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Cooperative web based bicycle routing database for trip planning, including dynamic weather integration

Poul Grashoff poulg@demis.nl

Marcus Wigan¹ mwigan@unimelb.edu.au

Michiel Benjanmins MichielB@demis.nl

Demis BV, Rotterdamseweg 183c, Delft 2629 HD, The Netherlands

ABSTRACT

Way finding is a key aspect of travel of all kinds, but the cost of inaccurate information is highest for human powered transport (bicycles and pedestrians). Even in the Netherlands, with the extensive provisions for bicycles, the management of routing information catering specifically for bicycle rider needs has many failings. To solve one major issue, the lack of reliable digital data, the Dutch bicycle trip planning system makes use of rider input on a continuing basis, and delivers a bicycle trip planning system that is the more reliable for it. The present paper describes how adding a real-time link to weather predictions can help users in deciding if postponing or advancing a trip helps in avoiding the rain. Recently, as part of the ROADIDEA EU FP7 project a real time link to the Dutch weather service (KNMI, see www.knmi.nl) was investigated as a potential additional service for on-line trip planning systems. The KNMI made real time weather data available for free for duration of the ROADIDEA project. The data provided is the two hour prediction for rainfall in the Netherlands on a one by one kilometer grid in five minute intervals. To see these forecasts one can look at the www.buienradar.nl web site.

This investigation resulted in a ROADIDEA Route Rainfall Prediction Planner demonstration that is publicly available at <http://www.roadidea.eu/pilots/pages/pilot5.aspx>. The ROADIDEA demonstration is based on a combination of the rainfall forecasts in Holland with routes generated by the Demis trip planner for Holland made operational specifically for ROADIDEA. The result is that as a road user (cyclist, motorcyclist, pedestrian, etc.) you can better decide when to leave so as to miss the rain that is coming in. The (free) Dutch road network data used come from the OpenStreetMap project (provided by AND, www.and.com). To illustrate the value of crowd-sourcing in *free network data* collection, the demonstration also includes an Online-GIS network editor InterNetter that allows users to add their own network data. The on-line GIS network editor is publicly accessible at <http://rain.roadidea.eu/route/editor.aspx> (please enter as username *test* and as password *test*). The demonstration also includes a link to a slide show in Powerpoint and a link to a survey (in Dutch!) on the need for rainfall prediction for on-line trip planners.

¹ Also Partner: at GAMUT the Volvo Centre of Excellence for Governance in Urban Management and Transport, and Professorial Fellow, Civil and Environmental Engineering, the University of Melbourne

The user feed-back through this survey received so far shows that there is public interest in adding a rainfall prediction service to the existing on-line bicycle trip planning service. A major obstacle is that the extra route rainfall prediction service should cost nothing for the users, as the original trip planner is also free of charge. This paper describes the ITS aspects of the system and focuses especially on integrating the real-time weather information with the trip planning system.

The on-line bicycle trip planner developed by Demis BV of Delft in The Netherlands, includes an on-line GIS network editor which allows volunteers to edit the bicycle network data. Together it is referred to as BicycleNetter. The Dutch cyclist union has mobilised hundreds of volunteers, who have already exceeded 3 million edits in operational use in just part of the Netherlands.

The broader potential of ITS applications in communication is one of the basic themes of the European Union ROADIDEA Framework 7 project, which is focused on two unusual aspects of ITS (www.roadidea.eu).

- Innovation processes that can be used to identify and anticipate innovative ITS applications
- Full integration of weather factors into ITS services and provision

The relevance of weather to human powered transport is clear. It is harder to avoid; and rain (let alone snow or ice) is a greater disincentive to taking a particular route or postponing the trip than it would be for a car. Providing real time weather forecast data along a route is highly beneficial for human powered transport.

The steady convergence of portable devices now offers telephone, mapping, navigation and mobile internet in one package in the current generation of smart mobile phones. This would appear to offer the opportunity to integrate weather and routing information via a mobile phone- but the Intellectual Property agreements with real-time weather providers presents itself as a further barrier.

Integration of weather and navigation information with mobile telephones is a fundamental area where innovations are expected and occurring, and these three elements recurred in a variety of different forms and applications in the ROADIDEA project innovation identification sessions. The ideas integrating snow and fog incidence with vehicle and travel requirements that arose are not as important for human powered transport as significantly fewer journeys are made by bicycle etc during such conditions: these services are and will continue to be more relevant – and important – for trucks and cars. The Demis system described in the present paper is one of the first deployed in public to integrate real-time weather data with specialised routing support – certainly the first for bicycles.

