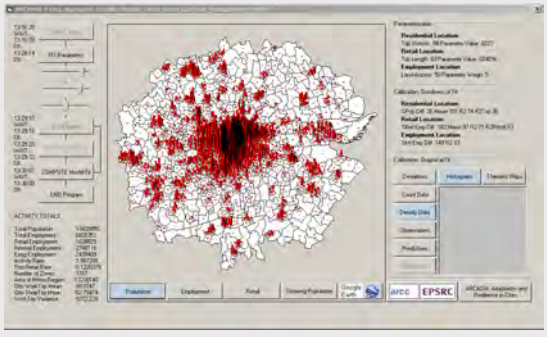
- We will now show the current model to present the logic of our framework. Our model has now been scaled up massively to include the outer met area – 1767 zones (33 – 633 – 1767 –and then 3202)
- It is now a three sector model, not simply a residential location model as it includes employment location, retail location and residential location
- So far, we now have modal split into 2 modes with 4 population categories and 6 employment types in terms of occupations –the model scales up to 48 times the size of the desktop model

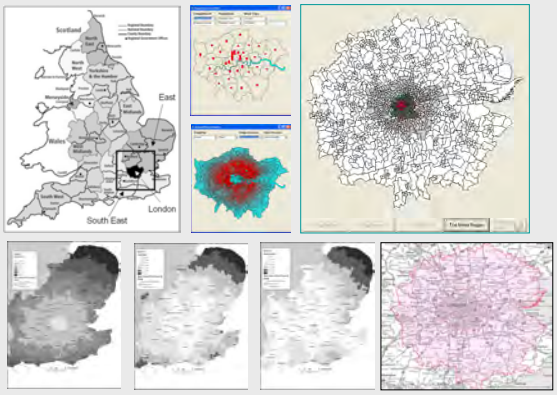
This is the order in which the operations take place











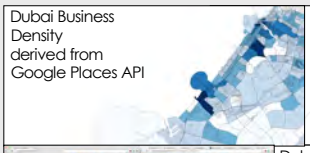
Applications

A New Retail Centre in Dubai

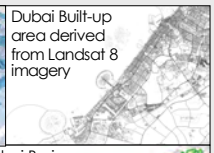


Where did we get the data – in a data poor environment?

