THE SPATIALLY KNOWLEDGEABLE CYCLIST

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Abstract
By definition cyclists are spatial beings. They use their bikes to get from one place to another, whether for errands, commuting, socialising or recreation. Route choices are governed by a variety of factors, some positive (where are the cycle lanes and where can I park my bike and meet my mates close to a cycle-friendly cafe) and some negative (where are the hazards and risks on a particular route so I know to avoid or mitigate them).

Enter Google Maps as a spatial resource for communities of cyclists to connect. Free to both construct and obtain information over the Internet via a web browser, Google Maps technology can offer a wealth of up to date information for cyclists. ARTA has teamed with Plexus Consulting Ltd to develop a consistent set of Google Cycling Maps across the Auckland region, expanding upon the popular paper-based MAXX cycling maps.

Cycle-friendly information includes:
- *Regional transportation hubs (ferries, buses & trains)*
- *Cycle paths*
- *Bike shops*
- *Cycle-friendly cafes and meeting spots*
- *Bike rentals*
- *Cycle parking and lockers*
- *Links to school travel plans*
- *Public toilets*
- *Territorial Authority consultation and proposed cycling infrastructure*
- *School Travel Plans.*

Cautionary information includes:
- *Steep gradients*
- *Hazardous locations*
- *Cycle vs motor vehicle crash data as extracted from the MOT's Crash Analysis System (CAS).*

While the presentation of spatial information is of considerable benefit to cyclists to aid in route planning, the next logical step is to perform a degree of automated route planning for cyclists similar in concept to the MAXX public transport Journey Planner. Consider the future where a cyclist will be able to request a cycle-friendly route, possibly consisting of multiple transport modes, and have these downloaded to a GPS-enabled PDA with detailed navigation instructions. Closer than you think?

Google Maps[3]

The world of mapping has been turned upside down with the advent of "free to consumer" street maps available on the Internet. Where once a paper map became outdated the moment it was published, electronic maps can be instantly updated and accessed once new information becomes available.

While lacking the power and capability of full Geographical Information Systems (GIS), their ease of access and use are such that they can be made extraordinarily functional, with workarounds available to overcome limitations such as dataset size and layering limitations.

The features offered by Google Maps (see Figure 1) in New Zealand through any Internet browser include:
- Maps of the entire country
- The ability to alternate between street map, satellite and terrain views
- The ability to zoom in from a map of New Zealand (1:20,000,000) to street and section level (around 1:1000)
- Panning and zooming at the click of a mouse
- The ability to jump to StreetView, viewing continuous digital photographs of the location
- The ability to plan a route from one point to another by car, walking, or public transport, though noting that walking routes carry a rider they may be missing sidewalks or pedestrian paths, and only Metrolink in the Wellington region is configured for public transport routing.
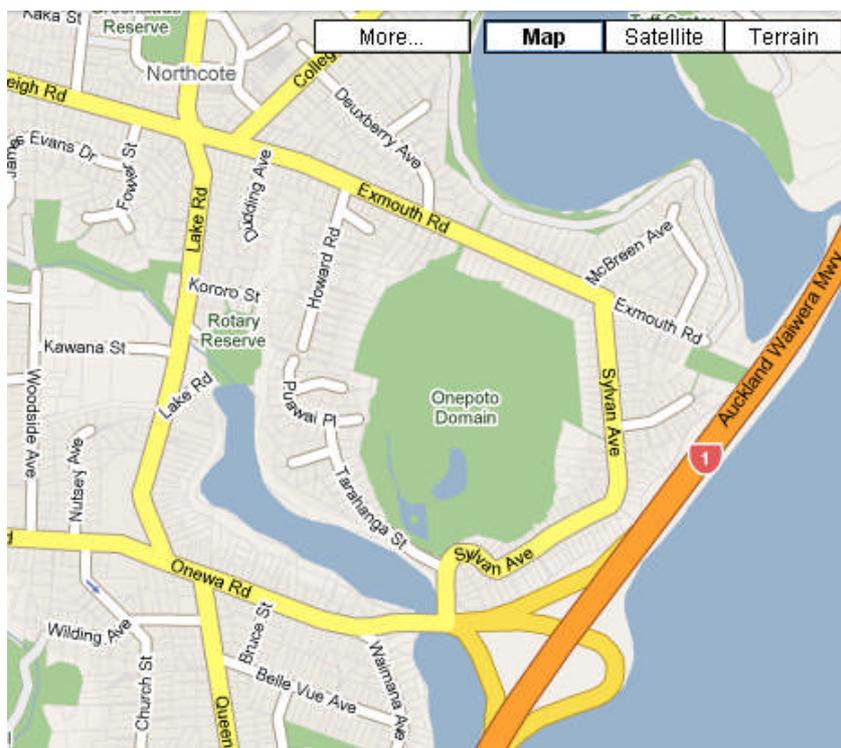

Figure 1 – Typical Google street map

While useful in itself, the full power of Google Maps is exploited when users utilise the base maps to add information of interest to various groups, and make them easily searchable or available by a single URL.

