RESEARCH REPORT 629

System dynamics investigation of freight flows, economic development and network performance

Full report: www.nzta.govt.nz/resources/research/reports/629

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New Zealand Government

Modelling the future for road freight

Research has developed models to explore how economic activity, in particular inter-regional trade, may affect future demand for freight transport and road space.

The project's purpose was to develop an experimental or pilot system dynamics model of traffic flows along the main road routes within the Auckland–Hamilton–Tauranga triangle.

The question being explored was whether such a model could be useful in understanding how increases in economic activity, particularly freight flows, affect the demand for road space and, in reverse, how road space affects travel times.

To this end, the research team, comprising members from Infometrics Consulting Ltd, Future Impact Ltd and Transport Futures Consulting Ltd, designed and constructed three models:

- two simple Bayesian vector autoregressive models to forecast economic activity and freight flows within the Auckland–Hamilton–Tauranga region
- a high-level system dynamics model for simulating freight flows along the main roads in the region.

Developing the system dynamics model

The research team chose to develop a system dynamics model for the main task of the project (to model freight flows), because of its ability to simulate processes such as traffic flows, including delays, congestion and capacity constraints.

System dynamics models are scenario or simulation models, rather than forecasting models, with their main use being to provide insight and understanding into how the real world works. They can be used to ask 'what if' questions around the scenario they are modelling, which in the context of the project, would include questions around future freight growth and infrastructure planning.

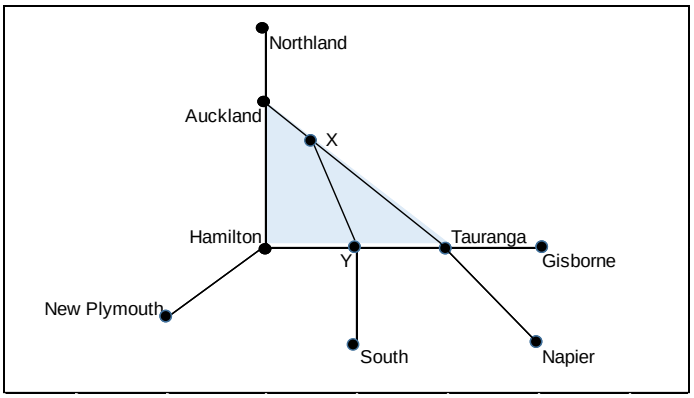
The team first used the two Bayesian models to forecast economic and freight growth in the region. The models showed that inter-regional freight flows within the Auckland–Hamilton–Tauranga triangle might grow by around 60% by 2025 (from 2012 levels). At this rate, the rate of growth of inter-regional trade was forecast to exceed each region's individual GDP growth rate.

The team then used the system dynamics model to map this forecast growth in freight on to the three main road routes in the Auckland–Hamilton–Tauranga triangle.

The diagram below shows the six routes the researchers were specifically interested in:

- Auckland to X (AX), where X is the intersection between SH2 and SH27
- X to Y (XY), along SH27
- X to Tauranga (XT), along SH2 via Waihi
- Auckland to Hamilton (AH), along SH1 and the Waikato Expressway
- Hamilton to Y (HY), along SH1, where Y is a general representation of various intersections in the area; 27 and 29, 1 and 29, 1 and 5, 5 and 28, 1 and 28, and 28 and 29
- Y to Tauranga (YT), along SH29.

The area covered by the system dynamics model is represented in the figure by the blue triangle.



What the model showed

The model showed that, in the absence of road improvements, this level of growth would cause travel times for southbound traffic to increase by around 5 to 10 minutes. On the SH1–SH29 route, however, the increase at peak time was likely to be almost 30 minutes.

For northbound journeys, the largest increase would be on the SH2 route, where the maximum difference would be over an hour.

The team also used the model to explore a selection of scenarios involving road improvements along the Waikato Expressway and Kaimai Range, more use of very large trucks and a constraint on driver working hours (this latter scenario doubled as a scenario for shifting more freight movements onto rail).

These scenarios suggest that road improvements will be crucial for dealing with the likely growth in freight. However, if the improvements induce traffic to move onto the upgraded routes, from parts of the network that have not been upgraded, the initial benefits could be negated.

The scenarios also showed that substituting rail for road freight movements would have virtually no effect on mean travel times on the road network, although the research team queried whether the scenario they had tested was 'ambitious enough'. Likewise, shifting freight onto longer and heavier trucks would reduce the number of trucks on the road, but would have a 'negligible' effect on congestion. This was due to the predominance of small vehicles on the road network, and the longer length of bigger trucks, which reduced the road space available to other vehicles.

Overall, the research team concluded the project had demonstrated that a system dynamics modelling approach could be used to model traffic flows, congestion and ways to ease congestion, at a high level.

'We would, however, recommend that if the model is ultimately to be applied to more real world questions, priority should go to testing the robustness of the model to a wider range of traffic patterns and input assumptions,' the team states in the research report.

They also caution that the model developed in the research was specific to its location and would not be 'immediately applicable' to other areas. There was scope, however, to adapt the modelling system to other areas, following further data gathering and testing.

In their report, the research team suggest some areas for further research to improve the model's usability and robustness, and to explore whether there is value in developing a 'larger, more sophisticated' system dynamics model.

The team concludes, 'As it stands the model is designed to look at high-level congestion resulting from increased traffic – all the time, not on particular days or during specific time periods. It is in effect a model of pressure on road space and how this pressure might be alleviated through different types of intervention such as more road space, re-assignment of routes and changes in the mix of vehicle types. Perhaps other issues are more important and undoubtedly there will be questions related to the movement of freight that are not capable of being analysed with this model. The model is complementary to other models such as the Waikato regional transport model, which has strengths in other areas, such as route assignment for example. Both should be used to investigate overlapping issues.'