The SIMULACRA Modelling Framework: Applications to London and the South East

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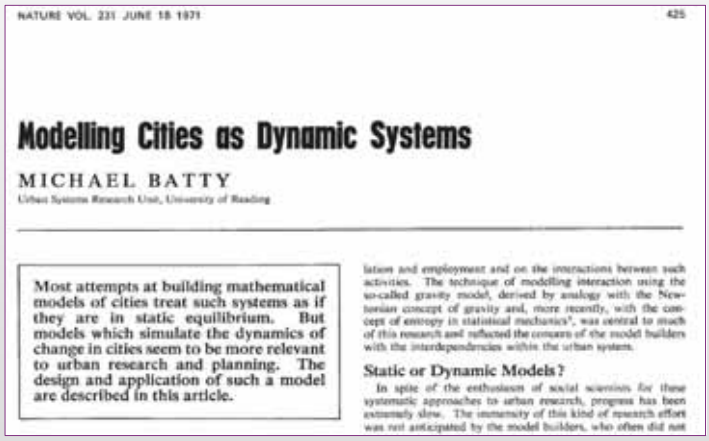
Although this is a paper and project essentially on equilibrium models, I must establish our pedigree first in dynamics !



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Modelling Cities as Dynamic Systems

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Most attempts at building mathematical models of cities treat such systems as if they are in static equilibrium. But models which simulate the dynamics of change in cities seem to be more relevant to urban research and planning. The design and application of such a model are described in this article.

lation and employment and on the interactions between such activities. The technique of modelling interaction using the so-called gravity model, derived by analogy with the Newtonian concept of gravity and, more recently, with the concept of entropy in statistical mechanics[2], was central to much of this research and reflected the concern of the model builders with the interdependencies within the urban system.

Static or Dynamic Models?

In spite of the enthusiasm of social scientists for these systematic approaches to urban research, progress has been extremely slow. The immensity of this kind of research effort was not anticipated by the model builders, who often did not

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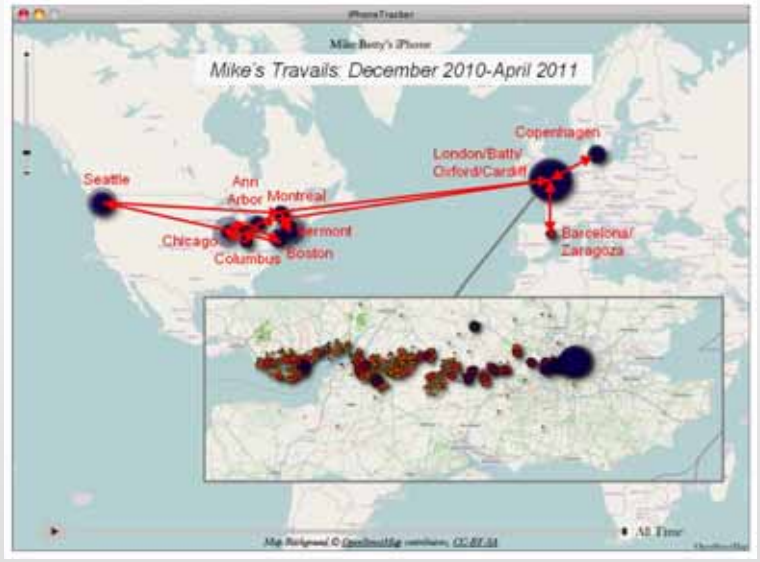

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Outline

- LUTI Models: A Little Bit of History, Early Graphics Interfaces, and the Tyndall Model
- SIMULACRA: ARCADIA and SCALE Projects
- Requirements: The Model Design: Models Flows: Physical Movements, Money & the Residential Model
- The Visual Template: The Desktop Model: Running It
- Building a Web-Based Model Interface
- Data Bases: Location, Interactions & Networks
- Current Challenges for Immediate Developments

LUTI Models: A Little Bit of History, Early Graphics Interfaces, and the Tyndall Model