Dubai Business Density derived from Google Places API

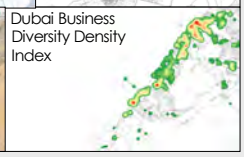


Dubai Built-up area derived from Landsat 8 imagery

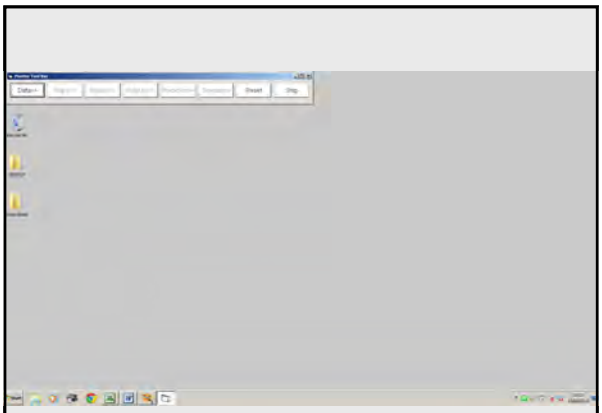


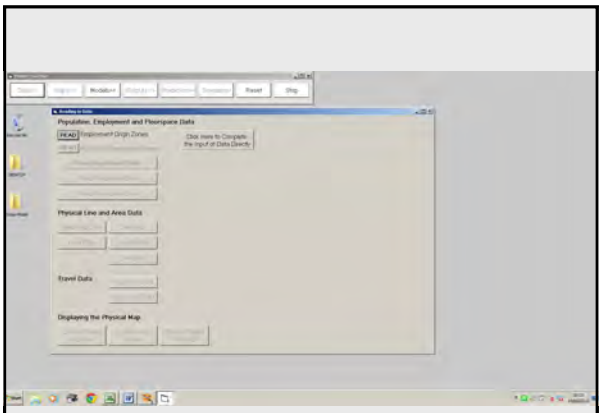


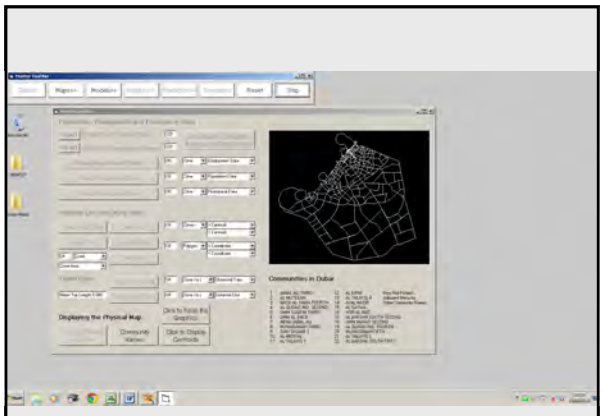
Dubai Business Diversity Density Index



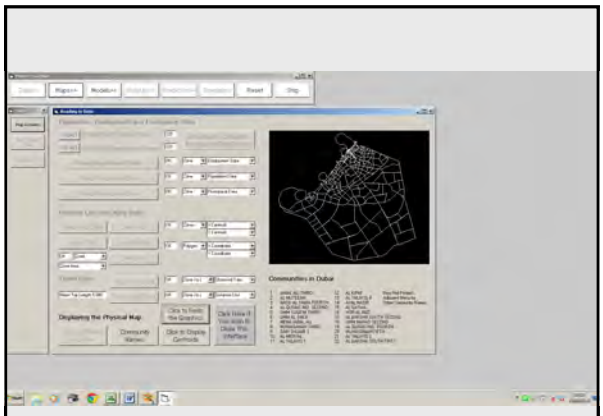




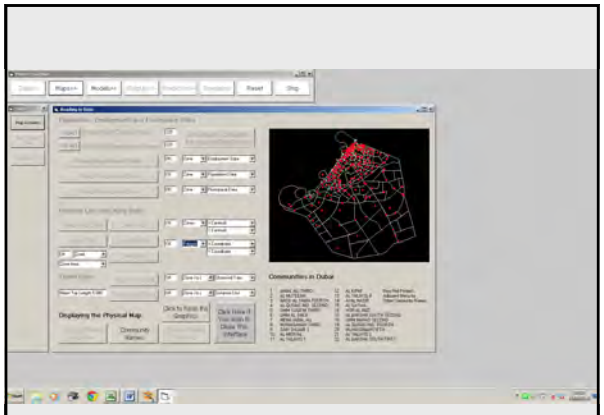




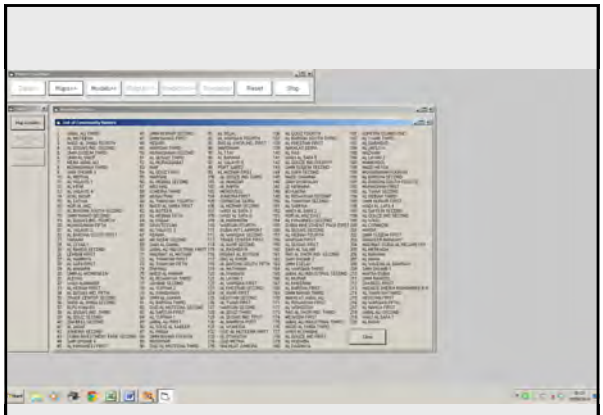
Urban Computer Models: The Basis for Urban Analytics



