Seminar 3: 'Moving beyond tax-benefit and demographic modelling'
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Modelling individual vehicle and driver behaviours

Stephen Cragg

[EDITED TRANSCRIPT]

Key: Words in [square brackets] indicate what was being pointed at on the slide.

Paul Williamson - I would like to introduce Stephen Cragg from SIAS Limited which is a commercial company which essentially models traffic flows, although I'm sure that's a very crude description! There is a fairly large traffic microsimulation community with which most of us in the room have had little contact but I'm sure that actually there's considerable scope for collaboration in the future, so I'm delighted to have Stephen here today.

Stephen Cragg:

[Slide 1] Thanks very much Paul, I'm a transport and traffic modeller, I work for a company called SIAS and we have a commercial product called S-Paramics and I'm going to hopefully go through and explain how we do traffic microsimulation.

[Slide 2; Movie 1] So first off I'll just show you, this is what we produce. My job is to make little grey boxes move around on a grey background which is effectively a road. On those little grey boxes you can do some nice things, you can put on shapes and one of my colleagues particularly likes Grolsch as you'll notice there, and you can also put other things into the model like buildings, street furniture, to make it all look wonderful. But essentially all of that other stuff that I've just put on there is nothing different to little grey boxes moving around on a road network. That is my job, is to try and get those little grey boxes to move around as best we can.

[Slide 3] I took Paul's suggested topic areas, so to start off with the methodological approach. I'm going to try and give an overview of how we actually get down to what I do because it is only a small part of the whole field. So when you talk about personal travel and as well as also being a commercial modeller I'm also a part-time civil servant where I'm responsible for Scotland's national transport and land use model, so all of these things fit into the other part of my job which is at the present all macromodelling, not micromodelling but I'm interested to see how that might change over time.

[Slide 4] So influences on personal travel, there are some things you can't change about yourself, you can't change your age, well I suppose you can change your sex but generally these are the things that stay fixed about yourself, age, sex and your health. There are other elements about personal travel which you have limited choice about, you have some choice about which employment you take, what income you choose to have, you can rarely get higher income but you can always go for the lower income job, how the household is composed, that affects car ownership and how many cars and where your house is. And then there are active choices that you can make about your lifestyle whether you have, whether you purchase a cycle, if you don't have a cycle it's difficult to do cycling.

[Slide 5] Moving down, from what we'd call high level information about people , we then have to decide how they're going to travel. So here is a series of questions that we work on, whilst I'm not going to touch on any of these today, all of these things are areas that I'm interested in seeing how microsimulation will go into it and I'm going to touch on that at the end of my presentation.

[Slide 6] So just to put that in context and what I'm going to be talking about, we have life, universe and everything which influences how people travel, we have transport models and just about on definitions: transport models, a transport model is about moving people and goods. I'm not talking about transport models today, I'm talking about traffic models and traffic models is once a person or a good has decided to get into a vehicle, this is where it becomes a traffic model, there is a lot of overlap between traffic and transport models, and then within that I'm going to be talking about driver and vehicle behaviour and how that operates.

[Slide 7] So some people see this slide, 99% of people see this slide and go “oh dear, I don’t like that”, 1% go “wow, brilliant!” Well, I’m afraid for those 1% we don’t have anything like this in S-Paramics. We do have equations in there, but that’s the last equation you’ll see today from me.

[Slide 8] Our models our logic based and if this situation occurs then do this based on my vehicle and driving style. Now to an audience who has never seen this, this is always tricky. To understand how situations work you need to understand how the driving and vehicle style works and to understand how the driving and vehicle style works you need to understand how the situation modelling works. There’s not a way I can get around that but it’s probably easier if I start off talking about the situational modelling and bear in mind that at the end of that I’m going to be talking about how the individual drivers are responding within that situation.

[Slide 9] Now compared to a lot of things, drivers are very simple to model actually; you only have really three decisions, you have to choose what lane you’re going to be in, some of that is mandatory as in: Stop line coming up, left hand lane says turn left, if you want to turn left you need to be in that lane. Other elements of lane choice are more discretionary, you’re driving on a three lane motorway and you either drive in lane 1, lane 2, lane 3. What speed am I going to go at? And what gap? Now I’ll touch on all these. There are just three decisions that vehicles have to make and with those three decisions you can model traffic.