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

Academics and consultants, Doug Hunt's argument

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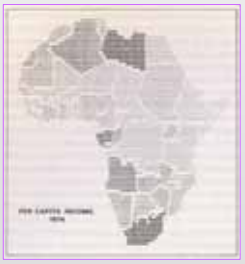
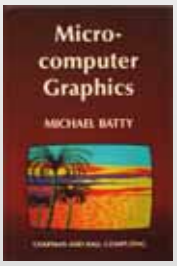
Early attempts at Visualisation: Traffic Flows in CATS, and Schmidt's model of the growth of East Lansing 1967

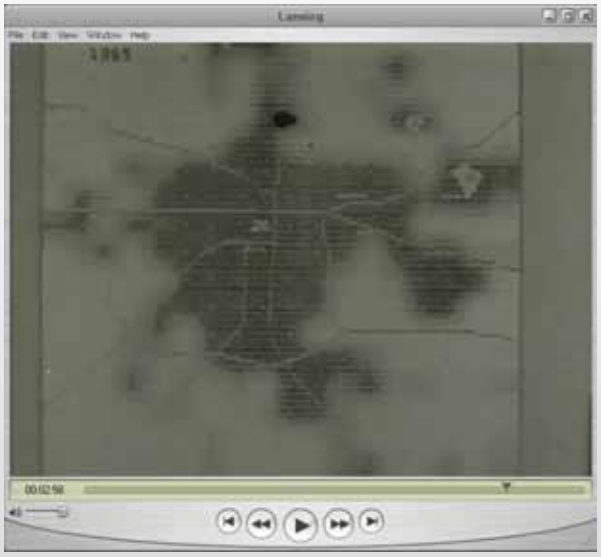
Harvard Lab: SYMAP – Symbol Mapping Systems, 1967-1970

Early cathode ray displays, 1960

Apart from some SYMAP applications, my own attempts began in the early 1980s with the Melbourne Model



I didn't work on these models as such from about 1982 onwards as I got into fractal type stuff with Paul (Longley) but I did develop quite a lot of visualisations really for demo and teaching purposes

Early version of Melbourne model in 1982 and then development of a WATFor77 version in 1986

The Melbourne Version is primitive and not nice to look at because we attached a video to the raster display device

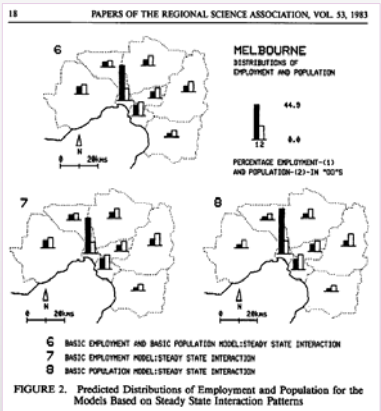


FIGURE 2. Predicted Distributions of Employment and Population for the Models Based on Steady State Interaction Patterns

From a VAX Terminal – A Raster 1982

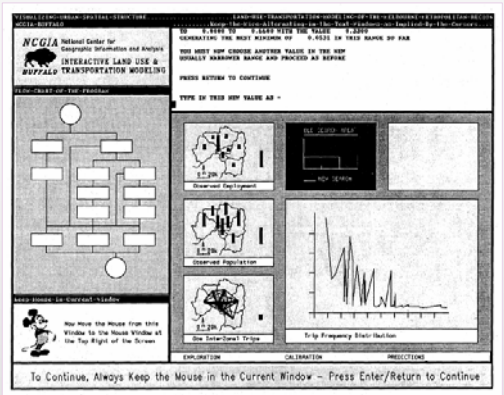


Figure 6. Progress in calibrating the model using dichotomous search.

