Traffic Simulation in 3D World

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ABSTRACT

This paper is the result of more than three months of research completed at the School of the Built Environment, Virtual Environment Suite. This study focusing on measuring the impacts of a change in the infrastructure using a 3D traffic simulation model. Various aspects about the research area and the simulation model were explained. Details on technical aspects of the simulation and the modelling are also given. The focus will lay on motor traffic and thus especially on the changes in traffic circulation as a result of relocating the car access of the City Site. The impacts of the infrastructure changes will be analysed, by simulating the current situation as well as the future situation. Comparison of the different simulations will show the impacts.

Keywords: traffic simulation, 3D city modelling

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INTRODUCTION

This paper is a summary of the report which was the result of the exploration on traffic simulation in 3D city models between May and August 2007. Currently, researchers in the School of the Built Environments are carrying out studies to explore different aspects of 3D city modelling in relation to Virtual NewcastleGateshead project and this present study shows the initial result of simulating traffic within the NewcastleGateshead 3D city model.

The modelling of an urban environment is an ever-developing area. As research in this area (Batty M. *et al*2000, Shiode N., 2001, Thompson E. *et al* 2006, Horne M., *et al* 2007, etc) identified, the city models can be used for variety of applications. Upon creation of the base model, different versions of the city model can be used for diverse applications such as planning and design related activities, infrastructure related activities, marketing, and teaching and learning and research related activities etc.

It is believed that the Northumbria University City Campus Master Plan 2005 brings several changes in the infrastructure of the campus and to its vicinity. And these changes will have a direct input to the traffic in this area. These planned changes can be summarized as:

- Pedestrianisation of the Northumberland Road (the main access road of the City Site towards all the parking areas).
- A new entrance to these parking areas at Sandyford Road (in the north).

These changes will influence the travel behaviour of the students and staff. Several examples of changes in travel behaviour can be summarized as:

- Students and staff will choose another route towards their parking lot.
- Travel times will change
- Because of less/more traffic, the congestion at several intersections will get bigger/smaller.

The aim of this research is to evaluate the effects of changing travel patterns of students and staff members as a result of infrastructure changes at the Northumbria University City Campus.

RESEARCH OBJECTIVES

The initial aim of this study was to investigate the integration of traffic simulation within the 3D city model by using VISSIM software. Whilst some initial compatibility studies were conducted the main objective of the study was to simulate traffic as realistic as possible within a part of the city model.

The objectives of this study can be stated as follows:

- Defining which aspects of traffic simulations are considered as important and which can be simplified or neglected within the simulation.
- Collecting enough traffic data to define and calibrate the traffic demand, the traffic parameters and the traffic control at the different intersections.
- Building a realistic simulation of motor traffic within and around the Northumbria University City Campus for the current situation as well as the (possible) future situation(s).
- Define several focus/problem areas which will be used to validate the simulation and evaluate the impacts of the infrastructure changes on the network and especially these focus areas.

Limitation of the Study

The traffic simulation kept limited to city campus and its vicinity due to amount of data required to be processed. The focus of the simulation was on the travel behaviour of the students and staff members. The change in routes of the other traffic was too hard to predict precisely. In addition to this, pedestrians and cyclists are not part of the simulations. The only involvement of pedestrians was at signalized intersection,

where pedestrian walking times are taken into account. Although simulation of the car parks would have really enhanced the visualization of traffic within the city model, because this would have taken too much computational power to simulate, these were omitted apart from entry and exit points.

PROBLEM ANALYSIS

There are several important roads near the City Campus and the City Centre:

- The A1 67 connects the north-western suburbs with the south (over the Tyne Bridge towards Gateshead and Durham).
- The Great North Road goes towards the northern suburbs and further.
- Jesmond Road goes towards the northeast and develops even into the main road towards the coast.
- New Bridge Street connects the eastern suburbs with the City Centre.
- From the southern roundabout Mosley street develops into Westgate Road, which connects the western suburbs with the City Centre

The most important connection between the north and the south near the City Centre is the A1 67. Every weekday more than 24000 vehicles are driving on the A167 (near the City Campus) in both directions and during peak hours even 2000 vehicles per hour.