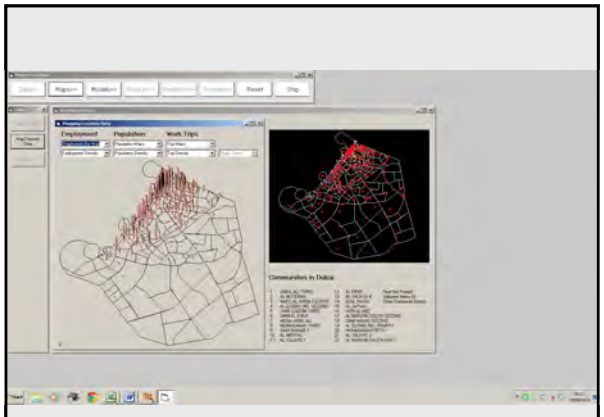
Urban Computer Models: The Basis for Urban Analytics



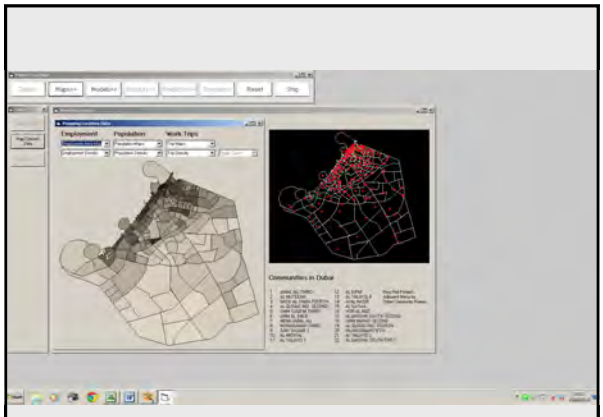
Urban Computer Models: The Basis for Urban Analytics



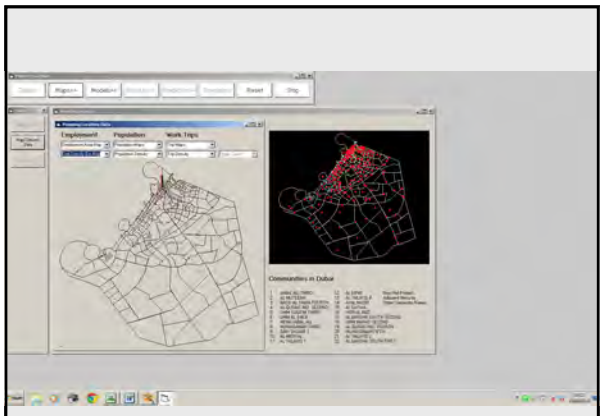
Urban Computer Models: The Basis for Urban Analytics



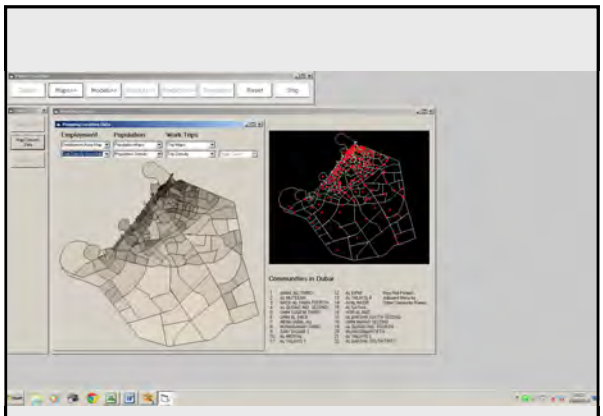
Urban Computer Models: The Basis for Urban Analytics



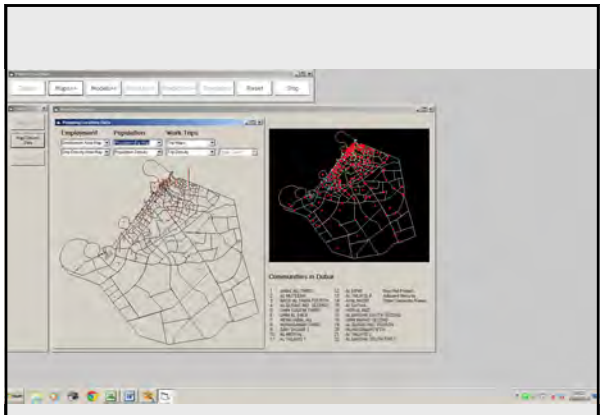
Urban Computer Models: The Basis for Urban Analytics