From a Sun Workstation – Simple Windows - 1991

I don't have time to show the 1986 demo – I showed it at CUPUM in fact in 2009 but it still runs under DOS on this laptop

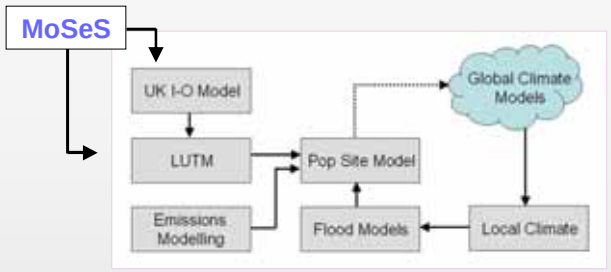
And bringing it all more up to date:

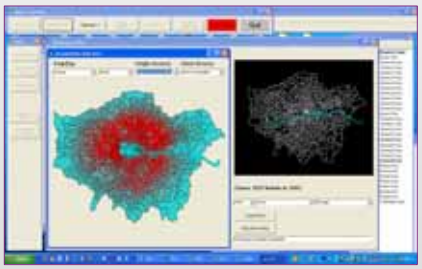
You have seen what we were involved in on the Tyndall Model where one of our guiding principles was to communicate the model as easily and as effectively as possible to our stakeholders

These were largely policy analysts and had some expertise in climate change problems and some knowledge of models of various kinds but not any one particular model

We also needed to communicate these ideas to other modellers, such as the flood modellers, the input-output people and so on

Hence our focus still on visualisation, besides the sort of complexity that these ideas portrayed which we believe requires visualisation at every stage of the process.





SIMULACRA: ARCADIA and SCALE Projects

SIMULACRA[1] 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

Like Francisco Martinez yesterday, we are very keen on building a model framework in which we can develop many different variants, easily and quickly.

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 while at the same time, enabling models to be tuned to the problem in hand.

[1] *SIMulation of Urban Landuse, And Commercial and Residential Activities*

We want to be able to do the following:

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

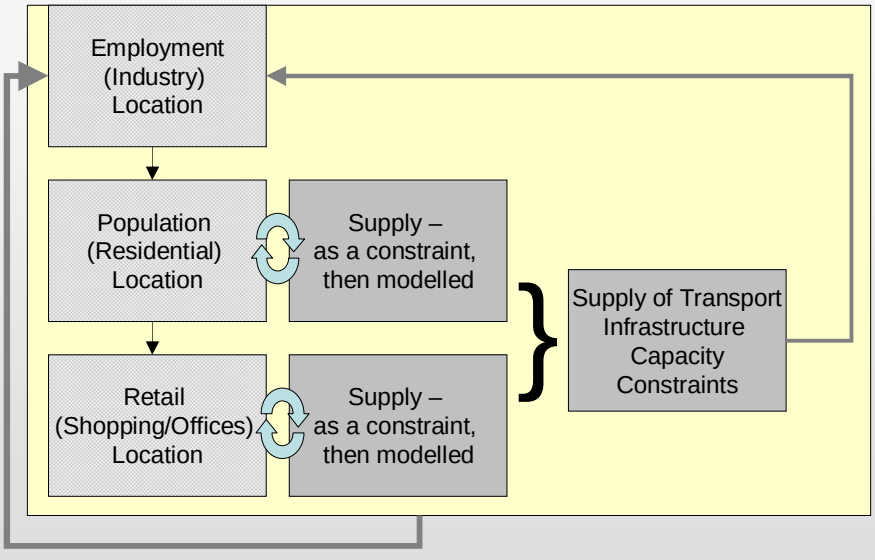
Requirements: The Model Design: Models Flows: Physical Movements, Money & the Residential Model

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)

