CTA Social Night – Tech Talk
GPS mapping for cycle touring

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Loftus Community Centre

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1. GPS mapping basics

1.1 GPS – what is it and how does it work?

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 32 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in all weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

Other navigation systems are:

- GLONAS (Russian)
- Galileo positioning system (EU)
- Compass navigation system (China)
- Indian Regional Navigational Satellite System

You need to have a GPS receiver device to be able to find your location using the GPS system.

However knowing your exact location is of little or no use without a digital map to display it on. You must have access to digital map data of the surrounding area to understand where you are and where you need to go.

1.2 Digital maps

1.2.1 Aerial view image of surrounding area

A digital map is an aerial view image of an area showing key features such as roads, streams, vegetation, buildings, contours etc. When you turn on the GPS receiver of your portable GPS device your location will be shown on the map and you should be able to identify where you are in relation to the surrounding countryside and where you want to go. This is a big advantage over conventional paper maps which cannot show you where you are on the map.

Digital maps have a second distinct advantage over paper maps – they contain a lot of information over a large area and at a range of scales. So you can easily zoom in on an area and get very detailed information or zoom out and get the big picture over a very large area. A paper map only covers one area at one scale. Hence, many maps are required to cover a large area at a range of scales.

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1.2.2 Types of map images

Bitmap (raster) image

A 'painting' made up of a set of pixels in a grid. Can't scale up and down – each zoom layer needs a different set of pixels. Hence needs to store lots of data and zooming in and out is a little slow. Google Maps is currently bitmap based.

Vector image

A 'drawing' made from a set of points and lines. Can easily scale up and down – same data used for all scales. Hence doesn't need much data and zooming in and out is quick. Apple maps is vector based.

1.2.3 Map sources

- *Google earth and Google maps* **–** bitmap based, own data
- *Apple maps* **–** vector based, own data
- *OpenStreetMap* **–** vector based, open source (i.e. publicly available and free to all)
- *Microsoft Bing* – own data
- *TomTom* – own data
- *Garmin maps*
- *Magellan maps*
- *Many others*

1.3 Route planning

Digital mapping is a very useful tool for planning a route for a cycle ride or cycle tour. Having access to detailed map information over a large geographic area that you may not be familiar with is a big help in the initial planning of a route. Distances can be calculated easily and key features identified for inclusion.

Modern mapping software applications make the job of creating a route much easier. The software will choose the shortest route to your destination along known roads or tracks. If you want to change the route you can select 'waypoints' on an alternative route to force it to follow the way you want to go. See section 2.2 below for more details.

All routes use 'waypoints' to mark the path. These are intermediate navigation or decision points at key points such as intersections that define the route selected.

These planned routes are 'theoretical' since they are based on the information on roads and tracks etc. contained in the mapping software. An alternative approach is to use actual tracks previously recorded by portable GPS devices. There are some good websites with many recorded tracks from all over the world that can be downloaded and used as the route for a cycle ride or tour. See section 2.3 below for details.

CTA is developing a map library of routes and tracks from current and past rides for this purpose. See section 4 below for details.

1.4 Track recording

Portable GPS devices enable you to record the track you have ridden on a cycle ride or tour. This provides a wealth of information on the actual route taken, distances, times, travel speeds and elevation profiles. These data can be saved on the device for later reference and/or exported. See section 3 below for details.

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1.5 Managing digital maps

1.5.1 File types

- ***.gpx** – GPS eXchange format –'open source' (not proprietary) GPS format → used by OpenStreetMap and many others
- ***.kml and *. kmz** – Keyhole Markup Language format → used by Google Maps and Google Earth

1.5.2 Importing and exporting routes and tracks

Cycle routes or tracks can be exported from the device on which they were created or recorded to another device you may own, or to someone else you may want to share it with.

For instance a cycle route created on your desktop/laptop device can be exported and sent via email to yourself or another person. You can then open the cycle route file (in say *.gpx format) on your portable GPS device application via email. The route can then be used on your portable device to follow the direction of your cycle ride or tour.