2 THE DEMIS BICYCLENETTER SYSTEM DESCRIPTION

For successful and specialist user-relevant route and planning advice information about both locations (nodes) and the connections between them (links) such as roads, rights of way and paths are also required. The ability to check, verify, edit and add to both locations and connections is needed. The necessary technical components required include:

- A basic road and facilities vector map
- The ability to edit these vectors, nodes and their associated attribute information over the web
- Compliance with OpenGIS standards to ensure maximum portability of the approach

The Demis MapServer (see www.demis.nl) meets these requirements. The need for a base map is clear, but the need to edit vectors on the map is less obvious. GIS systems comprise several

different types of data structure, the most common being rasters (bit map images with no other structure: ie a 'picture' of a map rather than a detailed data structure: the major component of Google's current Mapping tools) and vectors, where directed links (ie pathways connecting point A to point B) are held as a separate data structure, often overlaid on a raster. Road and other routing networks are networks of vectors) ie directed links between one point and another). Navigating through a road or bicycle network requires that one restricts ones movements to these links, and their connectivity is vital.

The significance of the OpenGIS standards for the basic hosting tool is that these are clearly defined standards for communicating with raster and vector entities, on and off the web. Anything that complies with these widely accepted standards can be used in place of, for example, the Demis MapServer, reducing the importance of choosing any specific tool.

A tool called the InterNetter had been developed in 2003 to allow data to be entered and edited over the web as a key part of the data collection stage of the first Dutch Bicycle Trip planner for South Holland and subsequently for the Reorient EU Framework 6 project (www.reorient.org.uk) on railways in the EU. This has subsequently been extended to allow the EU Framework 6 WorldNet project (www.worldnet.eu) to secure wide ranging input of freight movement data. There is public access to the WorldNetter test editor at <http://www3.demis.nl/worldnettertest/>² and to the ROADIDEA editor at <http://rain.roadidea.eu/route/editor.aspx> (user name test and password test).

Editing of more than simply the vectors is supported; additional attribute information can also be added, as well as link and other aspects of the network parts of the maps. As well as maps served through the OpenGIS protocol, Google maps can be linked as an image background to visualise the areas over which the networks run. Recently Google started moving in the crowd sourcing direction by allowing users to add their points, lines, polygons of interest to the maps. The additions by the users however are not yet used to add to or enhance the existing map information as is the case in InterNetter.

The amount of information that can be fed through web connections is often severely limited, compared to the density of information held in GIS system. Consequently the standard approach is to send only the information bounded by area covered by the screen used to view it on the receiving equipment, and preferably only the changes between successive screens. One way to do this is to use a highly efficient screen display tool such as Flash, and communicate between the GIS data source and the Flash client in the receiving device using XML with the necessary links between this XML communication and the GIS tool handled at the server end. This has been done in the Bicycle route editor and viewer (subsequently referred to as the 'BicycleNetter' for brevity, although the highly efficient binary mode version has been used in this family of systems), and so anyone wanting to use any system with BicycleNetter behind it needs only a W3C compliant web browser and the corresponding Flash client installed at their end.

This avoids any special features being required at the user end, yet enables the full range of functions to be provided. As an example of how this simple approach allows fast and clean mapping services to be used without any special programming, software or equipment, a range of many types of maps with interactive displays and menus can be viewed under 'Maps' on the ReOrient project website (www.reorient.org.uk).

² Enter username test and password test, and Zoom in so the network becomes visible