The City Campus is split into two sites by the A167 motorway. There are, in total, 550 parking spaces at the City Site (West), which are only accessible through the two entrances of the City Campus. These entrances are:

- The north entrance of College Street at Sandyford Road
- The south entrance of College Street and Ellison Place at Durant Road

Figure 1: Main roads in the area

The City Campus is not accessible for cars coming from the City Centre (West). This is the result of the policy of the City Council to motivate people to avoid the City Centre. In the future, College Street will not be used as much as it is now. The new car entrance will be constructed at the north of the City Site at Sandyford Road.

ACTOR ANALYSIS

Several parties are involved in the Master Plan and the decisions about the relocation of the new car entrance. Here, four of main actors points' in this decision making process, are analysed:

1. Northumbria University (Estate Department)

Northumbria University Master plan was created by the Estate Department. The goals of the Master Plan/Estate Department are as follows:

- Providing the highest quality of study, student and research support facilities
- Providing a stimulating and supportive work environment for all staff Providing
- first class residential accommodation for students
- Contributing to the economic, cultural and social development of the city
- Supporting the University's Growth Strategy

The Master Plan 2005 is a big step in satisfying these goals. Upon completion, the City Campus will look much better, will be a nicer place to work and study and will contribute to the development of the city.

On the field of transport and traffic management, the Estate Department has set following goals:

- Reduction in the amount of mileage by private cars
- Subsequent improvement to the environment
- Adjustment to the balance between traffic and people
- Encouragement of non motorized transport
- Encouragement of the use of public transport Promotion
- of wider access
- Changing travel habits

2. City Council Newcastle upon Tyne

City Council wants to satisfy as many inhabitants of Newcastle upon Tyne and beyond as possible. Current policies which came to power in 1990s are to minimize the amount of traffic within the City Centre. Several changes in infrastructure in the past are related to these policies. The City Council wants to decrease the amount of congestion within and around the City Centre and improve public transportation. In order to achieve the goals, the City Council focuses explicitly on the public transport and decreasing the amount of cars on the routes of the buses.

3. Students and Staff

The students and staff members want to have a healthy and stimulating work environment, where there is enough space to work and relax. The plans about more green space and pedestrianisationed city campus would satisfy these interests. From the transport and traffic point of view, the students and staff have diverse interests and concerns regarding to the accessibility of the City Campus. These concerns will be partially addressed with the new pedestrian bridge between Manors Site and City Site, the accessibility of the City Campus and especially the City Site increased. Not only are the university buildings connected, the City Site is now much better accessible from the south east, where the metro line and several other bus route have stops.

4. Other People Crossing This Area

A large part of the traffic is going towards or coming from the south (for example towards the Tyne Bridge) using the A1 67 which has effects on this area.

Chosen Area for Simulation

All possible routes from the different parts of the city towards the parking areas need to be simulated to find out which route will be chosen. The focus will lay on the main streets towards the City Centre, but closer to the City Campus, the other smaller streets will be also important.

Figure 2: Research Area with the simulated roads

In Figure 2 shows the simulated road. The main entrances of the network are on the main roads (A1 67, Great North Road, Jesmond Road and New Bridge Street) but there are also many other entrances which are located at small roads. The assumption has been made that the students and staff will use the main entrances in order to make calculations to a minimum.

Although the chosen area is large (approximately 1500 x 1500 meters) with many intersections and therefore creation of a true simulation might seem difficult but with enough traffic data of all the streets, some base data and some assumptions it will be possible to build a realistic simulation.

Chosen Focus Areas

The focus areas are used to validate the simulation and to compare the different future and current situations. The evaluation of the traffic circulation and the recommendations are based on the output data of the simulations. To make sure the simulations will give a realistic view and usable data, the simulations will be validated. Validating future situations is always difficult, because these simulations are based on several assumptions. On the other hand, it is possible to validate a simulation of the current situation if there is enough data available. Validating the whole simulation would need excessive field data.

Two main intersections are chosen for the simulation, because these are the biggest and most important intersections in the research area and these are the most difficult to adjust to the reality. Since these intersections have also many traffic circulation problems which results in a lot of congestion, the future changes on these intersections can also have significant and measurable effect. In addition, the validation takes in account the travel times of the buses. Therefore the focus of this study will be on "The New Bridge Street Roundabout", "Jesmond Road" (near the A167), and the bus routes between city centre and Jesmond and Heaton.

