MODELLING RAMP METERING – INCLUDING AN INTELLIGENT CONTROLLER IN A MICROSIMULATION MODEL

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INTRODUCTION

STUDY PURPOSE

Current ramp metering site evaluation techniques are expensive and inflexible. They require the installation of on-site equipment and limit the ability to test important aspects such as detector placement and control algorithms.

This paper introduces an application of ramp metering in Scotland, on the M8 Urban-Motorway through Glasgow. It presents the method of evaluation being developed by the Scottish Executive using Paramics Microsimulation interfaced to an external controller.

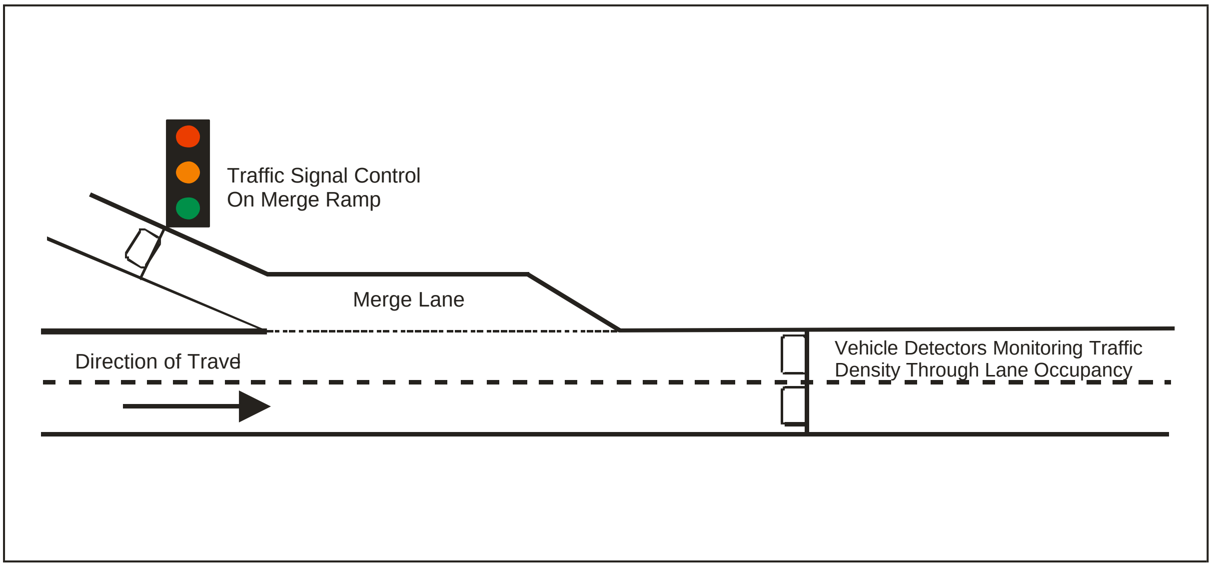

Figure 1: Schematic Layout of Ramp Metered Highway Merge

WHAT IS RAMP METERING?

This refers to the traffic signal control of access to dual carriageways and motorway, with the aim of maximising highway capacity and preventing traffic flow breakdown. Ramp metering may affect driver route choice and can be used to encourage alternative routes in corridor networks.

Asservissement Lineaire d'entrée Autoroutiere (ALINEA) is a local feedback ramp metering strategy. Field applications include both single and multiple ramps along the Boulevard Peripherique in Paris, at the A10 West motorway in Amsterdam and on the M8 in Glasgow.

EXPERIENCE IN GLASGOW

BACKGROUND

Scotland's first ramp metering application was implemented in 1996 at Junction 16 Eastbound on the M8 motorway in Glasgow, as part of NADICS (the *NAtional Driver Information and Control System*). The need for ramp metering arose from a substantial junction realignment, where the on ramp was changed from a "lane gain" arrangement to a merge. The system implemented in Glasgow was integrated within NADICS, and was designed with a high degree of user configureability. The ALINEA traffic responsive strategy was chosen because of its relative simplicity and previous implementations (1)(2).