Likewise a cycle track recorded on your portable device can be exported and sent via email to yourself or another person. You can then open and save the cycle track file on your desktop/laptop mapping application.

1.5.3 Storing and retrieving routes and tracks

Digital files of cycle routes created or tracks recorded can be stored on your desktop/laptop or portable device for later use. They can also be shared with others for their use. The CTA is creating a digital map library of CTA rides for members to be able to access, download and use (see section 4 below). There are also some good websites on the internet with large collections of cycle tracks contributed by individuals from many countries around the world (see section 2.3 below).

2. Desktop/laptop mapping

2.1 Route planning on a desktop or laptop

Planning a route is easier to do on a desktop or laptop computer mainly because of the larger display size (and even multiple displays) and the flexibility of a mouse or other pointing device. In planning a route we can either create our own from scratch or use an existing route.

2.2 Using software for creating routes

Sophisticated Geographical Information System (GIS) applications are outside the scope of this guide. We'll focus on some of the many websites and applications available for creating routes. Most are browser-based tools. These mainly use either Google Maps or OpenStreetMap data for their map base. The majority of these tools allow you to use our mouse pointer to set a start point and end point on the map to create a route along either roads or cycle paths. We'll use Ride with GPS as an example; it uses Google Maps data and Google search.

A process might be:

1. The majority of the tools require you to register to either use their route planning or save routes. In the case of Ride with GPS we need to register to plan a route. You simply register your email address and, after verifying you're who you say you are, you're ready to go

2. Choose the 'Plan' tab on the main page

3. You can jump to a Location, e.g. Murdoch Station or Rome. This uses Google search so you can go anywhere that Google knows about. Alternatively, you can use your mouse to locate a point on the map presented. Either way, you set a starting point for your route

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4. Set some options. For example, optimise for Walking, Cycling or Driving. You can either choose to Follow Roads or, if the roads aren't quite right, you can draw lines on the map

5. Using the same approach as previously you can navigate around the map to set an end point for the route

6. Ride with GPS will then calculate a route based upon your options. It will also generate a cuesheet describing the directions to take in following the route

7. You can modify the route by choosing a point on the route with your mouse and dragging it to your preferred route

8. You can also add control points (waypoints) along the route, add a Point Of Interest (POI), or add some details to the cuesheet

9. Once you're happy with the route you can save it (within Ride with GPS), give a description and make it either public or private

10. Once you've saved the route there are many options to get details on the route, save a map and/or profile of the route, and download it as a *.gpx or *.kml file

2.3   Software applications for producing routes

Most of the other browser-based tools have a similar process to produce a route. The following list has just some of the tools now available.

1. *Garmin Base Camp*

    http://www.garmin.com/en-US/shop/downloads/basecamp

    This is a freeware program provided by Garmin for interfacing with Garmin GPS units. There are Windows and Mac versions available. To be useful you need a Garmin GPS. Magellan have a similar program, Vantage Point, for their GPS units (http://www.magellangps.com/Store/VantagePoint_Software/VantagePoint)

2. *Google Maps & Google Earth*

    http://maps.google.com.au

    Google Maps is probably the most widespread and well-known browser-based map/navigation tool. As well as PC versions there are also tablet and smartphone versions. It has the power of the Google search engine for finding locations and directions. As well as just searching for a location in the search bar, there is a 'Get Directions' option to go from Point A to Point B to Point C, and so on. Among other options, you can choose a bicycle route although this is only in beta. These options will navigate your route along roads (cycle paths) rather than 'as the crow flies'. Using your mouse you can alter the route chosen.

    If you're register with Google+ then, once you've planned your route, you can save the route in 'My Places' and share it with others, export the route as a *.kml file or load it into Google Earth.

    Google Earth is a freeware program that provides a more globe-like view of the world. Within Google Earth you can also create or modify paths by specifying points, however, these are just coordinates rather than following a road or path. These routes can be saved as *.kml (or *.kmz) files.