Figure 4: Jesmond Road, Google Earth

Figure 5: Bus routes within the research area

Figure 3: New Bridge Street Roundabout, Google Earth and VISSIM simulation

TRAFFIC ANALYSIS AND DATA

The traffic data consist of several aspects. The traffic will enter the network at several entrances and it will take several simulation minutes before the whole network is filled with traffic. After calibrating the traffic demand, the input data will consist of two parts:

The amount of cars driving from the main entrances of the network towards the different car parks. These

- are mainly the student and staff car drivers. They can be redirected to use another route.

- Data about the other traffic, which are crossing the network. This include the amount of cars entering the network at all the entrances and the turning rates at all the intersections.

In order to analyse the traffic circulation at several moments of the day the data needs to be adjusted for all these moments. VISSIM gives the opportunity to define all the traffic data for certain time intervals. To get a representative simulation the total simulation will last 12 hours (from 7 am to 7 pm) and every hour the traffic data will change automatically.

Also public transport needs to be defined by making transit stops, routes and defining a serving rate. Parking lots can be built by de determining the number of cars stopping and their parking time.

City Campus Traffic

An important part of the simulation is the traffic around the City Campus. This part of the traffic has a high influence on the traffic circulation at the roads around the City Campus. Because of the planned infrastructure changes, these car drivers will choose their routes again, based on the travel time.

The data has been mainly collected from the Northumbria University Travel Plan (Atkins Transport Planning, 2005). Also some data will be added by data collected in the field.

Parking Areas

There are three categories defined for the parking areas at and around the City Campus:

- The Northumbria parking areas: parking permits required for Northumbria staff. These parking areas are located at the City Campus.
- Parking lots located along several roads at and around the City Campus.
- Other car parks around the City Campus, which are used by students and staff members.
- Other car parks around the City Campus: which are used by people, who aren't working/studying at the Northumbria

In order to get a realistic simulation the density of parked cars needs to be defined during the day for all car parks. Because of the high demand for parking spaces, all the car parks will be full at noon, but the

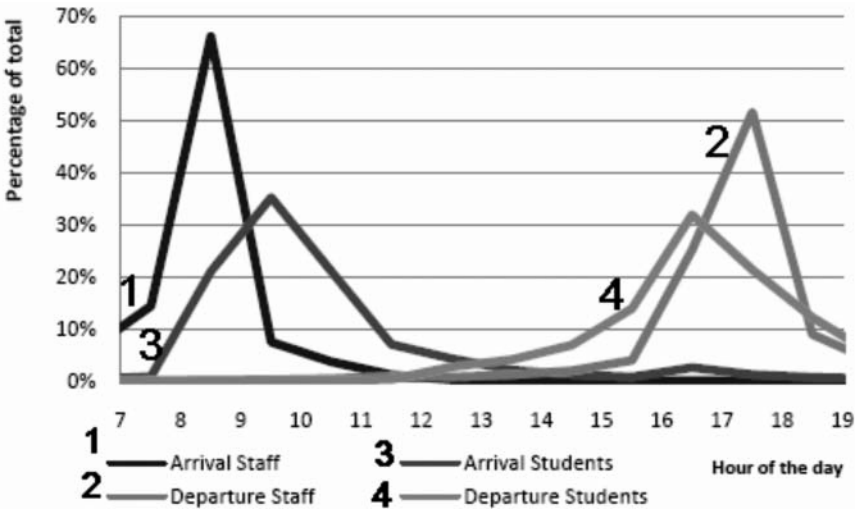

Figure 6: Arrivals and departures during day (will not change in the future)

car parks don't fill and get empty in the same pattern and same time. This distribution depends on several aspects, for example distance from the workplaces, costs and ease of access. It is hard to define the impacts of these aspects therefore the distribution between the different parking areas is defined by using field data.

Travel Behaviour of Students and Staff

The Northumbria University Travel Plan gives us several data about the students and staff members:

- Total of students and staff members (for 2005 and some future predictions).
- Modal split: which kind of travel mode is used? (for 2005 and some future goals).
- Number of working days during a week.
- Time of arrival and departure during day.