OPERATIONAL DETAIL

Features implemented include full user configuration of the main ALINEA strategy parameters(2). Serco Systems Ltd, the contractor, implemented an algorithm to determine the stage times required to minimise ramp platoon lengths for given flow levels. This helped to ease the merge process.

The scheme was evaluated under the auspices of the EU Fourth Framework ITS project, TABASCO (*Telematics Applications in BAvaria, SCotland and Others*). It demonstrated significant overall network benefits in terms of easing motorway and on-street flow. The ramp metering application was operationally integrated with both Variable Message Signing and Urban Traffic Control systems. When conditions dictated, drivers were encouraged to enter the motorway at an alternative downstream ramp.

The success of this first implementation identified ramp metering as a suitable tool for possible use elsewhere in Scotland. The Scottish Executive commissioned SIAS to integrate a ramp metering module within its Paramics traffic simulation software. A key requirement was to replicate the configuration options of the real controller, including the elements described above.

INTELLIGENT CONTROLLER DEVELOPMENT

The software development programme included creating a link to the Paramics microsimulation system using its SNMP (*Simple Network Management Protocol*) interface, and provision of a Ramp Metering Controller simulator based on ALINEA rules.

PARAMICS SNMP INTERFACE

SNMP was chosen for the Paramics interface as it is becoming a de-facto standard for networked device monitoring and control software. This includes applications ranging from office printer control to on-street detectors, VMS gantries and signal control.

The Paramics SNMP Interface enables the rapid development of external controllers with access to simulation data coupled to detailed control of signal timings, turn priorities and overall simulation control.

The separation of control logic and simulation software permits the independent development of controllers utilising proprietary or experimental algorithms. These can now be developed and marketed by third parties without reference to SIAS, the developers of the Paramics system, with no requirement for detailed knowledge of the internals of the software.

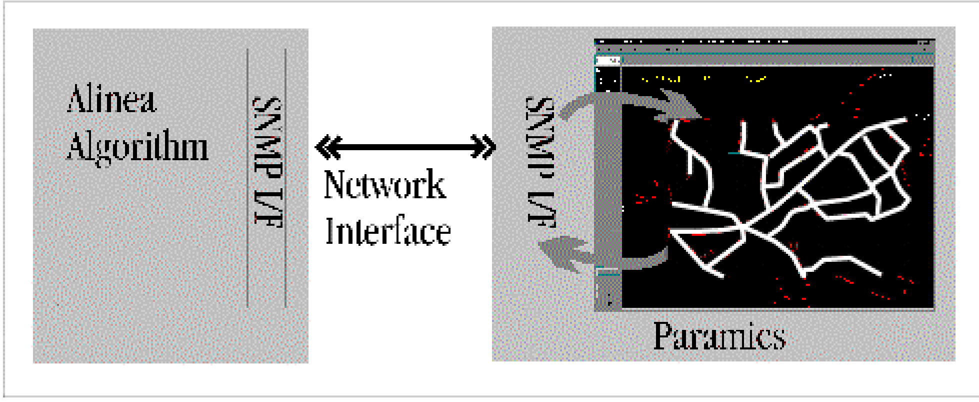

Figure 2: ALINEA/Paramics Software Design Architecture

In the above, the ALINEA controller requests data such as occupancy and flow rates from vehicle detector loops from the Paramics simulation and calculates signal timing changes which are transmitted back to the running model. Since SNMP is a network protocol, the ALINEA controller and the Paramics simulation may be located on a single computer or distributed between two computers.

ALINEA CONTROLLER

The controller was developed to be a model-independent simulation of the ALINEA system, collecting detector data directly from the running simulation and applying the actual ALINEA law algorithms in order to determine signal timings to achieve optimum platoon sizes. These signal timings were then fed immediately back to the simulation to control the merging of simulated traffic from the ramp onto the motorway.

As well as providing complete control over all normal variable parameters available within the real system, the simulation permits these values to be set to “out-of-range” values to allow the testing of alternative strategies. In addition, the control over values normally considered constants within the real system was provided within the developed controller.

During each simulation run all of the simulation data, intermediate calculated values and resulting signal timings can be collected for validation, calibration and analysis. A significant amount of additional data, not used in simulating the ALINEA law, was also included to assist in statistical scheme performance analysis.