The elements a user can add consist of:
- Placemarks identifying a single location, with identification via a palette of multi-coloured symbols, or user-defined symbols
- Line strings, with flexibility regarding colour, width and opacity, and with the ability to snap to roads

- Polygons (shapes), with flexibility regarding colour, bounding line width, and opacity.

Each element is associated with a descriptive text box identifying its title and description (see Figure 2). The description can include formatted text, URLs and images.
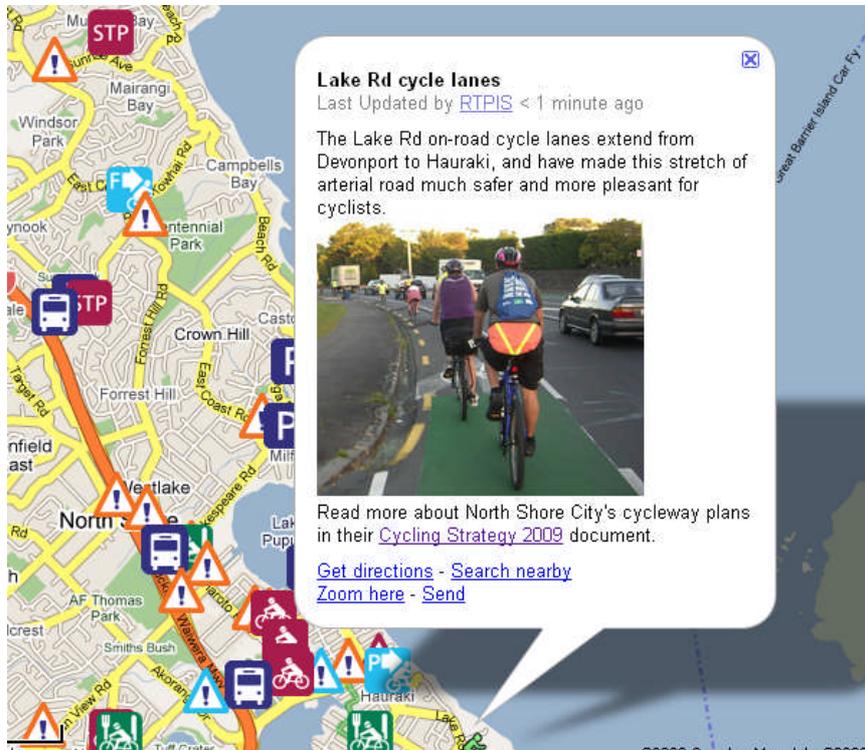

Figure 2 – Placemark showing descriptive text box

Limitations

Prior to constructing the ARTA cycling maps it was necessary to explore and understand some of the limitations Google Maps imposes.

The first limitation relates to dataset size. While a single Google Map can easily contain over 1,000 user-defined features, any more than 200 requires the user to manually advance through successive pages to view them. This was considered counter-intuitive for most users, so a decision was made to limit the number of features on any one map to 200. Note there is a manual way to utilise selective symbol display on zoom within Google Maps utilising Google Earth export/import, but this manually difficult process is not conducive to maintaining a set of production maps.

The second limitation relates to layering. While Geographical Information Systems efficiently accommodate the loading of data into different layers, Google Maps does not offer such a facility without advanced programming through the Application Programming Interface (API) library[4].

For the sake of simplicity, we chose to manage the datasets and implement layering by creating multiple Google Maps, any one of which could be viewed by a user clicking a URL, but to display multiple maps (whether coincident or adjacent) requires the user to log on to Google Maps and use the My Maps facility, placing a tick in the checkbox for all maps requiring concurrent display.

Assembling the ARTA Maps

Accommodating the limitations noted above required the Auckland Region to be broken down into six sub-regions, which roughly matched the regions covered by the MAXX paper cycling maps (see Figure 3).

These regions are denoted:
- North
- West
- East
- Gulf (includes Waiheke and Great Barrier Islands)
- Central
- South.