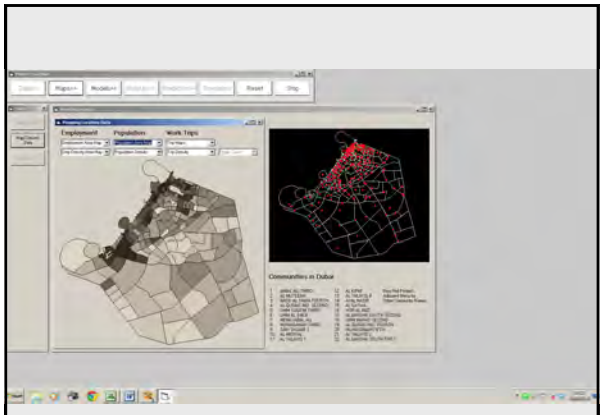
Urban Computer Models: The Basis for Urban Analytics



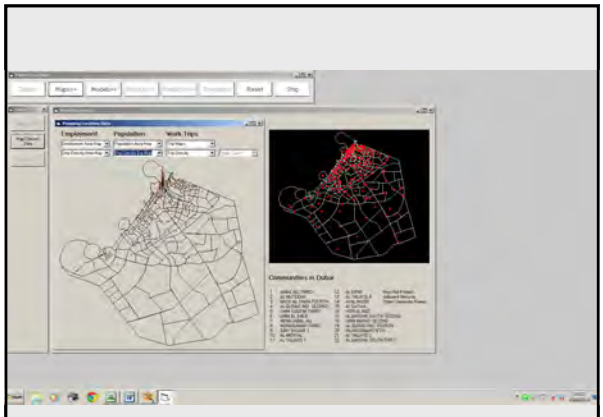
Urban Computer Models: The Basis for Urban Analytics



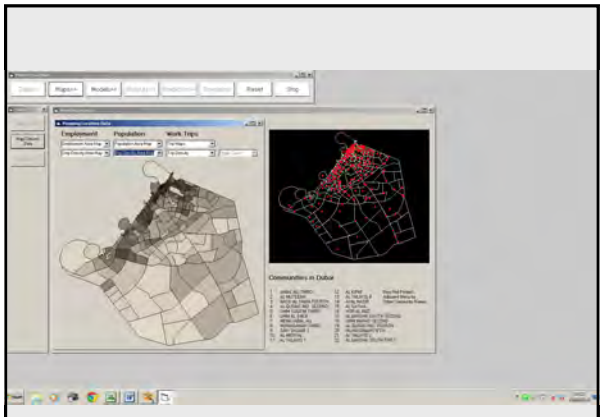
Urban Computer Models: The Basis for Urban Analytics



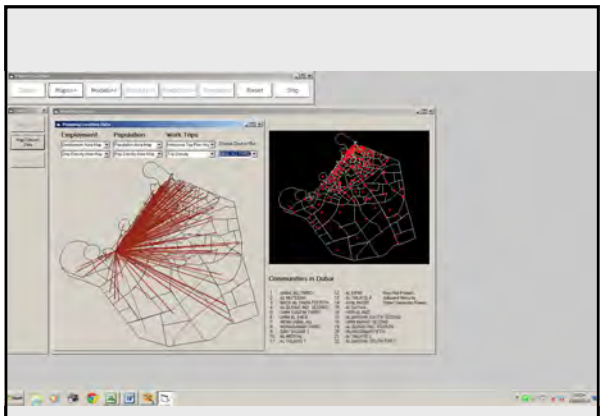
Urban Computer Models: The Basis for Urban Analytics