[Slide 10] So a bit more about what lane. I’ve already mentioned we have mandatory elements which is what lane do I need to be in, and we have to tell the individual vehicle that at some point in the future as they go down the road they’re going to have to be in a certain lane; that’s what we call rangers, it’s a mandatory thing and we have a signpost in the model which says you now know that you have to be in that lane at a certain point. If you’re not in the right lane, as you get closer and closer to what we call a hazard which is the point of final no return, your urgency to get into the lane increases.

[Slide 11] Next we have a whole load of discretionary ones [suggesters], and these are acting every time step in the model. We generally run at a half second interval, so every half second the drivers are looking at these broad six things and deciding which are affecting me? From that they make a decision and we do that with lane weightings.

[Slide 12] So this is an example of vehicle in a particular situation and the influences that are on it at that particular time. So we have a generic suggester [Left] which is that in the UK you’re supposed to keep to the left when you’re driving; we have a suggester [Bus] which is there’s a bus in that lane, do I really want to go in that lane, and that pushes that [red] vehicle out, gives the lane weighting to go into that [middle] lane; there’s a faster car coming up behind me, I may think that maybe I should just pull in [Behind] so that vehicle can get past, especially if he flashing his headlights; and there’s a slow car in front of me, maybe I should pull out [Slow]. So you have these thought processes going on in the driver, who’s going “well, where am I going to go”? In this particular instance you have a suggestion [Left] for lane 1, a suggestion [Behind] for lane 1, a suggestion [Bus] for lane 2 and a suggestion for lane 3, which would imply that you should move to the left whereas in reality of course you wouldn’t. And the reason for that is that the keep left [Left] suggester is non-situational, it’s a generic one that you should always generally keep to the left. So what we do is we have seniorities and certain suggestors override other ones, so if there’s any other suggestor acting, the keep left suggestor is ignored because that’s non-situational, so if the situational suggestor is working, non situational suggestors are ignored. So if we have equal weightings for all these, one, one, one, I’m happy to stay where I am. In that situation you would probably stay in lane 2. So that’s how broadly drivers choose what lane they want to be in where they have a choice.

[Slide 13] What speed? I’m not going to go all of these, effectively what speed is determined by your acceleration and all these things influence and they all return a suggestion to the vehicle going I’m not at the speed I want to be, I should go faster, oh but there’s a car in front in me, oh well I can’t do that, I’m going round a corner I’ll have to slow down etc, and that returns an acceleration, the acceleration might be zero. You do get some interesting ones, the one I particularly like is friction which is if you’re trying to go past another vehicle, if you have a nice big wide road you’ll happily fly past somebody at 60mph speed differential, like when you’ve got a tractor on a road, you’ll fly past them. If a road gets narrower and narrower and that horizontal gap between you and the other vehicle declines, at some point you’re going to be going “hmm I’m going to edge past this a bit slower”, until at some point effectively you go “ah I can’t get past that”. And that’s quite interesting on some of the motorways where we’re now looking at narrow lanes, and narrow lanes affect the speed at which vehicles will go past each other.

[Slide 14] And then on the speed there's a few other things like gradients which affect how fast you can accelerate, different vehicles have different abilities to accelerate from zero, acceleration isn't homogenous across the whole of the vehicle's range from zero to 70 mph, so drag and inertia are used to replicate that. And for goods vehicles on positive gradients they can't actually get up to their target speed anyway if it's sufficiently steep.

[Slide 15] And finally gaps. In lay people's minds a gap is physical distance, in microsimulation traffic modelling a gap is generally time based, everybody will hopefully have heard of the "only a fool breaks the two second rule". In reality, actually the average headway between the back of one vehicle and your vehicle is about one second, but to touch on the distribution of that, it's not every vehicle is one second, there is a distribution around that.

And also quite fascinating is junctions. Consider a vehicle trying to pull out of a side road; if you ask people to guess how far away a vehicle is, they're crap at estimating that. If you ask them to estimate what speed they're driving at, they're crap at estimating that. But people are really good at working out whether or not they can pull out. If you think there are millions of those manoeuvres every day and very very few accidents. Now when it goes wrong it can be tragic but generally people are actually very good at working out what the gap is. Final there is one physical distance gap; whilst you have a two second rule, if you're stationary that gap would go to zero, obviously you don't drive that close and two metres is on average the distance between the front of your vehicle and the back of the vehicle in front.

