EARLY EXPERIENCE WITH MODULE 5.36 (DETERMINISTIC TRANSIT ASSIGNMENT) USING THE LONDON TRANSPORT CURRENT YEAR MODEL

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ABSTRACT

The paper explains the decision to pilot Deterministic Transit Assignment (DTA) with this data, and outlines the additional data assembly required.

Results from using the software as a direct replacement for Module 5.31 are outlined, and the issue of computational effort discussed.

Additional assessments for individual O - D movements, using DTA and Disaggregate Transit Analysis (DISA or Module 5.35), are still to be analysed, together with the sensitivities detected with DTA.

The paper concludes with a discussion as to how this new Module could be used, with suggestions for its ongoing enhancement.

1 INTRODUCTION

When Heinz Spiess announced his thoughts on deterministic Transit Assignment at the Helsinki Conference last year, I became quite excited. Again, he had suggested to us a new feature, and one that offered the opportunity to incorporate disaggregate realism into our models. DTA will always pick the optimum itinerary for a given journey, rather than the multiple routes created with Module 5.31 or 5.35; this is reasonable given the additional information to set the journey in time. So, by the coffee break I was negotiating to be a development / test site. I had the advantage of a demonstration EMME/2 licence at home, and the possibility to use a reasonable sized network; well, actually a massive one. Further negotiation with Richard Hopkins at London Transport resulted in their agreement to my use of the Current Year Model, which I had just completed helping to develop.

This Paper tells the story of what followed, with a few omissions to avoid embarrassment of the innocent. It should be stressed that this was “all my own idea”, and there was no pressure from Flynn & Rothwell or London Transport; nothing in this Paper should be attributed to either Organisation.

2 THE LONDON TRANSPORT CURRENT YEAR MODEL

First, for those who do not already know, or who did not attend the Conference last year in Helsinki[1,2], I will give some background information on modelling with EMME/2 within London Transport (LT). LT was probably the first EMME/2 User in Britain, and probably also one of the most complex and extensive applications ever since. The family of models, called Railplan, started as a simple assignment tool for rail based public transport services in the London area. It grew progressively to include more local detail, bus services, a distribution and mode choice incremental model and a highway decongestion model. Up until the decision to develop the Current Year Model (CYM), it was always based on a 2001 A.M. Peak Period forecast from the London Transportation Study, which is a complex, although conventional, four-stage model, and is run usually on a mainframe.

As Railplan evolved, so did the business needs of London Transport. It became apparent that a model, based on another model for the A.M. Peak Period in some Future Year, was no longer appropriate. The decision was taken to develop CYM; based on the best available observed patterns of travel demand and network definition for Autumn 1995. It was also decided to develop an Inter-Peak model, with the intention of also developing models for the P.M. Peak and weekend periods when resources were available. In addition, it was decided to improve the zone system, from 978 zones to 1466 zones, to try to overcome some of the problems inherent in using a strategic model to look at local issues.

3 THE INTER-PEAK MODEL

The Inter-Peak model represents the weekday period from 10:00 a.m. to 16:00 p.m. Service patterns were coded from timetables, using a consistent definition of nodes and links to that already created for the A.M. Peak period. Similar global assumptions are used in the assignment process, see Table 1. These were reasonable for a peak period model, but more debatable in the Inter-Peak period; I had always been concerned about the global wait time factor and the lack of representation of inter-connecting services.

TABLE 1: CYM GLOBAL PARAMETERS

Parameter	Value
Wait Time Factor	Half Headway
Wait Time Weight	2
Walk Time Weight	2
Boarding Penalty (Bus)	7.5 min.
Boarding Penalty (Rail)	2.5 min.

In the A.M. Peak period, Railplan uses a Congested Transit Assignment algorithm (based on the CONGTRAS macro developed by Heinz Spiess); this adjusts the train segment transit times when services are carrying high numbers of passengers. This is retained in the Inter-Peak model for consistency, but is not a major element in travel time or route choice.

The Inter-Peak period model is quite extensive, as can be appreciated from the network statistics in Table 2.