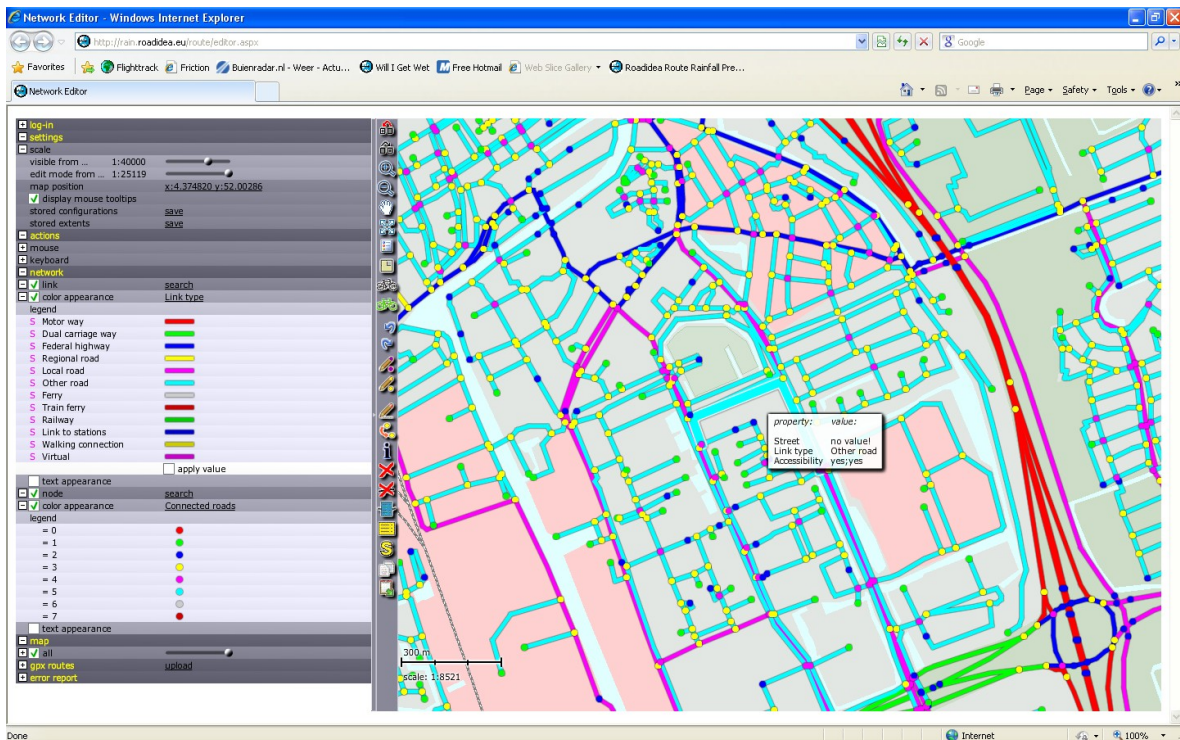


Figure 1 ROADIDEA network editor, showing road type

Once Flash clients are generally available for smart cell phones (they are as yet not available for the Apple iPhone series, although workarounds are now beginning to appear³) this will allow planning and mobile real time access to these systems, and the editing function with photo integration allowing onsite updates on items needing enhancement, visualisation or correction. Once in wider use, this will then allow on-route access to routing systems to realtime supported systems such as the proven Demis BicycleNetter as iPhones are suitable mobile systems to use on a bicycle (or indeed on foot), where realtime and short term route-specific weather forecasts will be valued... and on route adjustments to the facilities encountered can be submitted, as provided for by the BicycleNetter.

This highlights the problems of success: who monitors the accuracy and reliability of such edits? Who audits the added information? These are issues that have indeed arisen in the Netherlands for the BicycleNetter, and later on we consider the takeup and operational issues of the live experience of making such a service publicly available on a mass scale over some years.

This has already been done in the Netherlands and the accumulated experience can now be used by other places wishing to offer similar services to bicycle and HPT users. The basic user-taste specified variants in route construction were of course also provided from the start (shortest, scenic etc).

3 INTEGRATING WEATHER INFORMATION

The weather information used in the ROADIDEA demonstration concerns rainfall predictions from the Royal Dutch Weather Service KNMI. The predictions are based on actual radar weather measurements and a predicted wind field.

3.1 KNMI actual weather measurements

³ http://www.adobe.com/devnet/logged_in/abansod_iphone.html

The KNMI operates two Doppler Radars, one in De Bilt and one in Den Helder, which are used for measurement of precipitation over The Netherlands and the surrounding area. The radars emit and receive radio waves that can be used in two ways. First as a conventional Radar where the intensity of the received, scattered Radio-waves is measured (based on Radar reflectivity). Second the radars can be used as a genuine Doppler Radar where the velocity distribution of the scattering particles is measured.

The Radar reflectivity delivers a view of the three-dimensional distribution of reflectivity in the atmosphere. The Radars of the KNMI perform a small scan over just 4 low elevations every 5 minutes and a large scan over 14 elevations up to 12 degrees every 15 minutes. The well-known radar precipitation images (as shown in figure 2) are just a horizontal cross-section at constant altitude above the earth surface through the three-dimensional data of the small scan.