Figure 3 – Region breakdown

Phase 1 of the project required the presentation of placemarks identifying locations both friendly and cautionary to cyclists, as follows:

🚆	MAXX train station	🚌	MAXX bus station	⛴	MAXX ferry terminal
P	Cycle parking	🔒	Cycle lockers	🚲	Cycle friendly cafe
⚠	Advisory/informational note	⚠	Cautionary note	⚠	Hazardous note
R	Cycle rental	🚲	Cycle shop	L	Learn to ride facility
🚲	Recreational cycling	🚻	Public toilets	STP	School Travel Plan
P	Proposed cycling infrastructure	F	Future cycling infrastructure		
C	Minor cycle crash	C	Serious cycle crash	C	Fatal cycle crash

The maps displaying this information are created and maintained by ARTA, and are read-only for users. One additional map maintained by Plexus Consulting Ltd covers the entire Auckland region, and is designated a "Cyclist Input Map". This map is publicly updateable, and invites anyone to add

information of interest to cyclists. The Cyclist Input Map is routinely reviewed, and relevant information transferred to the ARTA-controlled base maps as appropriate.

Phase 2 of the project will include line strings denoting the location of various types of cycle lanes and cycle paths, plus public toilets and gradient information.

Information Sources and Presentation
A number of organisations and individuals have contributed to the base information:
- ARTA – MAXX facilities, cycle parking, cycle lockers, school travel plans
- Cyclist input – informational/hazardous locations, cycle friendly cafes and recreational cycling (Cyclists are typically members and friends of Cycle Action Auckland, and members of various riding groups)
- Cycle shops and rentals – Yellow Pages
- Learn to Ride, School Travel Plans, Proposed infrastructure, Future infrastructure, Public toilets – Territorial Local Authorities (ie local Councils)
- Cycle crashes – Ministry of Transport Crash Analysis System (CAS) database.[5]

All data apart from cycle crashes is able to be contained on a single region map. Crash data is contained on a separate set of maps, with the 200 most recent cycle crashes for each region able to be displayed. This separation was not just for technical reasons. In order to promote cycling we want to focus on the positive aspects and highlight the cycle-friendly facilities first.

Phase 2 cycle lane data will be obtained initially from the MAXX paper cycle maps, and subsequently updated from the Terralink GIS.

Crash data
We believe we have achieved a New Zealand first in extracting data from CAS and presenting it on Google Maps (see Figure 4)
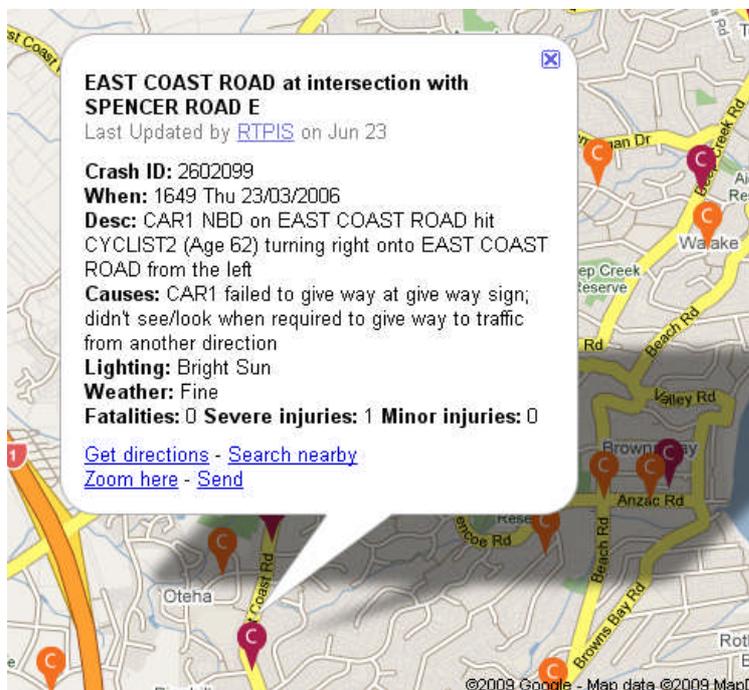

Figure 4 – CAS data on Google Maps

While not wanting to dwell on some of the more negative aspects of cycling, it's important that cyclists have as much information at their fingertips as possible when planning a route. The crash

maps allow routes with a high density of crashes to be shown at a glance, while the drill-down for each crash identifies the type of hazard to watch for.

Note that only a small subset of available crash information is displayed. Specifically, "fault" is not included as there is no simple field in CAS which clearly assigns it. This is reasonable as not all crashes are clear cut in terms of fault.

CAS is a world-class motor vehicle crash repository, however the data is not accessible to the general public, and it requires a reasonable level of training and skill to use the system to extract crashes based on spatial and attribute criteria.