TABLE 2: CYM INTER-PEAK NETWORK STATISTICS

Parameter	Value
Zones	1,466
Regular Nodes	15,001
Links	49,254
Segments	66,105
Bus Lines	563
Rail Lines	627
Total Demand (6 hours)	2,386,168

4 DATA ASSEMBLY FOR DTA

Data Requirements

Module 5.36, or the deterministic transit assignment, needs to “know the timetable”. This is provided by two additional items of information, which are required for each transit line, and held in ut1 and ut2 respectively. These define the time at which the first journey starts on the line (held in ut1) and the number of journeys made throughout the day (held in ut2). The time is defined as an integer, as “minutes from midnight”. For the remainder of this paper I use the same time notation as the DTA Module, i.e. 14h35 represents 2:35 p.m..

For a model with 1190 transit lines, assembling this additional data for all transit lines is not a trivial task. As this exercise was in the way of an experiment, the time to obtain and apply such data could not be justified. So, a series of simplifying assumptions were developed. These are outlined separately for Bus Services, Underground and Light Rail Services, and Mainline Rail Services in the following sub-sections.

Bus Services

Obtaining realistic timetable information for bus services was likely to be difficult. In addition, traffic delays mean that bus services do not run to timetable in London, and passengers generally have become accustomed to this and plan accordingly. So, I presume that there is little planned interconnection of journeys using two bus routes, where the passenger takes much account of the timetable, even if they know it. So there seemed little point in the effort to obtain and code realistic values. The approach used was to assume the first bus commenced its journey at a random proportion of its headway after 6h00. So, using a simple notation:

ut1 = (6*60) + (hdwy * rnd(1))

Where rnd(1) is some random number between 0 and 1.

Also I have assumed all bus services run throughout the day until 22h00, which is probably an over-statement of the service pattern, as some Inter-Peak services will stop around 16h00. However, the DTA will only use journeys that operate during the time frame of the demand being assigned, so there is no need to curtail such services. So the second term can also be specified in a similar simple notation:

ut2 = ((22*60) – ut1) / hdwy) + 1

The next step was to find how to calculate rnd(1) in the Network Calculator. I was sure this could be done, but it was time to apply the First Rule of Modelling with EMME/2:

> "If you don't know how to do something obscure, first read the Manual, then either read EMME/2 News, or fax Heinz."

The answer is in Number 9, dated April 1990, and Heinz was kind enough to ensure my application was correct:

ut1 = (6*60) + hdwy * put(int(get(1)*430+2531).mod.11979)/11979

If you want a mathematical explanation of that, either read the references in EMME/2 News No. 9, or discuss it with Heinz. I relied on his assurances that it would work, although I did a quick check on the results, and they seemed reasonable.

Underground and Light Rail Services

London Underground and Docklands Light Railway operate generally high frequency services to a regular pattern. The passenger is unlikely to be able to obtain timetable information, especially for the Inter-Peak period. The public information is generally limited to typical journey times and frequencies, plus the time of the first and last journey. The most straightforward approach was to use the same assumptions and calculations as those already described for bus services.

Mainline Rail Services

These were where I expected prior knowledge of the timetable to be a realistic assumption. Passengers can purchase timetables, and local route timetables are available free at rail stations. Both show potential interchanges to other services, and services tend to operate at a relatively large headway, but there is a degree of integration, particularly for popular interchanges. In addition, service frequencies and route patterns make planned interchange a reality, and service reliability is sufficiently good for it to be meaningful. So there was no excuse to justify a simplification, it was a case of browsing the timetable.

I used Module 2.24 to produce a transit line summary of all the mainline rail transit lines, remembering to use a “dummy” printer with 999 lines per page to suppress page headers, and imported the data into Excel. Fortunately the line descriptions in CYM already defined the start and end stations, and I had already stored the number of intermediate stops in a “ut” data item. By using this information and the headway I was able to relate the transit line to the published timetable, and note the time the first train after 06h00 and the last train before 22h00 started. This information was inserted into the spreadsheet, and the number of journeys operated calculated, assuming the line ran at the coded headway throughout the day. This is a simplification, as many lines operate to different timetables during the day, but the alternative would have been to create additional transit lines, and CYM is too big already, and it would have taken too long. The exercise of finding and defining 470 transit lines was bad enough. The data was output from the spreadsheet as a print file, which was read in via “batch entry” in module 2.41.