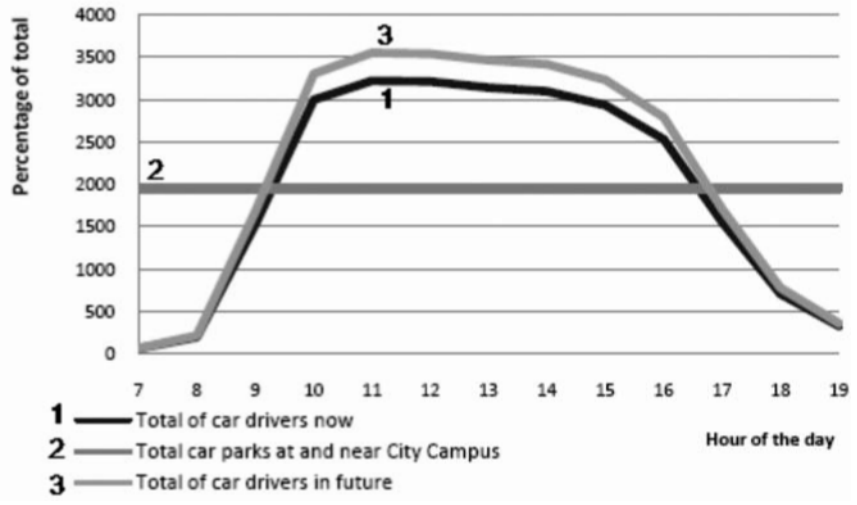

Figure 7: Total car drivers compared to total parking spaces at and near the City Campus

The above graphs indicate the following:

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- In general, students will arrive later, leave earlier and the arrivals and departures are distributed more through the day.
- At 10:00 am, most of the parking areas at and near the City Campus are already full.
- The parking areas at and near the City Campus, will stay full until 4:30 pm
- Between 11:00 am and 3:00 pm small amounts of cars will enter and leave the parking areas.

In the future the amount of car drivers will increase (because of an increase in students) which leads to car parks getting full earlier in the morning.

Origins of the Students and Staff

Data showing which entrance people will enter and leave the network is a major requirement in order to simulate cars driving towards and leaving the City Campus realistically. Analysis of the Atkins Transport Planning (2005) and the infrastructure around the city and the City Campus indicates that the following entrances are most likely to be used:

- A1 67 NW (northwest of the City Centre) Great
- North Road (north of the City Centre) Jesmond
- Road (northeast of the City Centre) New
- Bridge Street (east of the City Centre) A1 67 S
- (going towards the Tyne Bridge)

City Campus Traffic During the Day

Following data is available:

- Total amount of car drivers going to the City Campus during day (for every hour).
- Origins: The distribution between the origins of the students and staff members over the flow areas, which belong to the several entrances and exits of the network.
- Destinations
- Total number of car drivers leaving the City Campus during day (for every hour).

Surrounding Traffic

In order to have a realistic simulation VISSIM needs traffic data about the amount of vehicles entering the network at the entrances and the routes which the vehicles will follow.

Available Data

- The Tyne and Wear Traffic and Accident Data Unit (TADU) manages two key data
- sets: Road traffic casualty data

  Traffic flow data in Tyne and Wear
- The available traffic databases provide different traffic flow data:
- Traffic counts at several locations along the roads: Data of vehicles driving in both directions Traffic

counts at several intersections: data of vehicles crossing the intersection in all the directions.

All the data consists of total number of vehicle, distributed per vehicle type and measured over every 15 minutes during a day. The data is collected between 1990 and 2006, mainly focusing the period between 2005 and 2006.

All the above data needs calibration in order to be used in the VISSIM software.

Other Data Requirements

The simulation requires other data such as: traffic signals, vehicle types and the public transport.

VISSIM SIMULATION

VISSIM is designed for traffic simulation on a microscopic scale, with its unique high level of detail, it accurately simulates urban and highway traffic. One of the important aspects of the software for 3D visualisation is that it does simulate every single car's behaviour. In addition to the 3D recoding function of the software, several standard objects can be added in 3D mode and new objects can be created. Import and export between VISSIM and 3DsMax software can be done easily and this allow importing city data to the simulation environment.

Most VISSIM models are created as an "overlay" to a background drawing such as a CAD drawing or an aerial photo such as GoogleEarth etc. In this study a 3DsMax version of the Newcastle City model was used.