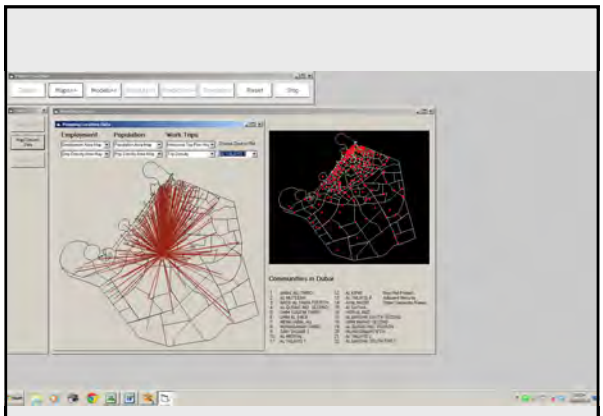
Urban Computer Models: The Basis for Urban Analytics



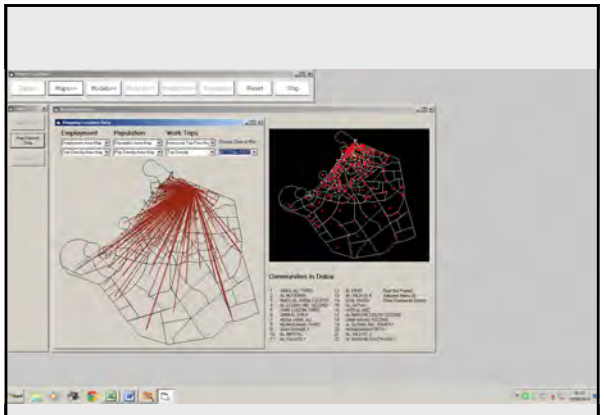
Urban Computer Models: The Basis for Urban Analytics



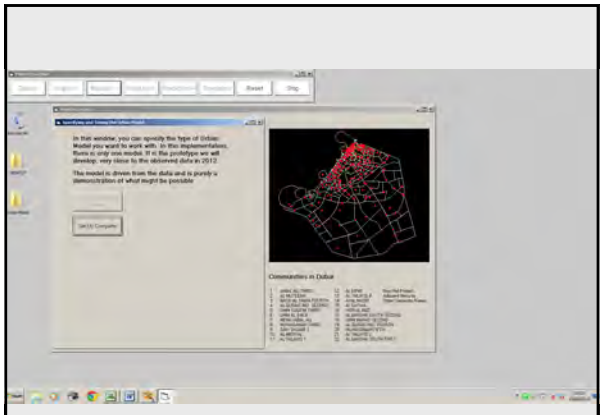
Urban Computer Models: The Basis for Urban Analytics



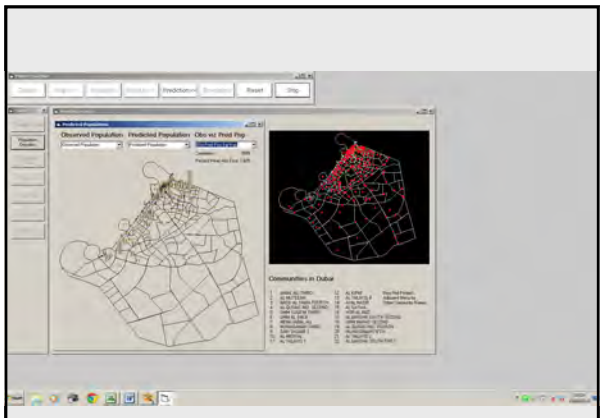
Urban Computer Models: The Basis for Urban Analytics



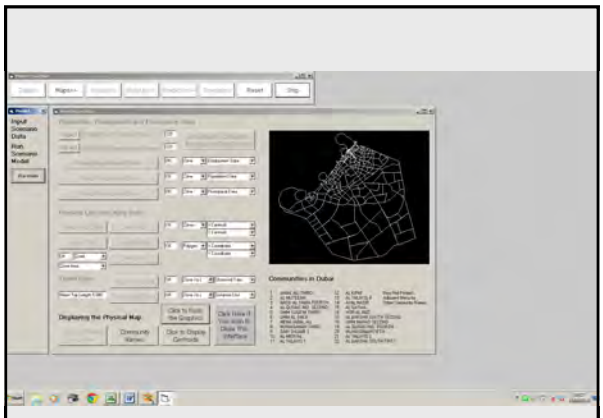
Urban Computer Models: The Basis for Urban Analytics