5 HARDWARE AND RESOURCE CONSTRAINTS

Up until this testing started, I had a size 7 (1400 zone) licence, running on a PC with a 486-66 processor with a mere 8 MB of memory. To run CYM, this had to be replaced by a size 16 (4000 zone) licence, with an upgrade to 16MB of memory. The enlarged binaries were supplied by INRO, followed by the beta test version of Module 5.36. All was well at first, but then I found that this size of binary for module 5.36 required a minimum of 17MB, even when running under DOS. In addition my 486 was somewhat slow.

The interim workaround was to borrow a Pentium laptop from Flynn & Rothwell, but that created problems of not owning the PC. The final solution, avoided for some time, was to upgrade my machine to something slightly less ancient. This also avoided the issue of running out of disc space, which was an inevitable problem of both my old machine and using a loaned one.

6 RUNNING DTA AS A REPLACEMENT ASSIGNMENT ALGORITHM

The first test was to try how the new DTA algorithm performed in comparison to the conventional use of module 5.31. For this test, I decided to factor the demand matrix to represent one hour’s demand, and then undertake six incremental assignments, representing the hours commencing at 10h00, 11h00, etc. There was no better data to undertake this factoring than a simple divide by 6.

Some additional parameters have to be defined for DTA. In general, these were adopted to be reasonably consistent with a conventional Railplan CYM assignment. The major difference in the two sets of assignment parameters was that in DTA there is no way to weight time spent waiting. A minimum wait time of 2 minutes was specified, an early penalty of 5 cost units per minute, and a late penalty of 10 cost units per minute.

The first issue to be aware of is a significant increase in computer runtime. A simple module 5.31 assignment on the laptop took about 30 minutes, and generally a single iteration was sufficient (rather than the 10 iterations with crowding calculations used in the A.M. Peak). Each module 5.36 DTA took about 190 minutes, so to incrementally assign six hourly demand slices took about 19 hours; done with a macro I hasten to add. These times were from the laptop, which has a 200 Mhz Pentium chip, and was running via Emtoolw under Win95. So, it was apparent that this was not going to be a way of improving runtimes, even if it was a more elegant algorithm (or at least one that avoided a hypothetical assumption on waiting).

7 RESULTS FROM DTA

Initial results, commonly used in Railplan, take the form of global network statistics. They will be found in Table 3.

TABLE 3: NETWORK STATISTICS

Parameter	**Mode**	**Module 5.31**	**Module 5.36**
Boarders by mode:	Bus	1,239,770	1,278,879
	Light Rail	13,529	13,905
	Mainline Rail	429,777	474,553
	Underground	963,604	850,478
	Special Bus	1,675	1,964
Total Boarders		**2,648,355**	**2,619,779**
Pass. Hours by Mode:	Bus	310,761	329,729
	Light Rail	2,319	2,443
	Mainline Rail	229,600	227,889
	Underground	174,922	167,164
	Special Bus	386	381
Total Pass. Hrs (IVT)		**717,988**	**727,606**
Pass. Kms. By Mode	Bus	3,921,556	4,154,951
	Light Rail	56,896	60,906
	Mainline Rail	17,407,878	16,546,249
	Underground	5,781,228	5,539,258
	Special Bus	5,439	5,457
Sub Total Pass Kms	**In Vehicle**	**27,172,997**	**26,306,821**
Aux. Transit Pass. Kms	In Station	548,978	528,233
	On Street	1,118,160	938,830
	Zone connector	5,069,842	4,875,073
Sub Total Pass Kms	**Walk**	**6,736,980**	**6,342,136**
Total Pass Kms		**33,909,977**	**32,648,957**

It is always difficult to draw conclusions from network statistics; the immediate surprise was how similar the results were. Of course, the public transport system is principally radial, and the same demand was assigned in each case, so that would constrain the trips towards the same corridors and lines. To check that hypothesis, I next looked at a specific rail corridor, where Railplan has traditionally had difficulty in getting the balance right between a number of competing routes and services. The results are summarised in Table 4.