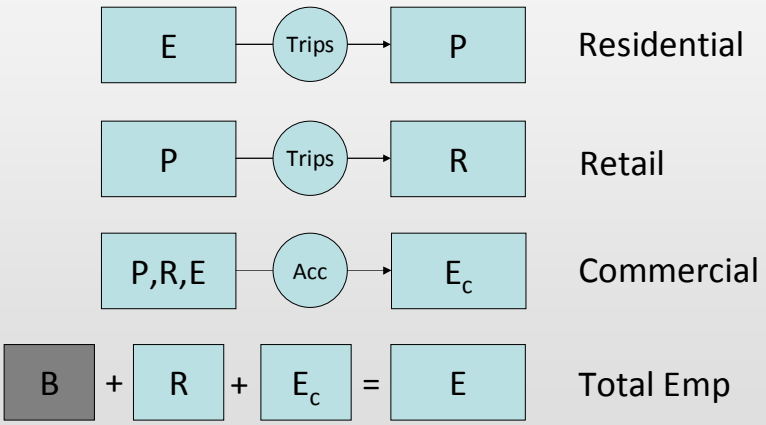
It is now a three sector model, not simply a residential location model as it includes internal employment location, retail location and residential location

So far, we do not have modal split or any disaggregation of the sectors but we will have five modes and then probably 5 population categories and maybe 5 employment types in terms of occupations – in short the model will ultimately scale up to some 100 times the size of the current model

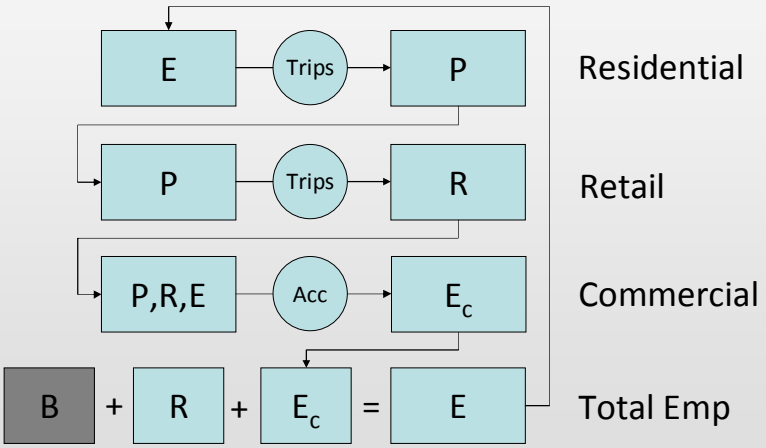
Essentially the model can be pictured as follows:



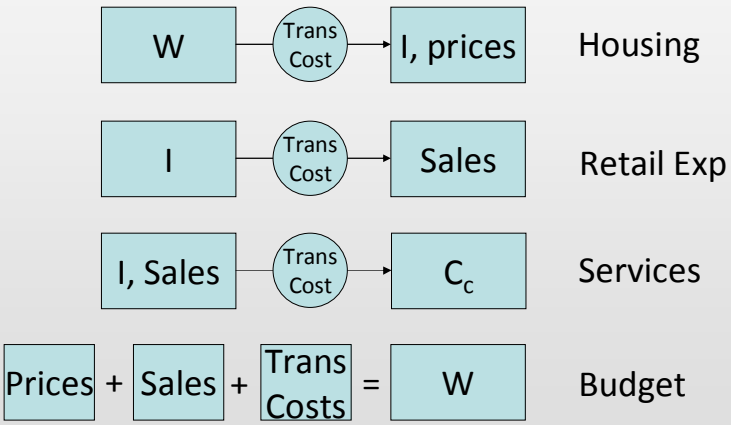
In fact it is easier to show the model structure as follows where we can see how we can elaborate it as a static or dynamic equilibrium model in terms of physical flows



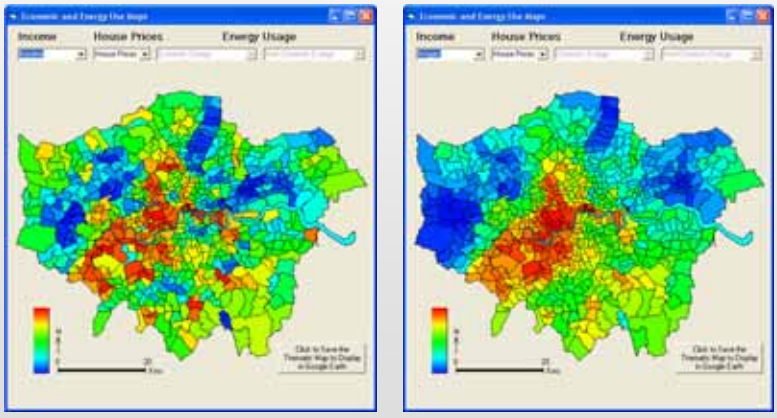
We can now show many ways in which these modules might be connected into an equilibrium framework: this is just one.