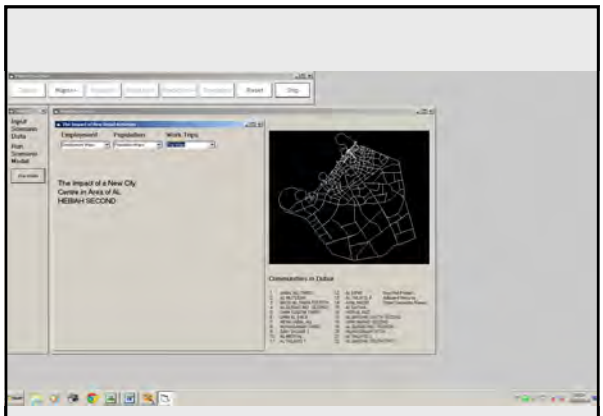
Urban Computer Models: The Basis for Urban Analytics



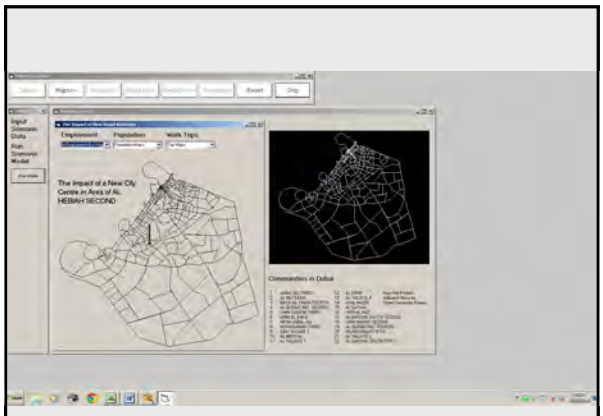
Urban Computer Models: The Basis for Urban Analytics



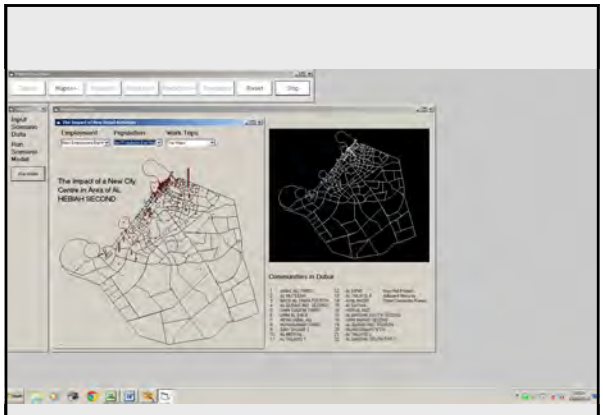
Urban Computer Models: The Basis for Urban Analytics



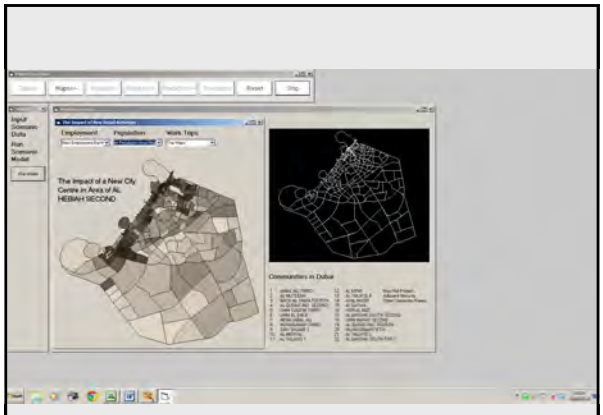
Urban Computer Models: The Basis for Urban Analytics