3. *GPSies*

    http://www.gpsies.com

    GPSies.com is, in their words, the leading platform and community for GPS recorded tracks and is used by thousands of outdoor enthusiasts around the world. Its map base is a combination of MapQuest and OpenStreetMaps data.

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There is a Track Creator option that allows you to create a new route. You can also download the route in a whole range of filetypes. (By default, distances are in miles; this can be changed by an option to the right of the page).

4. *MapMyRide*

    http://www.mapmyride.com

    MapMyRide is another browser-based map/navigation tool but perhaps more attuned to cycle training. It can use either Google Maps, Open Street Maps or WorldTopo as it map base. Again, if you're registered you can save routes in *.gpx or *.kml format

5. *Ride with GPS*

    http://ridewithgps.com/

    Ride with GPS is one of the best browser-based map/navigation tools for cycle touring. The usage is similar to Google Maps and Google Earth but seems a little easier. There is good control on route drawing even when planning for off road. The base map data is based on Google Maps.

    If you've registered with Ride with GPS you can again save your map for either private or public use and Export it a number of formats (*.gpx, *.kml). The tool also shows elevation of the route and overall metrics

2.4   Websites and map libraries for selecting existing routes

Many of sites above have collections of local tracks from around the world to select routes; these include Google Maps, GPSies, MapMyRide and Ride with GPS. Some, such as Ride with GPS, require you to subscribe for a fee to access the full list of routes.

GPSies has a vast range of options to choose a route that fits your desired criteria – start point, distance, elevation, total climb, and so on.

3. Portable GPS devices

3.1   Devices

The last decade has seen a huge change in the availability of portable devices for navigation using GPS and other geographic location networks. We can divide these devices into two general categories.

3.1.1 Dedicated GPS devices

These are dedicated portable GPS receiving devices, such as Garmin and Magellan.

Advantages:

- Robust
- Weather proof
- Onboard maps (no need for internet link via cell network to access maps in the field)

Disadvantages:

- Cost of onboard maps
- Smaller screen size
- No direct access to internet

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Example device: Garmin 650T GPS

General

Robust, weatherproof, handlebar mountable, dedicated, multifunctional GPS designed for motorcycles, bicycles, vehicles, hiking, aircraft, and ships. It has SD card capabilities to store large amounts of mapping data on board so that a 3G connection is not required for any of its functions. The GPS comes with a topographical road map of Australia but maps for other zones (e.g. Europe) need to be purchased separately. It does not have WiFi and needs to be connected to a PC (Laptop or Netbook) to download and upload routing information, as well as to do file management. You can easily create routes on your bike whilst riding without a PC. These are automatically updated as and when you stray from the created route.

Combining Route Types

When in unknown areas (e.g. Europe), combining route types is very valuable as the Garmin permits you to have parallel Ride With GPS generated and GPSies generated *.gpx routes displayed on the GPS, so you can visualize both routes at the same time when riding. You can 'lock on' to one route and see the other at the same time. Switching between routes can be done easily using the GoTo Route Function

Example device: Magellan Cyclo 500 series

Full colour touch screen device with cycle computer and GPS functionality and the ability to save and share ride data. A standout feature of the Cyclo 500 series is localised Australian cycling maps. On top of Australian street map information, the Cyclo 500 series has bike map information from Bicycling Australia (Where to Ride series) as well as cycle route and cycling path data from governments, which will provide cyclists with better routes and mapping. With this cyclist friendly mapping, Magellan aim to open up their audience beyond performance orientated cyclists to also appeal to mountain bikers and recreational cyclists and touring cyclists who can benefit from having this relevant mapping and routing ability.

Additional features include WiFi Sync so that map data can be automatically uploaded at the touch of a button; the ride data can be automatically shared with preferred services.

3.1.2 Smartphones and tablets

Smartphones and tablets with GPS built-in receivers and mobile (cell) and/or WiFi access to the Internet have become available since about 2007, leading to an explosion in tools to enhance navigation and geographic positioning.