The user interface was designed with a main “front page” allowing the entry and selection of the main control parameters, activation scheduling and immediate feedback on critical calculated values as they become available. Further pages allow the entry of detailed configuration parameters, viewing and saving of historical data and the selection and viewing of “fake data”.

This "fake data" page was used in the development of the system in order to prove the accuracy of the controller. By separating it from the simulation and forcing it to use real-world data in its algorithms, the results obtained from this were then checked directly against the matching real-world data. Any discrepancies were quickly identified and cured prior to using the controller with the simulation.

One aspect of the controller that was not in the original specification was Queue Dissipation, whereby additional detectors are used to monitor queues building on the ramp and the ALINEA calculations adjusted or overridden in order to mitigate the queues. A complete simulation of this aspect of the system was added in a later phase.

The only aspect of the real world system not implemented within the controller was the concept of intra-cycle timing adjustments whereby the actual platoon sizes are monitored and small adjustments to the green phase are made in an attempt to force the desired platoon sizes. Simulating to this level of detail was not specified for this project although it is quite possible within the software architecture developed for the project.

Although access to all variables and constants was provided through the interface, it was recognised that changes to the underlying algorithms, or a need to test alternative algorithms, could result in a need to modify the controller at the source code level. The controller was therefore developed using Microsoft Visual Basic 6.0 with fully documented and commented code in order to allow rapid ongoing development of the controller by the client or their representatives.

MODELLED APPLICATION USING PARAMICS

M8 JUNCTION 16

A model of the M8 through Glasgow was developed and validated against the recognised standards set out within the Design Manual for Roads and Bridges (DMRB), Volume 12. Figure 3 shows the study area within Central Glasgow that the model encompasses. The route alternative for drivers via Junction 15 is also indicated.

The model was developed for the PM peak period (15:00 – 19:00) based on the most robust data available from the NADICS traffic database. Information for the average Wednesday in June 2001 proved the most reliable data set.

Observed to modelled comparisons included traffic flows at 15 minute intervals, lane usage on the M8 through Junction 16 and vehicle detector occupancy on the M8.