[Slide 16] So back to behaviour model, I've discussed the situations, now on to the vehicle and driving style, and the driving style is what's quite interesting.

[Slide 17] We have two parameters, we have aggression which is how I behave and we have awareness which is how I respond to others' actions. We use those to modify behaviour, because the worst thing for traffic microsimulation is homogeneity. If everybody is acting in the same way you do not replicate what actually happens out on the roads, and obviously our purpose is to try and replicate what really happens.

So we need to have this distribution, the default is a normal distribution, you apply a spread to that and we assign values of one to nine, nine generally being the most aggressive or the most aware, one being the least aggressive or least aware, 26% of drivers have the mean aggression or awareness of the normal distribution. We can apply a spread parameter to that so that mean value applies across a whole range of different factors in driving. So your mean headway, how you respond to other vehicles' speeds, your target speed, how fast you want to drive, etc.; these are all controlled by this.

[Slide 18] So we have a spread but then not all distributions are normal so we're able to apply a skew. So for example headway, I mentioned we have a mean headway of about one second, some drivers, very aggressive drivers are up there at about 0.5 seconds and it makes people feel quite uncomfortable but you do have drivers with a 0.5 second headway, but at the other end you have people who drive with a three and four second headway, so it's not a normal distribution. So we can apply skews to these distributions to try and generate this heterogeneous behaviour in the agents. And that's an example of just skewing the distribution.

And around this when we talk about heterogeneity, not all drivers with a level five have exactly the same value, we put a little bit of perturbation around this so there is a distribution within one value, so not everybody is exactly the same.

[Slide 19] And then finally we have vehicle characteristics. There are physical characteristics [Top Speed]; heavy goods vehicles are speed limited to 90 kph or 56 mph. Not all vehicles have the same acceleration and braking characteristics, you need to take those into account when you're doing modelling. And finally the sheer dimensions of the vehicle influence things.

So that's the methodological overview of how we do individual driver and vehicle behaviours.

[Slide 20] Key achievements. I spoke to a guy at a training course, he first started doing vehicle microsimulation modelling in the 1960s where each time step was done on a sheet of paper, and it was a flip book is how they actually looked at things! That was an academic application. The first commercial one was by us we think. But when we first started in this, my managing director would go places and the macromodellers would say, "you're wasting your time, pointless, stupid idea, it will never work, there are fundamental problems in there that you just will never get across, why are you bothering?" Well we did and there are now a whole load of other similar products on the market, so presumably everybody else looked at this field and went "oh actually there might be something in this" and have followed suit. OK, they were probably developing at the same time as us anyway, so I'm not going to claim that everybody has followed us, as these concepts have been around for a long time.

[Slide 21] Improved understanding. Not all answers are good, and that's good. In our industry there has been in the past a tendency of clients saying "we want this, but oh Govt funding means that we have to go through due process, can you build us a model to prove this is the answer?" Thankfully most of those clients are now gone and also you do things and you learn things through doing the traffic microsimulation, you go "oh God yeah, damn, never thought of that", "oh, if we close that road, vehicles going from here to here now no longer have a valid route to get around, how are we going to deal with those?" So before you ever put it on the ground, (for example, I did modelling for a motorway across the south side of Glasgow, £750 million which is being built at the moment), you hope you got it right. But we made design changes as a result of the modelling which will hopefully make it work better.

It gives us confidence in the design and I'll touch in the next slide on some of the new and novel ideas. One of the challenges of macromodelling is that it's empirically based so when you come up with a new concept, a new scheme, a new idea, like hard shoulder running, high occupancy vehicle lanes; the macro models can't deal with those situations particularly well because they never had the empirical data to create them in the first place. I'm not saying they can't do them but it's difficult for them to deal with them.

Transport modelling has always suffered from, oh it's a black box, the number of times I've heard "you're transport modellers it's just a black box and you decide what the answers should be". Hopefully that movie I showed you at the start, demonstrates it's actually very accessible to non modellers, and it's bloody hard to hide really bad models, really bad models stick out like a sore thumb because it's so visual.