If you're choosing a device you need to note that not all smartphone and tablet models have GPS receivers.

The types of devices available can be broadly categorised by the operating system they run. This provides the basis for functionality offered and the suite of applications (Apps) available.

1. *iOS (Apple)* – Apple iPhone and iPad devices. This is a proprietary operating system. Apps are available from the Apple store

2. *Android (Google)* – This is a version of Linux and is open source allowing device manufacturers and others to freely modify it. Samsung uses Android as do many others. Apps are available from Google Play but there are other App sources

3. *Windows (Microsoft)* – Windows tablet, Nokia etc. Apps are available from the Windows store

Advantages

- Multipurpose usage
- Larger screen size (than dedicated GPS devices)
- Availability of many Apps

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- Free maps that can be downloaded and saved for offline use in the field without cell network connection
- Direct access to the Internet through WiFi or mobile (cell) network

Disadvantages

- Not robust,
- Limited battery life – may need additional battery packs
- Need a waterproof/protective case

Smartphone or tablet?

There are also choices to be made between smartphones and tablets. The advantage of a smartphone over a tablet is the wider availability of an Internet connection through the phone's mobile (cell) network. The advantage of a tablet is a larger screen size (although this could be seen as a disadvantage too) and possibly the advantage of more storage. The continuing development of both types of devices is minimising these relative differences. This can also be said of the relative differences between these devices and dedicated GPS devices.

Off-line maps

Off-line map capability is important when using smartphones or tablets. Internet access via mobile (cell) network or WiFi is often not available away from urban areas in Australia, or when travelling overseas. Hence, you cannot use mapping applications like Google Maps or Apple Maps on the go as they rely on internet access to get map data.

Fortunately there are now a number of applications for smartphones and tablets that allow you to download and store maps from the internet for free. The better applications (such as Pocket Earth for Apple devices) use vector based maps, which are quick to download and don't require a lot of storage space on your device's memory capacity. So, when you have mobile (cell) network or WiFi access, you download all the maps you need and store them on your device's memory. Then when you do not have cell network or WiFi access, you can still use your portable GPS device with full use of the off-line maps.

3.2   Using a portable device for cycle touring

The availability of a wide range of GPS navigation applications enhances the use of portable devices for cycle touring. Some of the advantages they offer include:

- See where you are and where you need to go
- Locating amenities and points of interest
- Simple route planning using the application
- Importing a route from a desktop computer or website map library
- Following a pre-set route as you ride
- Track recording – record where you went, stats about distances, elevations, speed, etc.
- Exporting a track recording to a desktop or map library

4. CTA electronic ride map library

The CTA is establishing an electronic ride map library on its website to assist committee members of the Association. Committee members can access rides from the map library to:

1. Provide future ride leaders with ideas and directions for rides to lead. Ride leaders can then forward the maps to participants who request GPS information
2. Print off a paper copy of a coming ride to follow the ride route

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3. Import cycle route file into a portable GPS device application to follow the ride route on the portable device

4. Import cycle route file into a desktop application for viewing or adapting to prepare a new/revised route

The CTA electronic ride map library process involves the following steps:

- Receiving ride routes/tracks – members send ride routes to CTA Webmaster, in *.gpx format

- Storing ride routes/tracks – CTA Webmaster currently creates PDF maps (new committee position of Map Coordinator required), *.gpx files and *.kml files for the track and stores these in CTA website map directory

- Accessing routes/tracks – committee members access and select ride routes from the CTA website map directory (future updates to website may allow member to have direct access to maps)

5. Personal approaches and applications

5.1   Gus – Android smartphone & tablet

" I have an Android tablet (Google Nexus 7 2012 version) with WiFi access. Utilising WiFi and the range of offline maps available I've been using my tablet mainly for tracking where I'm going. Battery usage is reasonable – it will last several days before requiring recharging. I have some PedalPower devices (totaling 7800mAh) for recharging our electronic devices from either the mains or a hub dynamo. The tablet fits neatly into the map case of my handlebar bag and still allows me to operate it's touchscreen.