For the simulation of the traffic, various data needed to be input to VISSIM software. After loading and scaling down the background image in VISSIM, the connectors were drawn and vehicle inputs were set.

Following this; routes, traffic lights and non-signalized intersections, public transport data were added to the system. Eventually the simulation run for evaluation. Road network needed to be adjusted to the 3D city model, especially height of the different links however the final result was very pleasing. This exercise also verified that a complex 3DsMax city data can be used with VISSIM software

Figure 8: A screenshot from VISSIM in 3D Model

CONCLUSION

The simulation of the current situation in VISSIM is used as basis for the future situations. All the possible routes are simulated. The final routes are found by measuring the different travel times of the routes, the fastest routes will be chosen by the students and staff. This final simulation is representative because a large amount of traffic data, many calibrations and the validation of the simulation with the field data went into this simulation.

The relocation of the car entrance at the City Site leads to a change in routes towards this entrance. The changes in routes are based on the new possible routes to the new car entrance and the different travel times. The City Council and the Estates Department were at the time of this research discussing about the two options of the new car entrance:

Option 1: new car entrance accessible from both side (east and west)

Option 2: new car entrance only accessible from the east: forcing people to avoid the City Centre.

Initially it can be said that the traffic and the congestion is re-directed.

Comparison of the results:

1. Northumbria University and the students and staff:

Improving the quality of the work and study environment at the City Campus: The quality will be improved by separating the motor traffic and the pedestrians, which will result in fewer conflicts between the pedestrians and the cars. Option 1 causes a decrease of 25% in the amount of cars in College Street, but Option 2 will cause even a decrease of 75%.

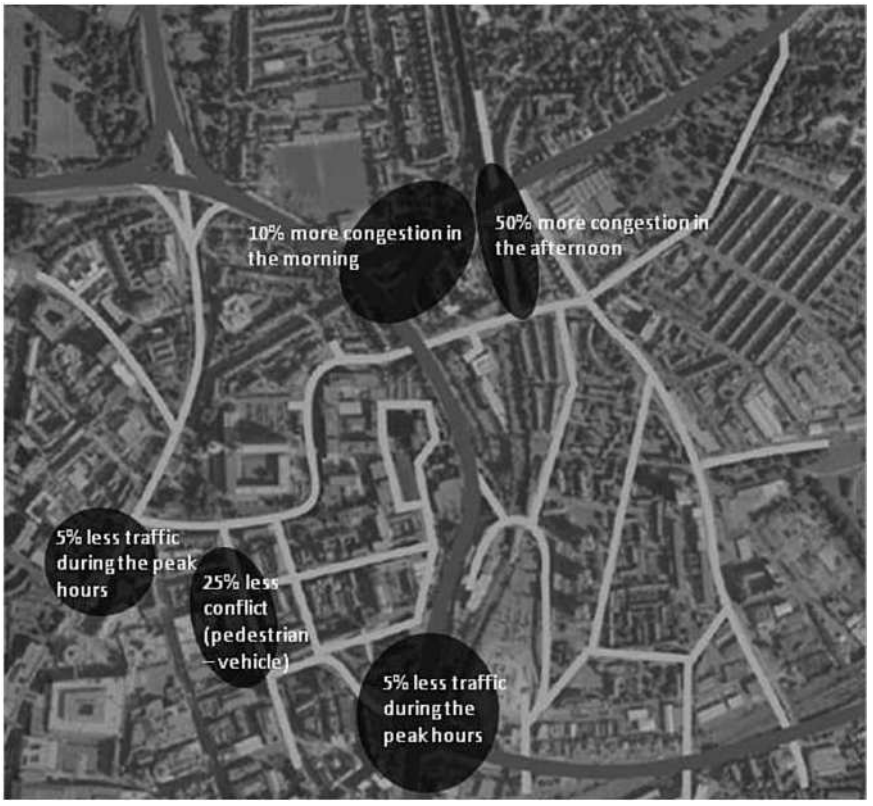

Figure 9: Impacts of Option 1 (compared to the current situation)

Encouragement in changing travel habits (Northumbria University) and accessibility of the City Campus (students and staff): relocation of the car entrance will lead to different routes towards the City Site. Overall the travel times will stay the same. The quality of the pedestrian routes will be increased, because of less cars and the new pedestrian bridge between Manors Site and City Site. This might have a positive effect on the use of public transport. Due to the number of parking lots at and near the City Campus will slightly decrease, more use of public transport is expected.