We can have also developed this model in money flows rather than physical flows with wages driving the process



I want to just show very briefly the sort of data that we have in the money sector that is driving this variant of the model and also state the residential location equation so you have some sense of what is going on



And the model is formalised as

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

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

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

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

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

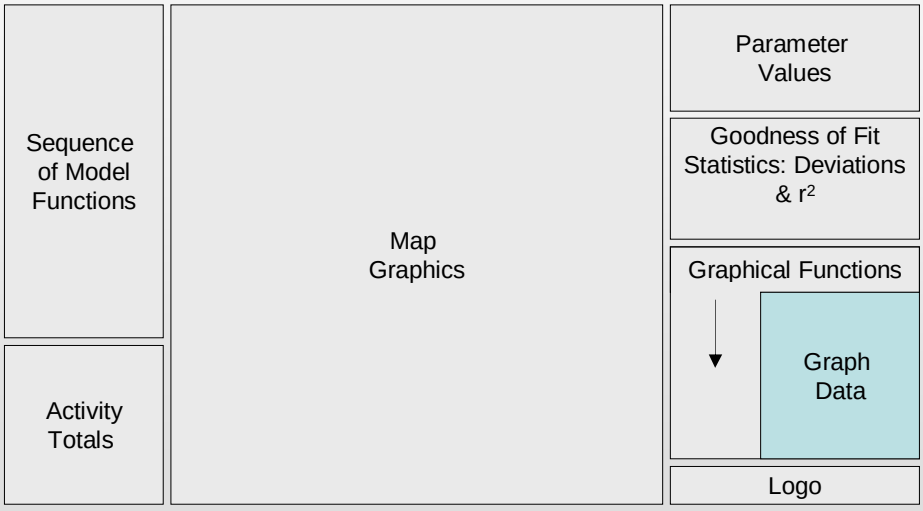
The Visual Template: The Desktop Model

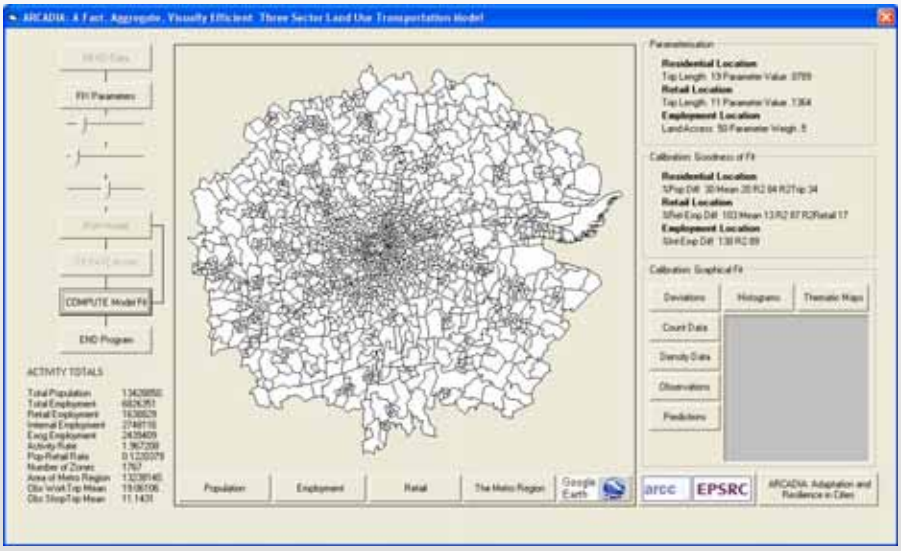
Ok – let me quickly tell you our strategy – we are building a fully fledged model using state of the art software and various web–based interfaces which is highly visual and will be as fast as possible