Plexus Consulting Ltd has developed an algorithm that takes a CAS extract and automatically converts it to a KML file, the standard method of loading data to Google Maps.

The algorithm can be simply extended to plot any output from CAS, and has already been used to plot pedestrian vs motor vehicle crashes in Auckland City.

Route Planning

The purpose of the ARTA Google Maps is to aid cyclists when planning or reviewing a route. Unlike most motorists, cyclists take a number of factors into account when planning a route:

- Directness (as per motor vehicles seeking time/cost minimisation)
- Safety (cycle lanes, hazards) with regard to their skill level
- Terrain (some cyclists actually seek out hills)
- Environment (pleasant surroundings).

In its current form, a cyclist would use the ARTA Google Maps as follows:

- Use the Google "Get directions" route planner to plan the route. A number of iterations may be required to find a route that avoids motorways, either by choosing the "Walking" or "Avoid Highways" options. However the route is not guaranteed to be either cycleable or free from significant hazards, nor will it include Auckland's ferries as a means of getting across the Harbour
- Turn on the appropriate cycle resource map and cyclist input map for the region in question and review the features close to the chosen route. Perhaps there's a cycle lane, cycle-friendly cafe or recommended bypass that would make the journey safer or more pleasant
- Switch on the crash map. Is there a particular part of the route where care needs to be taken?
- Modify the route accordingly.

Automated Route Planning

The ultimate aim of the ARTA Google Maps project is to automate cyclists' route planning. There are already many route planning devices available in Auckland, such as:

- Google Maps (motor vehicle and walking oriented)
- Satellite navigation systems (Navman, Garmin etc – motor vehicle oriented)
- MAXX Journey Planner[6] (public transport oriented).

The difficulty is that none of these is suitable for cycle route planning. This is due not just to cycling being a minority transportation mode; it is also due to lack of cycleway map data, and the considerable variability in cyclist capability. There is a world of difference between a high speed adult commuter cyclist racing for the ferry, a family taking a recreational ride together, and an inexperienced child riding between home and school.

Variable cyclist skill and purpose combined with the factors identified in the previous section present a multiplicity of options and alternative route choices. These serve to complicate automated route planning algorithms.

Anecdotally, Google is believed to be working on both mapping cycle paths and developing its "Get Directions" algorithm to include cycling as an option, and a number of other interesting prototypes have been developed.

Some existing journey planners facilitate cycle routing based solely on where cyclists can legally travel, with the Greater Wellington Regional Council's Cycling and Walking journey planner an excellent example[7].

Extending to cyclist capability and preferences, a research initiative at Auckland University's School of Engineering is currently in progress to investigate bi-objective shortest path algorithms[8], which are directly applicable to cycling, and introduce the safety/amenity factor into route selection.

One of the more interesting working prototypes is A-Train - Atlanta Transit Riders' Advocacy & Information Network[9]. The A-Train trip planner uses Google Maps as its base, and incorporates walking, cycling and public transport (including a mix of these modes), with the cycle route choice modified by both facility type (ie cycle-friendly vs cycle-hostile route segments), and topography.

A newer version of the A-Train planner incorporates a novel Bike Triangle widget allowing the user to specify the relative importance of trip length, route topography, and roadway/facility type.
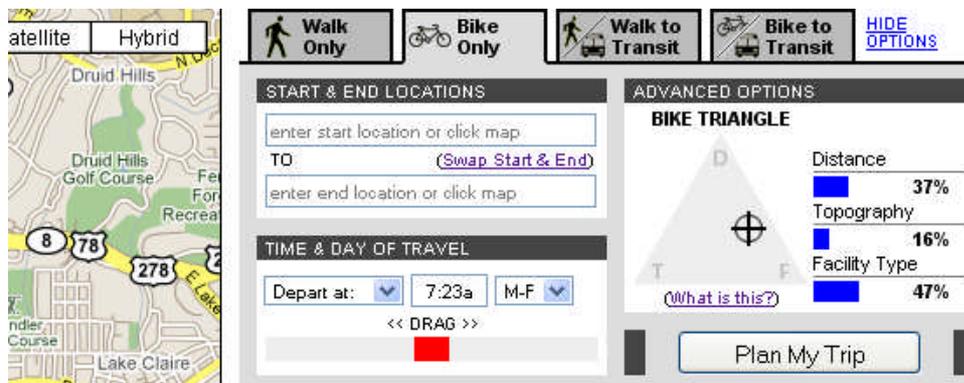