[Slide 22] And we get new metrics. Macro models, equilibrium models; it's very difficult to get journey time reliability. The Govt is now really interested, not in just improving journey times, but in improving journey time reliability. Micro models are much better at this, inherently microsimulation gives you that kind of variation that macro models have a lot of problems providing.
We can give improved predictions of environmental impacts and climate change is one that's really hitting home for transport now. In Scotland we've got reduce our emissions by 80% by 2050 and every prediction I've got at the moment shows it going up. We want to travel more, now that's with the assumptions we've got in there at the moment, electric cars and all these sort of things will change that but still we want to travel more.
Effects of incidents; for example, somebody breaking down, one of our first big projects was on the bypass round Edinburgh where the question came "there's lots of breakdowns, there's no hard shoulder, should you build a hard shoulder or should we build a third lane, or should we build refuges?" We looked at the number of incidents, the impact of those incidents, the economic effect of those incidents; I think we recommended a hard shoulder.

[Slide 23] And the world's changing, managed highways like the M42 with active traffic management, hard shoulder running, the M25 variable speed limit, there's various other voluntary speed limit things which is all to do with queues and managing the effects of that.
We have selective vehicle priority such as, high occupancy vehicle lanes, high occupancy / toll lanes, bus lanes.
An interesting one is what happens if we educate our drivers? Last year we had very very high fuel prices, the Govt started sayng "drive more economically, accelerate gentler, brake gentler, leave bigger gaps". If a proportion of the population picked that up and said "OK you know we'll do that"; what if that reduces the capacity of the roads such that you end up with a lot more congestion, hence everybody is then burning more fuel because you're sitting in stop/start conditions. I don't know if that would happen, but the point is that with microsimulation you can actually try it out and see if it does.
An ageing population. Most 17 year olds drive quite differently to 70 year olds. We have a population that his growing older, how is that going to affect how things work?

[Slide 24 / 25] So finally currently and future challenges. Data, very difficult to capture individual data and difficult means expensive. I will be up front and honest and say because we've got to try and produce a commercial model we have had to use values in the models which are not calibrated and validated to real world observations. I'll hold my hands up because trying to observe that broad spread of people we, all we get is macro results or kind of the aggregate results of what happens on roads and we have to try and look at the values and use our engineering judgement, our knowledge, our understanding of how people behave, does it replicate the net result that comes out to that we see on the roads, like phantom traffic jams etc, and that is unfortunately the best we can do at the moment in terms of putting a lot of the parameters at the front end. And speed, a macro model runs very very fast (in comparison). Others have touched on it, microsimulation can take a lot longer time to run and we do multiple runs because when you drive on the road, then you drive on the same road the next day, the same time, it's a different experience for you. That's reality; we try and put in multiple runs to get more robust answers. All that takes a lot more computing time; much more difficult.

[Slide 27] An interesting one, probably doesn't apply in this audience but certainly in my field of transport planning, micro and small are seen as synonymous. If you're building a microsimulation model well it must only be a junction, you can't be building anything more than one or two or three junctions. We've got models of the whole of Plymouth and its Travel to Work area, one of our agents has whole regions of the Netherlands modelled. We're trying to train people to understand that micro and small are not synonymous. We have a huge industry of modellers who have never worked in microsimulation, you have to change your thinking, so many people come up with a "ah but what we need is this", and we're saying "ah that's the aggregate result, if you want to get that aggregate result you've got to look at the individual vehicles and think why are they not producing that aggregate result?" Totally different mindset, it takes a lot of work to get people around to that.

[Slide 28] If you can think back to kind of Venn-like diagram I had at the front (Slide 6], you have everything feeding down, down to the point of people going right OK I've now got in my car I'm going to drive from here to there. That also then ripples back out. When we change the route that people will drive from here to there or we change the number of people who are going to be on that route, those effects need to ripple back out through to how people are going to choose where they're going to live, what mode of travel, transport they're going to use, what routes they're going to take although we do route assignment already. And I'm really keen, we've taken our first tentative steps on doing the mode choice and how people change their destinations. So "oh you've closed that road, oh right well in that case instead of going and shopping at Morrisons I'm now going to go and shop at Tesco". That's a destination choice because of how we have changed the transport network, the transport infrastructure.

So I'm going to New York in a few weeks' time and I'm really keen on meeting the guy over there who is doing activity based microsimulation modelling for the whole of New York, 20 million people microsimulation model they have, I'm really keen to find out how they do that and take it, bring it back here.

[**Slide 29; Movie 2]** So that's me, I'll leave you with some nice pretty pictures of Edinburgh. Any questions?