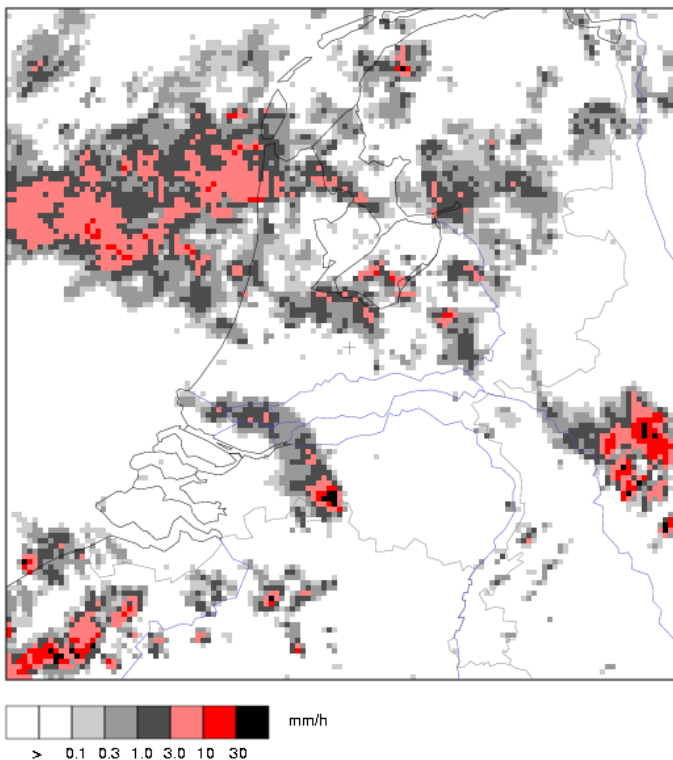


Figure 2: Example of a precipitation image

For a more detailed technical discussion of the radar measurement and precipitation determination we refer to [5], [6], [7] and [8]. After the projection of KNMI radar images [9] the precipitation data results in 1-by-1 kilometre grids containing rainfall intensity values. These measured base values are used in the KNMI rainfall prediction method to determine precipitation forecasts for the next two hours.

3.2 KNMI rainfall prediction method

The currently applied KNMI method for rainfall prediction uses the current (last measured) status of rainfall intensity which was described above. The method extrapolates the values of the rainfall for the next two hours based on the wind direction and wind strength [2] for 5 minute intervals. This method does not take the future changes of the rainfall intensity into account. Currently KNMI is testing a three hour rainfall prediction that is based on 9 extra foreign radar stations.

3.3 Linking the rainfall prediction to a route

The ROADIDEA trip planner works on the basis of finding the best route between a given start and end point along (optional) intermediate points. Usually within a route planning algorithm it is possible to assign the value of some planning parameters, such as preferences to a certain type of route / road. This is the case in the BicycleNetter planner for (parts of) the Netherlands. This however has not (yet) been applied in the ROADIDEA rain-route planner, mainly due to the limited quality of the underlying road network in terms of being applicable for bicycle route planning. The rain forecast is applied to the calculated route, resulting in the average and maximum intensity of rain encountered on the route. These values are available for each route segment (called: network link) and can be consulted accordingly.

For determining the amount of rainfall (both average and maximum intensity) on the network links, the complete trajectory of the route with nodes and link points is passed on from the route planning algorithm to the rainfall determination algorithm. These nodes or link points contain both a place (map coordinates) and time denomination (a 5 minute time frame). The rainfall prediction is provided as a grid dataset in five minute time intervals. In figure 3 a link is drawn (taken from the WORLDNET editor): the red points being nodes and the purple intermediate points being the link points that determine the link's trajectory.