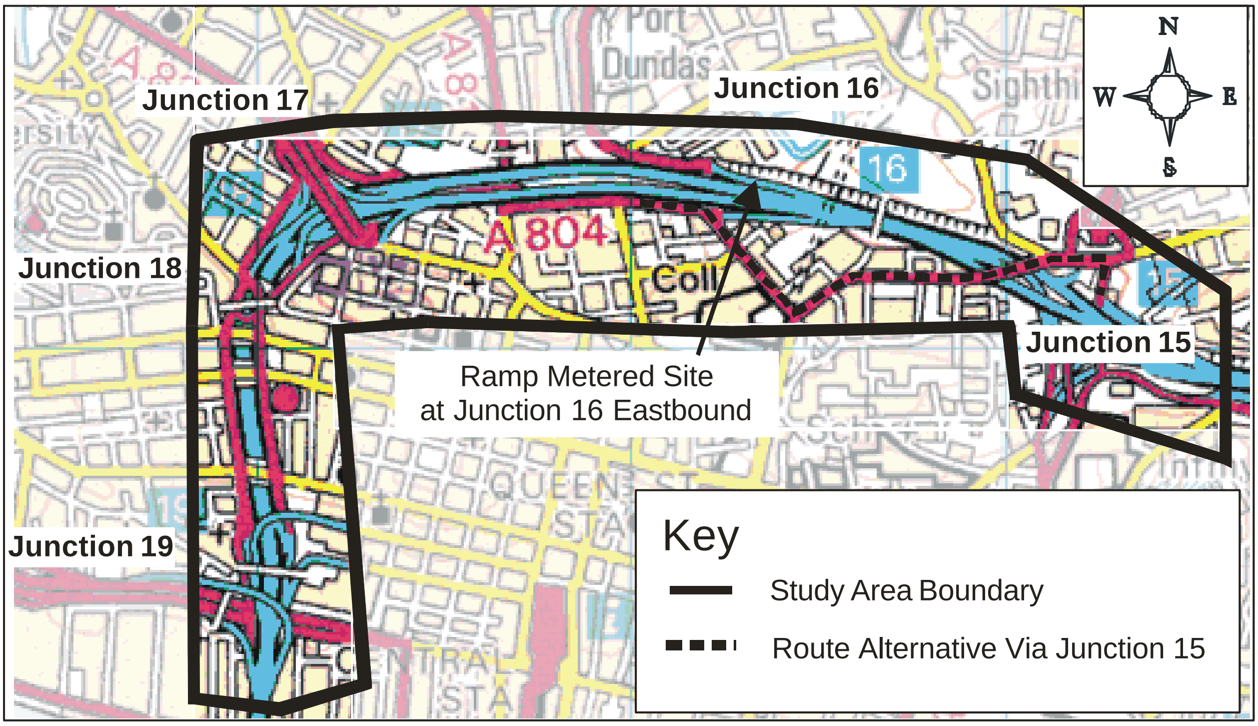

Figure 3 . Study Area Within Central Glasgow

MODEL RESULTS

Figure 4 shows the modelled and observed traffic flows for the Junction 16 Eastbound merging ramp at 15 minute intervals.

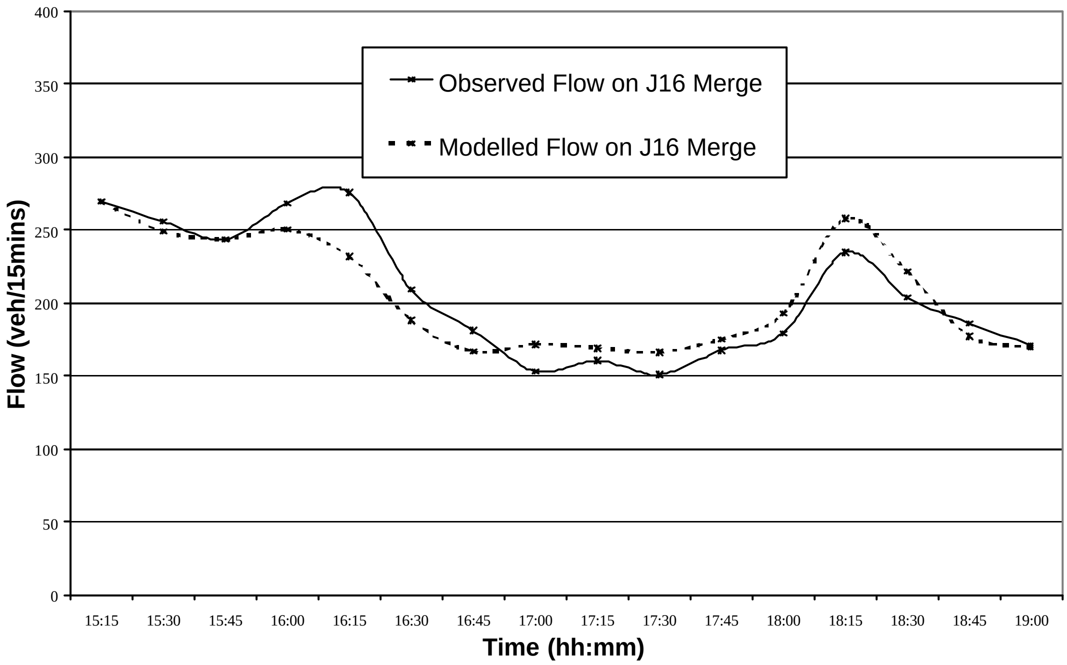

Figure 4 . Modelled and Observed Traffic Flows - Junction 16 Merging Ramp

The traffic flow on the Junction 16 merge within the model is controlled by the interface between the Paramics/ALINEA software. This made it an important success factor for confirming the ability of the traffic model to simulate typical observed conditions. The comparison presented in Figure 4 show that the model was able to reflect the trend of observed data.