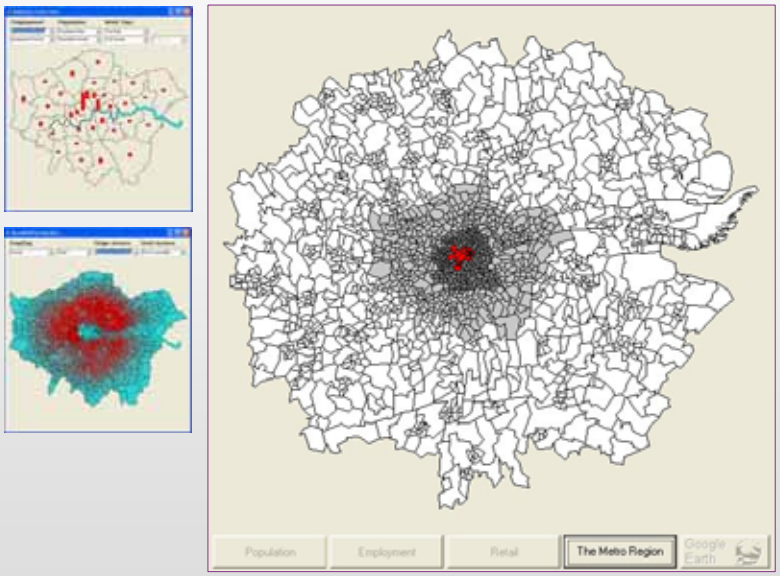
We are also building a mirror model on the desktop which is my contribution to the project and this is a one window minimal model which is for comparative purposes and to enable the bigger model to be tested

This is the model I will now show and then I will sketch the bigger application very briefly which Camilo in our group is developing

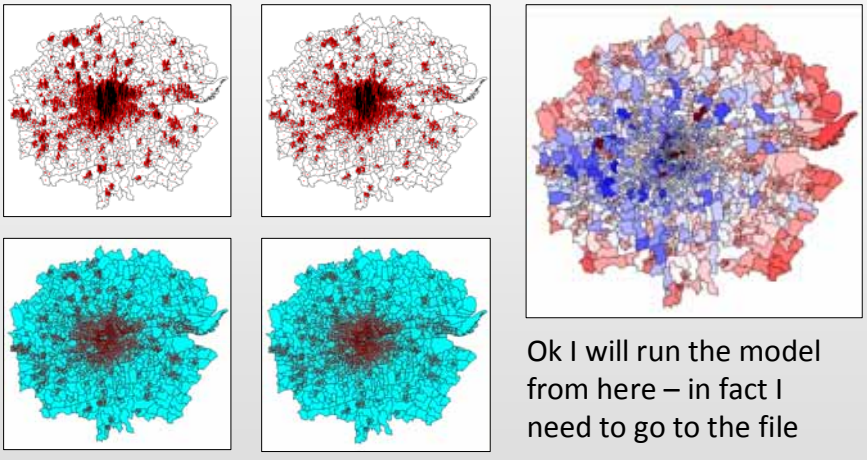
This is the order in which the operations take place





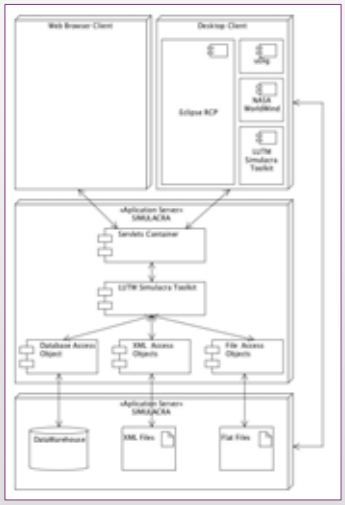


Here are some sample outputs – I will run the model as speed is important – here goes