Again, the differences are not significant. It would have been good to be able to compare such results with observed data, but there is little real observed data available. The demand used for the CYM model was based on the best available data in 1995, so it is a little late to return and do some additional manual check counts.

TABLE 4: FLOWS IN A PARTICULAR CORRIDOR

Route	Mode	Module 5.31	Module 5.36
In from Stratford	Underground	15,590	13,858
	Mainline Rail	5,159	5,995
	Subtotal	20,749	19,853
In via Limehouse	Light Rail	3,745	4,057
	Mainline Rail	2,367	2,236
	Subtotal	6,112	6,293
In towards Mile End	Underground	13,362	12,713
Total		40,223	38,859

8 ANALYSIS OF SPECIFIC O-D PAIRS

The next step is to use module 5.35 to analyse the routes used for specific O-D pairs, and compare those results, which would be consistent with the module 5.31 assignment algorithm, with results from assigning specific trips with module 5.36. So that I could assess if I believed either algorithm, I chose first the route from my local station (Arnos Grove on London Underground) to London Transport's offices at St James' Park. The second check is to be the route from Richard Hopkins' local station (Hastings), again to St James' Park. We should then be able to confer about how credible the results are or aren't; an approach I commend to any transport modeller. I hope to be able to answer that question at the Conference.

9 CONCLUSIONS ON THE TRIALS

DTA does not offer an easy alternative to module 5.31, even if the assembly of the additional timetable data is simple. The algorithm is likely to take extensively longer to compute.

In this network, overall network statistics were very similar, as were flows by sub-modes in a particular corridor where Railplan has traditionally had difficulties in replicating the observed balance between competing routes.

The next step, of inspecting specific O-D routes with both algorithms, is still in hand. An update will be presented at the Conference.

10 THE NEXT STEPS WITH DTA

I understand from Heinz that internally DTA uses two entirely different datasets for the times and the costs. Times are used to ensure a particular itinerary is feasible, whilst costs are used to determine which itinerary is the optimum. It follows that in theory it would be possible to have segment specific cost weights, which I find an interesting development, compared with the current weighting of in-vehicle time used in CONGTRAS; which can lead to misinterpretation of model results. So there is a reasonably elegant way to implement crowding possible in the future with DTA. I think a means to apply a cost to auxiliary transit time would also be of advantage.

As an analytical tool, DTA is unlikely to replace conventional assignments. However, it does enable the user to look at specific optimum itineraries, between a specific origin and destination, at different departure or arrival times. By creating a set of such itineraries, spread across the modelled time period, they can be compared to a disaggregate transit analysis from Module 5.35, and give further insight into the network.

In a large and complex model such as CYM, especially one involving a crowding feature with CONGTRAS, DTA could be used as a post assignment tool. I anticipate the main demand assignment would remain as a conventional CONGTRAS assignment, and the resulting congested network would be used to look at the pattern of travel for specific passengers using a DTA assignment. This would give a rapid insight into their likely travel patterns. Because it is possible to assign a demand matrix specifying a constraint matrix and a sub matrix, the degree of flexibility is there to say: “assign only those trips with origins in the Study Area and which are forecast to have a reduced travel time in a system-wide prior assignment”. As is often the case with EMME/2, we have a new tool with the power and flexibility to answer questions we hadn’t thought of before.

A futuristic thought for those who believe that transport models are completely true. Replace passenger information systems and timetables with a validated EMME/2 model and use DTA to determine the optimum itinerary!

REFERENCES

1 How Strategic Passenger Demand Models at London Transport have developed with EMME/2; Chris Smith, 6th European EMME/2 Users Conference, Helsinki, 1997

2 The Development of the Current Year Model for London Transport; Steve Miller, 6th European EMME/2 Users Conference, Helsinki, 1997

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