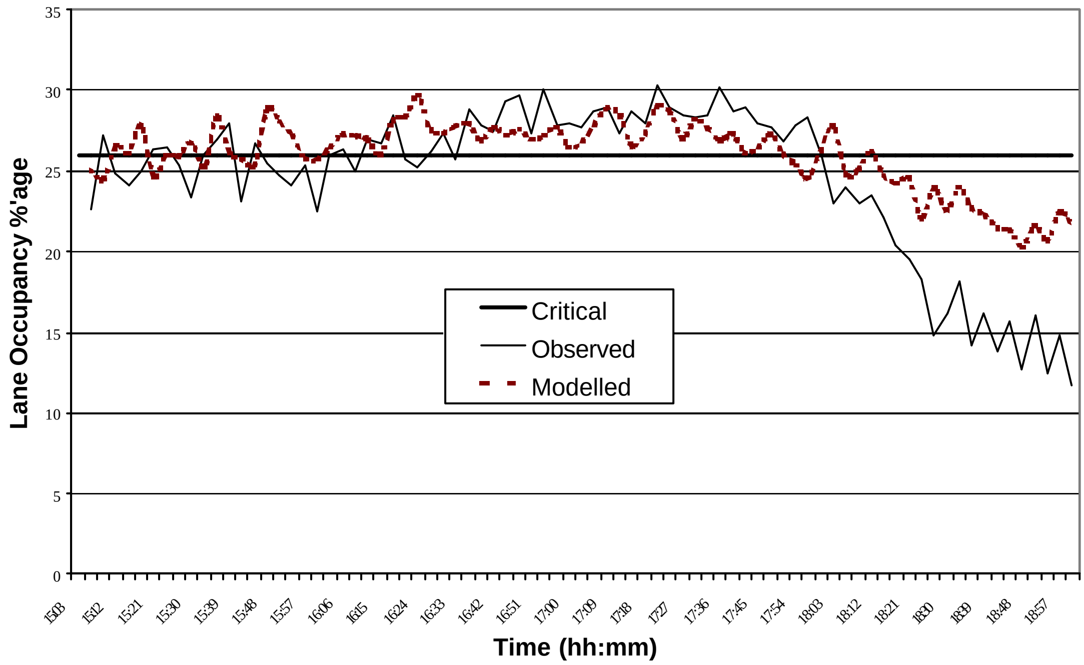

Figure 5 . Modelled and Observed Lane Occupancy on the M8 at Junction 16

Figure 5 shows how the recorded lane occupancy from the model compares to that collected from the in-situ loop at Junction 16 on the M8. Critical lane occupancy defines the boundary above which the ALINEA strategy will begin to control traffic. It will seek to achieve this occupancy level during its period of operation.

The definition of lane occupancy is expressed as the percentage of time that a loop is indicating presence. This is evaluated every measurable period (currently one minute) at the site and this is simulated within the model.

Figure 5 shows that the modelled lane occupancy is replicating the general trend of the observed lane occupancy. The only exception being the decay period after 18:00 where the distribution of traffic between the monitored lane occupancy lanes is over estimated.

Overall the model produced a high level of accuracy, and comparisons showed the model adequately met the DMRB validation criteria for hourly traffic flow comparisons (3) (4).

The results showed that the ALINEA/Paramics software is suitable to model ramp metering. As part of the Paramics statistical output, it is possible to conduct operational, economic, and environmental assessments and compare the before ramp metering and after ramp metering scenarios in fine detail prior to any field trials.

Screen captures from the modelling software at Junction 16 of the M8 are shown in Figure 6.