My favourite App is GPS Essentials, available for both Android and Apple devices. It's easy to track your route with a nice graph of speed and elevation. Depending on what it has in its map storage (cache) it may or may not display your track on the map. You can also set waypoints to plan a route with voice navigation. I also have an App, AirDroid, for easy file transfer and management between the tablet and my desktop/laptop computers (it does require internet access).

I have used my tablet a little for checking a route but tend not to use it continuously as it's fairly draining on battery life – mainly because of using the screen full time.

Recently I've been looking at three GPS Navigation Apps for route planning. All three use OpenStreetMaps data so are inexpensive to use as the map data is public – and have similar data deficiencies. At this stage I'm still deciding which I prefer. The Apps are MapFactor Navigator, Navfree and OsmAnd. Hopefully soon I'll make up my mind :-)

5.2   Roy – Apple smartphone

" I have an Apple iPhone 4 with full GPS location finding capability. The iPhone is vulnerable to damage when cycling so I use a 'LifeProof' case to make it fully drop-proof, water-proof and dust-proof. I also have a 'LifeProof' cycle mounting bracket to attach my iPhone in its case to my bike handlebar stem. I can then follow a pre-set route when riding along. Under continuous GPS use the battery life is limited to 4–6 hours so I use a 'Mophie Juicepack Powerstation' 4,000 mAh battery pack to recharge the battery during riding. This can be recharged every day or so while touring when you have access to mains power. I also have a 'GoalZero Guide 10 Plus' battery pack powered by a 'Nomad 7' solar panel for recharging.

I use an excellent software application called 'Pocket Earth' to download and use off-line maps for a range of cycling and travelling purposes. The maps are available for anywhere in the world for free as they are based on the open source OpenStreetMap data. The application enables you to: create and save routes from one location to another via car, bicycle or walking; find addresses, public transport, restaurants, etc; save favorite points of interest (POI), addresses

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from my contact list, pins, routes and tracks. It also has useful Wikipedia information on countries, regions, cities and towns and POI. The application can import or export routes or tracks.

5.3 Keith – Garmin handheld

❝ I have a Garmin 650T mounted on my handlebars. I create numerous touring routes on Ride with GPS or Garmin Basecamp and also download routes by other riders on GPSies.com. These are all stored along with the on board maps in the Garmin GPS. While touring, I use these preloaded routes as a guide but often create temporary new routes to amenities (while riding) such as supermarkets, ATMS, hotels, campsites and tourist attractions etc., etc., as required. After visiting the amenities or camping etc., I enter 'Go To Route' which takes me back to the planned route to continue the ride. While touring, I travel with a Netbook for personal use and can use this in the evening for emails and downloading new routes that I have heard about during my travels etc. I use a PedalPower+ battery pack and hub dynamo so never need to plug the GPS in at night.

6. Supporting hardware

6.1 Bicycle mounting hardware for portable GPS devices

A company by the name of RAM Mounting Systems (http://www.ram-mount.com.au or http://www.rammount.com) produces an extensive range of very robust and lightweight hardware kits that are designed to mount dedicated GPS devices, smart phones, and other mobile devices onto bicycle and motorcycle handle bars. These kits typically consist of three separate parts:

- The handlebar attachment clamp.
- A device cradle specific to each type of GPS
- A riser (or arm) connecting the cradle to the handlebar clamp.

6.2 External GPS power supplies

Due to battery storage restrictions, most navigation devices cannot supply enough power to remain continuously active for 5 to 6 hours per day, even if the manufacturers' literature states that it can. This is because there are no standardized methods of rating the battery life for these devices so the manufacturers' ratings assume that the device is not fully utilized during the 'rated' time period So, if an extensive tour in an unfamiliar country is planned and you need your GPS or other mobile device on for a long and continuous period, an external battery pack is necessary.