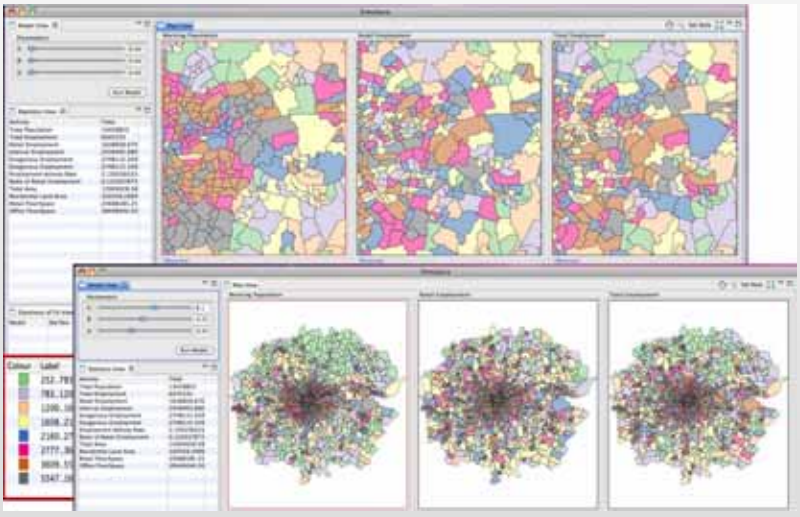


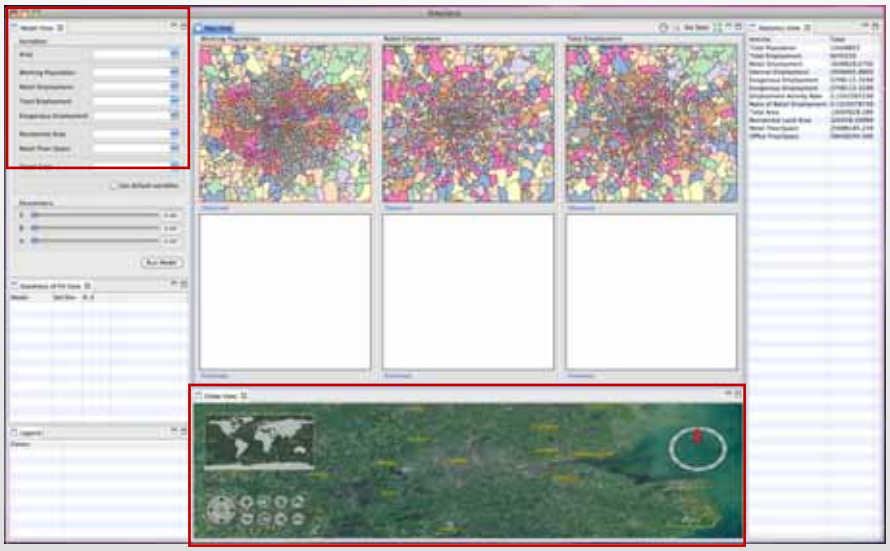
Ok I will run the model from here – in fact I need to go to the file

Building a Web-Based Model Interface



And here are some screen shots from the desktop version of this ultimately to be a web based application – on Mac and PC





Data Bases: Location, Interactions & Networks

We have a big problem in getting the networks sorted out for the aggregate model as these networks are at a very fine scale

We need them to be at a coarser scale for the model as we need to do all the assignment and capacity checking at the level of the model