Figure 5 – A-Train bike triangle widget

The resultant route (see Figure 6) is displayed superimposed on the map base, with a colour-coded elevation profile, plus step by step turn instructions.
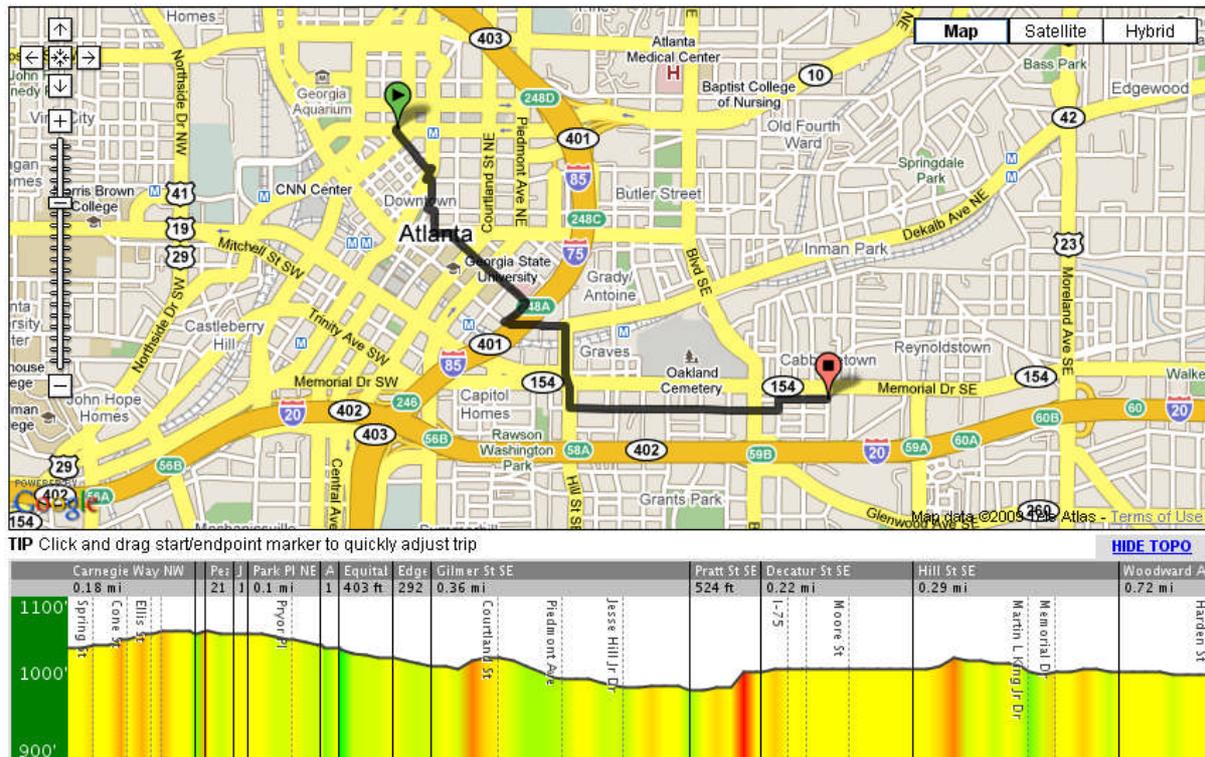
Figure 6 – A-Train route with elevation profile

The A-Train team are currently working on PDA presentation, allowing the map, route instructions, and current GPS position to be available on a mobile device.

The ARTA Project
The ARTA Google Maps project is split into three phases. Phase 1, using placemarks to highlight cycle-friendly and cycle-cautionary information is now available.

Phase 2 adds further cycle-friendly information to the base maps, including cycle lanes, cycle paths, public toilets and the location of steep gradients.

Phase 3 to include automated route planning is currently under discussion, but will likely follow the following steps once funding is allocated:
- Perform a more extensive literature review to identify and subsequently select a routing algorithm suitable for cycle route planning in Auckland. In particular, the system must integrate with public transport due to Auckland's size and limitations on cyclist travel imposed by the motorway network
- Prepare the base map data, including all information (both positive and negative) that will influence route choice
- Develop an interface to solicit user information so skill levels, experience, preferences and risk aversion can be taken into account
- Develop the routing algorithm to generate a route with explanations, modifiable with user feedback
- Provide a capability to download the route to a hand-held (or handlebar mounted) GPS-enabled PDA or navigation unit, with both visual display and audible turn instructions.

The working journey planners and prototypes available suggest this approach is feasible, though some simplifications may be necessary to match funding limitations, with those components offering the most favourable cost/benefit developed first.

References

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