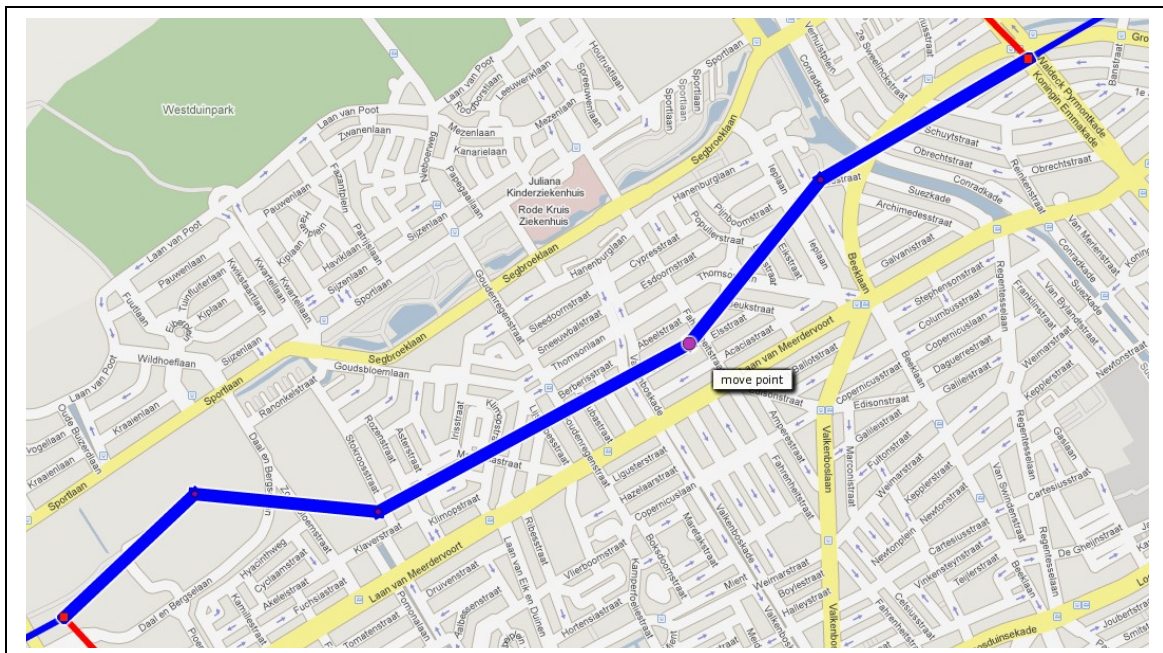


Figure 3: Example of network link in network editor

For each link the route-rainfall algorithm determines:

- The link is divided in segments that fall within the same (5-minute) time frame;
- For each time series of link segments:
 - What grid cell(s) do the segments pass through? For those grid cells acquire the rainfall values for each grid cell within the time frame;
 - Determine the average and maximum rainfall over the grid cells. The average is the non-weighted average of the grid cell rainfall values, so non-dependant of the distance travelled within a grid;

- For each link (when subtotals are determined for the link segments): determine average and maximum intensity values on the link;
- Return the values for the links to the route planner algorithm.

This current algorithm works fairly well when applied specifically to bicyclists with a constant and relatively low speed, but will need revision when applied to motorized vehicles with varying (due to different types of road) and higher speed. The algorithm is implemented in the ROADIDEA rain-route planner in such a way that the user can vary the time of departure and the average speed.

Adding real time information leads to a new range of operational issues:

- It allows trip planning feedback to include things that change continually while planning (i.e. new rainfall prediction every five minutes).
- It raises the question of providing information or warnings while riding

The RoadIdea project is focussed on innovations in ITS, and one of the Ideas identified at an early stage was routing and information services tailored specifically for minority road users (such as powered two wheelers) and human powered transport (bicycles, pedestrians). Some of the Ideas indentified in the innovation process were then selected for pilot explorations to test the practicality and possible implementation frameworks [1]. The ideas have a strong emphasis on including weather factors, as meteorology and weather information is still poorly integrated into ITS and transport services, and the Roadidea team includes many weather information and analysis members.

The Ideas process is of intrinsic interest as an innovation process itself, and the RoadIdea website is specifically open for external participation comment and input through the RoadIdea Wikis at www.roadidea.eu (www.roadidea.eu/community/wikis/Innovations/Home.aspx), and do not require logging in or identification. This site will be open until well late 2010 and readers are encouraged to review it and add their own comments, ideas, links and inputs. And also to explore BicycleNetter and its progressively more advanced Location Based weather services as they are continuously added.

The Geolocation API of the World Wide Web Consortium (W3C) and the implementation of that API in Google Gears has allowed adding LBS (Location Based Services) to the RoadIdea website cited above, and allows detailed locations to be derived automatically even when no GPS chip is present. Other similar location support facilities are now emerging⁴, allowing a steadily wider range of mobile devices to be supported.