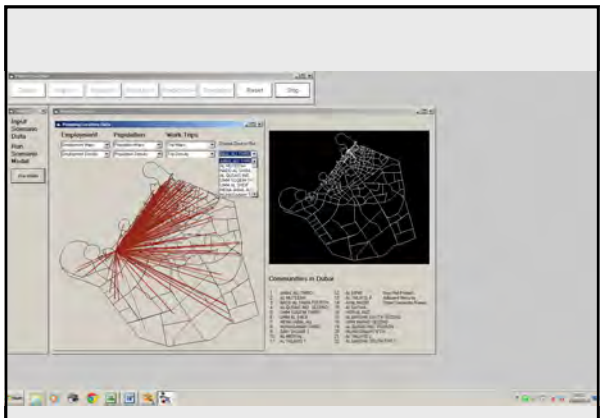
Urban Computer Models: The Basis for Urban Analytics



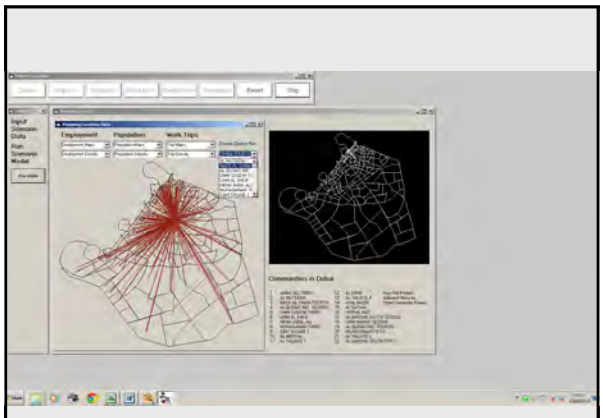
Urban Computer Models: The Basis for Urban Analytics



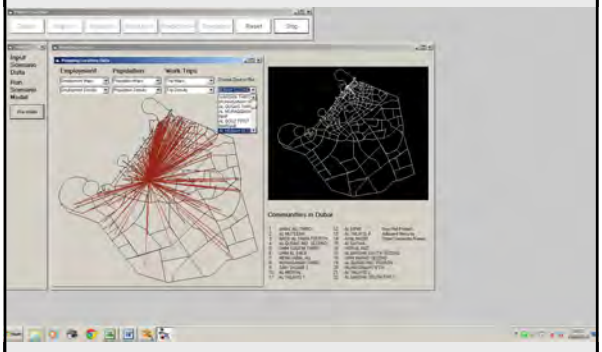
Urban Computer Models: The Basis for Urban Analytics



Urban Computer Models: The Basis for Urban Analytics

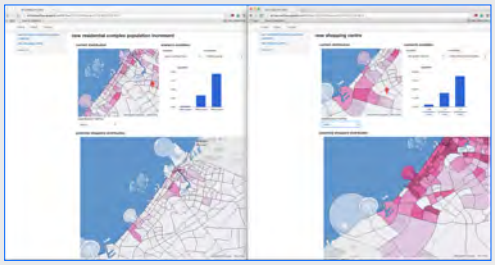


Urban Computer Models: The Basis for Urban Analytics



Applications

A New Retail Centre in Dubai



Building a Web-Based Model Interface

We are extending our models to the web so all can use them

I will talk about this model on the first day of the ICUI conference and it is designed to be used by everyone – a kind of crowd-modelling for every one

We have also extended it to the whole country – E S W and this means all local planning agencies can use it for broadbrush scenario planning

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

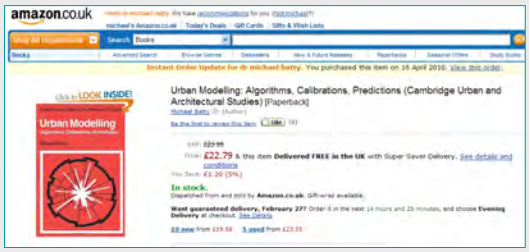
http://quant.casa.ucl.ac.uk/



m.batty@ucl.ac.uk
richard.milton@ucl.ac.uk

CATAPULT Future Cities
UKCRIC
UK Collaboratorium for Research in Infrastructure & Cities
Infrastructure and Projects Authority
National Infrastructure Commission

The book is quite old – older than most of you – you can get it at



Or download the book from
http://www.casa.ucl.ac.uk/urbanmodelling/

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

m.batty@ucl.ac.uk