2. City Council Newcastle upon Tyne:

Less traffic in the City Centre: Both options will lead to a slight decrease in amount of cars near Haymarket. Also Option 2 will abandon most of the cars from the City Site. The traffic circulation at the New Bridge Street Roundabout will improve (especially at option 2), but congestion will increase at the junction A1 67-Jesmond Road.

Better traffic circulation on the routes of the buses: the buses overtaking the New Bridge Roundabout are positively affected by the better traffic circulation at the roundabout. However, the buses on Sandyford Road will be negatively affected by the increase in cars at the east of the new entrance. Option 2 will affect these aspects more than Option 1, but still, the impacts on the travel times of the buses are small.

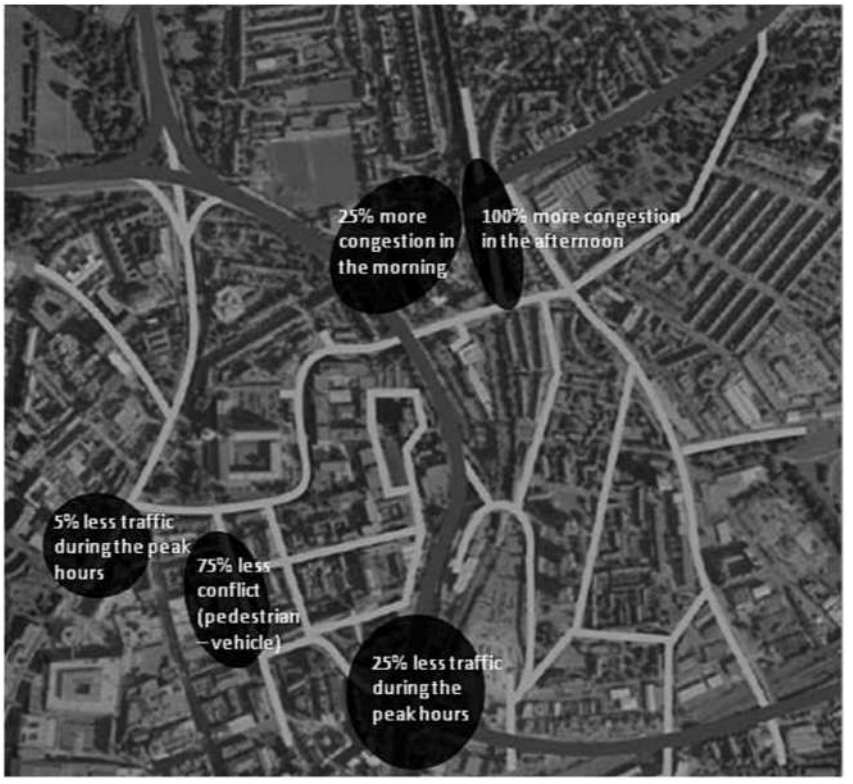

Figure 10: Impacts of Option 2 (compared to the current situation)

3. Other people crossing the area:

Traffic circulation: The traffic circulation at the New Bridge Street Roundabout will get better, especially if Option 2 is chosen. However, the options will cause more congestion at the exit roads of the A167 towards Jesmond Road.

One of the main conclusions: just a small change in infrastructure can result into big impact on the surrounding traffics. In an area like the City Centre, such a decision can be very important.

Analysing the interests of the different parties and the impacts will result in Option 2 as the best option. The new car entrance will be less accessible, but the average travel times towards the City Site will be almost the same as in the current situations. A big positive impact is that a large part of the student and staff car drivers will be abandoned from the City Centre and the City Site (75% decrease of cars at College Street). This will result in a higher quality of the work and study environment for the students and staff. In addition, the traffic circulation at the New Bridge Street Roundabout will become much better. The effect on the bus routes is small: the buses on the New Bridge Street will be positively affected, because of the better traffic circulation; the ones on Sandyford Road will have a small delay of a few seconds, because of more traffic in that area. The main discussion point is the junction at Jesmond Road and the exit roads of the A1 67. The queue lengths will get longer and this will affect a large part of the traffic in Newcastle upon Tyne. On the other hand, this might stimulate the people to change their travel mode, as the City Council is hoping.

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