The whole field of ITS and human powered transport and vulnerable road users has as yet not attracted very much professional, research or policy attention, and one of the ways of securing a broader balance in such ITS work is to position ideas that link the needs and demands of these minority groups.

The change to add real time information to the BicycleNetter brings it several steps closer to the broad vision of the i-Travel EU Framework 7 project (<http://www.i-travelproject.com/en/news/>) which includes suppliers working towards integrated travel information available on a mobile base. One example of such a proprietary system is TomTom Traffic, where commercial sources of traffic data are fed to TomTom users with mobile

⁴ <http://mobiforge.com/developing/story/developing-location-based-services-introducing-location-api-j2me>

connections. The differences that are important for the far less well resources human powered transport area are the need to access Open Source data and to avoid closed systems.

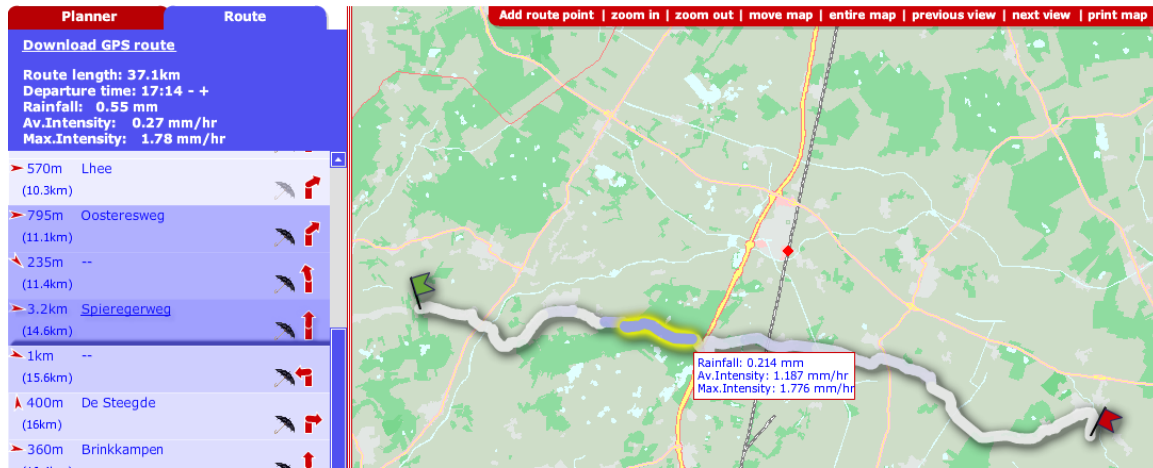


Figure 4 Rainfall prediction in blue added along the suggested route (more rain is darker)

4 CONCLUSION

Human powered transport has special needs that can be served by ITS approaches. The barriers to their creation and use are more similar to ITS for cars and trucks than is immediately apparent. The rapid success and takeup by governments of the Demis BicycleNetter bicycle routing and planning system in the Netherlands – with its huge volume of user contributed improvements- demonstrates that there is a real need to focus on human powered and vulnerable road user applications. Breaking down the barriers to entry in planning and transport by crowd sourcing of data has wider implications for the balance of information than for cycling alone.

Providing real time weather forecast data along a route is highly beneficial for human powered transport. Bad weather is hard to avoid; and rain (let alone snow or ice) is a greater disincentive to taking a particular route or postponing the trip than it would be for a car. The user feed-back through the ROADIDEA survey received so far shows that there is public interest in adding a rainfall prediction service to the existing on-line bicycle trip planning service as long as it stays a free service. This has implications for the business model of the added service.

5 REFERENCES

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8. H.R. Wessels - KNMI radar methods (available on <http://www.knmi.nl/~holleman>);
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ACRONYM SUMMARY

- HPT Human Powered Transport, usually walking and cycling, but includes in line skates, skateboards, manual scooters, and other often neglected ‘light’ and difficult to classify modes
- GPS Geographic Positioning Systems, provided for many years by the US GPS satellite constellation, the Russian Federation GLAVCOSMOS systems, the European GALILEO systems etc. Usually referred to collectively simply as ‘GPS’
- PTW Powered Two Wheelers, included mopeds, motorcycles, scooters, motorcycles and a range of less easy to classify intermediate modes, but under present conventions to date still exclude mobility scooters, golf buggies and as electrically powered bicycles

SPECIAL TERMS

- BicycleNetter The combination of Flash client and Open GIS mapping server tuned for bicycle route development, improvement and use