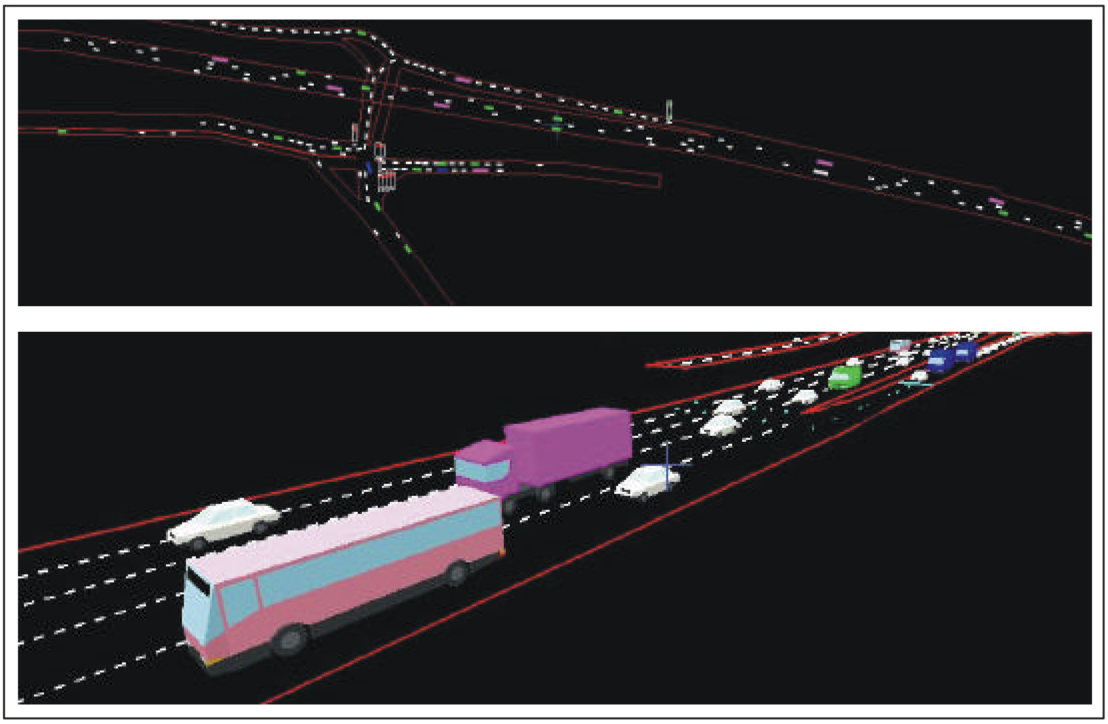

Figure 6 . Images Captured from ALINEA/Paramics Software

SUMMARY

The Scottish Executive commissioned SIAS Ltd, in partnership with Glasgow City Council, to develop a modelling tool for evaluating ramp metering with a vision to assist with future network management.

Glasgow City Council's experience and development of the ALINEA traffic responsive strategy at Junction 16 on the M8 was fundamental in developing the modelling tool.

FINDINGS

The software written to interface with Paramics Microsimulation showed that it was possible to mimic the complexities and responses of the ALINEA within a modelled environment.

The Paramics model was used to evaluate and produce detailed analysis which have determined that traffic modelling can provide a cost efficient alternative to on field trials.

The M8 model demonstrates that Paramics with the ALINEA interface produces a high level of validation using detailed data for comparison. From traffic flow comparisons at 15-minute intervals to detailed ALINEA output comparisons of lane occupancy the model simulates the M8 site well.

CONCLUSIONS

As an essential part of the software design, the ALINEA/Paramics software permits fully interactive user control over all key configuration parameters required to assess detailed installation criteria for various alternative approaches within the confines of the ALINEA strategy, prior to field installation. The software can be applied to any Paramics model , allowing potential ramp metering sites to be evaluated with changes to a simple configuration to specify which loops and signals are to be used. Indeed, since this initial study, the software has been used to assess the potential benefits of introducing ramp metering at other congested junctions.

While in this instance the SNMP interface has been used specifically to closely reproduce ALINEA, its range of applications includes interfacing with urban traffic control (UTC) tools from SCOOT to SCATS, and the potential to develop totally new network management control devices.

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References :

1) Haj-Salem, H., Blosseville, J.-M and Papageorgiou, M (1990) ALINEA-A local feedback control law for on-ramp metering: a real life study. 3rd IEE International Conference on Road Traffic Control, London, pp. 194-198
2) Papageorgiou, M., Haj-Salem, H. and Blosseville, J.-M (1991) ALINEA: a local feedback control law for on-ramp metering. Transportation Research Records 1320, 58-64.
3) Stewart, P., Hutchison, B., (2002) Ramp Metering Study. Scottish Executive Final Report.
4) Design Manual For Roads and Bridges, Volume 12

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