6.2.1 Battery packs

A Battery Pack connected to the Hub Dynamo can store energy whenever the cycle is moving regardless of whether the GPS is connected or being used. The capacity recommended for touring would be around 6000 mAh. Battery Pack voltage should be nominally 5VDC which is the standard USB voltage. Battery Packs large enough to power mobile phones, radios and GPSs probably need to be located in the front handlebar bag. Some of the more popular battery packs for portable devices are:

- PedalPower+ V4i – available separately or in a 'kit' complete with all cables and connectors required from PedalPower+ (http://www.pedalpower.com.au/). This Battery Pack is sufficient for long distance touring if it remains connected to the hub dynamo at all times
- Anker Astro Series – up to 10,000 mAh
- Mophie Juice Pack Powerstations – up to 6,000 mAh
- New Trent iCarrier/iGeek – up to 12,000 mAh

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6.2.2 Hub dynamos

These usually come preinstalled on Touring Bikes but can be easily fitted to the front wheel of any bicycle. The front wheel will need to be re-spoked to fit the new hub. Care must be taken to ensure the hub is matched to wheel diameter to ensure proper voltage output. This information should be available from the hub supplier. Dynamo Hubs can also be purchased from PedalPower+ and can be matched to the wheel size and the above Battery Pack 'kit'. Most Dynamo Hubs nowadays come with an internal rectifier to convert the AC coming from the Dynamo to 5VDC to charge the battery.

6.2.3 Solar panels

Compact rugged solar panels suitable for hiking and cycle touring are now starting to come on the market. The 'GoalZero' 'Nomad 7' solar panel (30 cm by 20 cm when opened out) can maintain a portable device in operation or it can recharge their 'Guide10Plus' battery pack over about 4 hours of good sunlight.

Unfortunately, at this time smaller solar panels than this do not provide sufficient power to maintain a GPS in continuing operation.

6.3 Cables and connectors

6.3.1 Cables.

- *Hub to Battery Cable.* A specific type of cable with inbuilt filters is required to connect the Dynamo Hub to the Battery Pack as the Hub may produce electrical noise which can damage electronics. This special cable should come complete with necessary connectors for the Battery Pack and the Dynamo Hub. Some Hubs have inbuilt filters as well but it is still best to be safe and have a filter in the cable as well. You can't be too careful when dealing with electrical noise spikes and expensive electronic equipment. For this reason it is best to purchase this special cable from the Battery Pack supplier.

- *Battery to GPS or Mobile Device Cables.* For connecting devices, such as GPS and Telephones etc., to the Battery you can use standard, off-the-shelf UBS, Mini USB and Micro USB cables with ends to suit the devices you are connecting.

6.3.2 Connections.

- *Cable Ends.* One important aspect of cabling is to ensure that when cables connect to ANY equipment on your bike the connectors at the end of the cable should be 'L' shaped (or '90 deg right angle' type). The cable can then be strapped to side of the device which it is being attached to with an elastic band, Velcro strap, or similar. If this is not done and a 'straight' connector is used, the constant vibration combined with the leverage inherent with a long, straight connector will eventually damage the connector and the 'female' input connection on the device leading to a costly repair job. These 'L' shaped USB cables are available from PedalPower+ or from Chinese suppliers on the internet and are very inexpensive.

- *Dynamo Hub Splitters.* In order for the Dynamo Hub to provide power to both the bike light and the battery pack, you will need a spade lug splitter which fits onto your Dynamo Hub output terminals and allows two cables to be connected in an 'y' configuration. These are also available at PedalPower+ and very inexpensive. It would be a good idea to travel with a few spare hub splitters because, if you have problems with the hub connection due to an accident, any technician can repair the connection as long as you have the splitters with you.

- *Adaptors.* It is always a good idea to carry various connection adaptors with you when touring. These can save your bacon if you need to mix and match different cables to various equipment due to failures or new equipment purchased etc. They weigh nothing, are very small, and come as part of the PedalPower+ standard 'kit'.