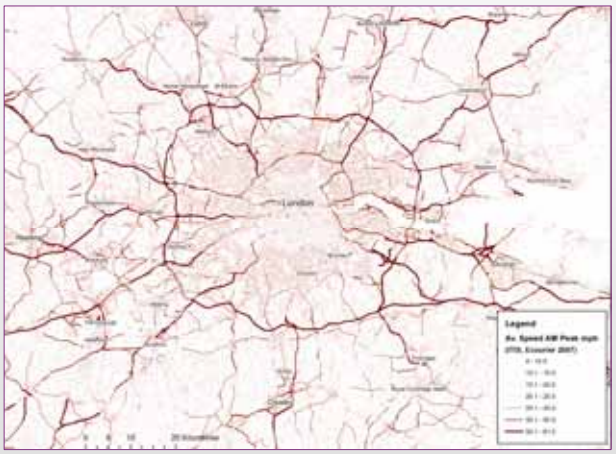
This is a long standing issue, we know, but we cannot afford to move down the local fine scale level to do the assignment of trips to the network because this would simply destroy our basic principle of accessibility of the model to users and also the speed requirements we need

We will show some of the detail we have by way of illustrating our work in progress.

Road Costs

Used GPS data for realistic road speeds across the South East. Sourced from ITIS and Ecourier.

Future improvements with dynamic consideration of congestion.



Public Transport Costs

Based on network geometry and timetabled services. Initially using model presented by Duncan last term. Allows multi-modal PT trips.

TransXchange

Full UK PT timetable available in XML format. Could be used to automate process of generating PT networks.

Key Challenges for Immediate Developments

- Speed of Models
- Quick and Effective Visualisation
- Running the Model with Users/Stakeholders
- Building a Residential Model Based on the Housing Market Cost, prices, travel and energy costs etc - The Wegener Principle
- Moving to a Semi-Dynamic Model with Inertia and Internal Migration
- A Local UK Dimension: Thinking of the Modelling Strategy as being Informed by National Data Bases such as Neighbourhood Statistics

I would like to refer you to our Blog on this

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

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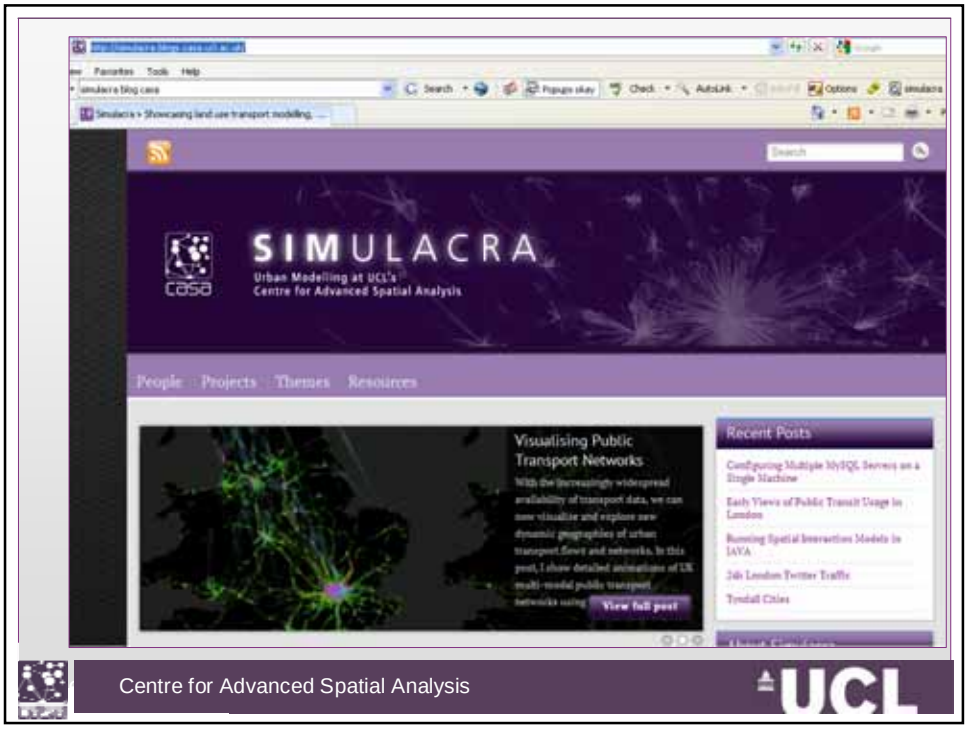
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