QUESTIONS

Female question 1 –First of all I have to say you have given a wonderful presentation. I had a few years research in transport planning and policy, so I can appreciate how much effort has been put into this work. Secondly, just out of curiosity, have you ever considered using agent based modelling? Because according to the model, lots of behaviours are going on, lots of mood based actions and interactions between road layout, traffic, single systems ...

Stephen Cragg – That is what I want to do, that is why I'm really interested in finding out about activity based modelling of land use. At the moment we've just focused on vehicles as being the agents rather than the people as being the agents, and I'm really keen as our next step is to move from looking at the vehicle to looking at the people and to move into that agent based modelling is my goal, that's what I want to go and learn about next and find out how that happens, so we get that responsiveness in there.

Paul Williamson – I've got two questions, one is if you could just explain a bit more what activity based modelling is and how it might differ from what you've just told us about, and the second one is for something like Plymouth how do you actually generate the origins and destinations?

Stephen Cragg – Right, this (presentation) is just about traffic, it doesn't take any consideration, at present you tell the model that people are going to go from here to here, there's no choice, there's no feedback in that to go "how am I going to change the activities of my household as a response to you building a new motorway outside my front door?". If you build a new motorway outside my front door my activities will change, I will now start to use that motorway to access things far further away than I ever did before, I might get rid of my bus pass and buy myself a car. That is activity based, it's looking at the whole household and how their activities are influenced by transport. At present, we don't really have that feedback or interaction loop within our product. At present, we do it with higher tier modelling, where we have macro type models for example, for the whole of Scotland, and you've already had a lecture from David Simmonds I believe on the Delta software which is more along the lines of an activity based model which feeds into a transport model, which then feeds into the traffic modelling. What we don't have is the loop going back the way. I'm not 100% convinced that feeding micro costs or responses back up into macro modelling will work, and that's where I'm interested in more of the activity microsimulation modelling; it's very fledgling in this country, there's only been one or two applications that I know of, but it's a bit more developed over in the US. So I'm keen to see this, because that's much more about individual individuals.

Plymouth, how do we get our origin and destination matrices? Census, roadside interview and anything we can get our hands on! I wasn't involved in the Plymouth model, but there would probably have been a model in the past that we would have used as a donor model. These are the likely things, then there'd have been a gravity type model probably built at some point which is looking at the land uses and going right well this is where all the households are, this is where all the jobs are, how do people get between them. As it happens, that whole load of equations that I put at the front was from an economist colleague of mine where we wrote a paper a couple of years ago about how inherently we want to live close to where we work but we don't want to live close to where we work. I'll also throw in the concept called consistency of travel time, whether you live in Africa, Europe or wherever, in general we all travel about 1.1 hours a day on average and that has remained constant for at least 30 years in the UK, at least according to the National Travel Diary. So if you reduce the time of travel for you to get from your house to your work, the next time that you move house you'll move further away. So the average distance that we commute keeps on increasing every time we increase the capacity of road network. When people talk about, "you're going to build a new road it will just fill up with traffic", well yes it will, that's the whole point of building the new road, if we didn't build the new road and it didn't fill up with traffic there'd be no point in building the new road! That is why you build the new road. But the traffic isn't necessarily new car trips, it's people who are already travelling, it's generally filled with people who are now travelling further, and accessing different opportunities. For example, I generally shop at Tesco, it's a mile away from me, but it's actually not too difficult to travel to Sainsbury which is four miles away, it's a little bit longer but I have more choice. Work at home and the technology side of things is another interesting topic: I have a car, four days a week I never use my car because I get the train from Dundee to Glasgow, 80 miles there and back, I'm out of the house for twelve hours and I'm knackered when I get home. The day I work from home is the day that my car gets used extensively, I drop my son off from school, I pick him up from school, I then go to the shops, I do the errands, I go to B & Q to get my partner who wants some more compost for the garden, that's when I do it all! So working at home increases my car travel, not reduces it.

Male question 1 – That was found in the Netherlands too with the use of the car by the partner more extensively, so they had a shift from the car being used for commuting to being used for during the day activities, so it decreased congestion in the peaks but it's just spread it out during the day.

Paul Williamson – Thanks very much Stephen (CLAPPING)

[END OF RECORDING]

Post Presentation Note: SIAS Limited is pleased to to offer a free copy of its S-Paramics Principles booklet to anyone interested in learning more about microsimulation modelling in the context of road traffic. Please email admin@sias.com with your request and a note of your postal address.