

Navigate different.

GPS navigation in a Jeep Wrangler using an Apple Powerbook.



Introduction to GPS

The NAVSTAR Global Positioning System (GPS), operated by the United States Government is accessible to civilian users all over the world. It was originally designed jointly by the US Navy and the US Air Force.

A small receiver (on a ship, aircraft, vehicle or hand held) uses data from orbiting satellites to display to the user their location to within a few metres. The user's location is calculated by triangulating the measured range to each of several satellites.

Four very accurate atomic clocks in each satellite provide the exact time that the satellite signal is transmitted. The user's receiver takes the coded time data from a satellite, identifies that satellite, and then generates a replica code. The amount by which the replica code must be shifted by the receiver to match the satellite timing data, multiplied by the speed of light, is the range to each satellite (this is a gross oversimplification).

The space segment of the system consists of 24 satellites that orbit the earth every 12 hours. The satellites follow circular orbits at an altitude of 20,200 km and are moving at 3.87 km/second. The entire group of satellites is referred to as a constellation.

The satellite orbits repeat almost the same ground track once each day. There are six orbital planes (with four satellites in each), equally spaced, and inclined at about fifty-five degrees in relation to the earth's equatorial plane. The GPS constellation provides the user with between five and eight satellites visible from any point on the earth.

The satellites were built by Rockwell International - the first were launched in 1978 and the last in 1985. The Master Ground Control Station for the GPS is located at Schriever Air Force Base in Colorado.

This Project

The aim of this project was to assemble an Apple Powerbook-based navigation system which can locate and display onto a moving digital map, in real time, the location of my Jeep Wrangler anywhere in Australia, in any weather, day or night using GPS. The most time consuming part of this project was making the custom mount for the Powerbook. The ideal mount needed to:

- Be strong enough for off-road use.
- Be visible to both driver and front passenger.
- Be easy to remove from the vehicle.
- Allow normal access to driving controls.

Components

- Jeep Wrangler (1997 TJ). Any colour will work. <http://www.jeepunpaved.com>
- Apple Powerbook (1999 model - aka Lombard/bronze). <http://www.apple.com>
- 12/24 volt automotive power adapter for same.
- Garmin GPS receiver (CX12). <http://www.garmin.com>
- Garmin GA27 external antenna (PN 010-10052-00).
- Garmin data/power cable (PN 010-10165-00).
- Garmin swivel mount (PN 010-10048-00).
- Keyspan PDA serial adapter cable (PN USA-19). <http://www.keyspan.com>
- Custom removable mount for the Powerbook (this is the tricky part).
- GPSy Pro moving map software (this is Mac only software).
- Scanned map files (in this case 1:100K and 1:250K topographic).

Apart from the custom mount, everything I used for this project is available 'off the shelf'.



This is how it looks from the rear seat.

Hardware

My Wrangler has an automatic transmission and a centre console with a lockable storage bin, so attaching the fixed base for the removable support arm was going to be challenging.

I fabricated a plate from 2mm stainless steel which bolts to the top front edge of the storage bin. This allows the lid to close and does not restrict access to the storage bin. A stainless steel tube was welded to the underside of the plate to provide a third point to bolt the fixed base. I drilled a hole through the top plate, aligned with the centre of the tube, matching the size of the pin at the base of the removable support arm (1/2 inch dia. or @12mm). There are 2 moulded openings in the console in front of the storage bin to hold drink containers. The rear one is useful to carry the 12/24volt power adapter for the Powerbook and the forward one is still available to hold a can or bottle of drink.

I recycled a heavy duty desk lamp as the basis for the support. After removing the lamp I cut down the length of the arms to fit comfortably between the base on the console and the dash. I added a locating pin, made from 6mm stainless steel (can you tell I like stainless steel?) to the lower half of the arm which prevents the support arm from rotating. This enables the arm to be removed quickly by lifting it directly upwards.

As a mounting plate for under the base of the Powerbook I used 3mm aluminium sheet, (cut to 260mm x 300mm with a 10mm radius on the corners). Two 3mm countersunk bolts hold this to the top of the arm. There is a lockable hinge in the centre of the arm which allows adjustment of the angle of the upper half of the arm and base plate.

To hold the Powerbook onto the base plate I used Velcro. There are 8 self adhesive loop buttons on the bottom of the powerbook and matching hook pieces on the base plate. I had originally planned something far more complicated to clamp the Powerbook to the plate but opted for the very simple velcro solution because it was easy and seems to work perfectly. It only takes a few seconds to unplug the USB and power cables to remove the Powerbook from the mounting plate.

The only way it could fall out is if the vehicle is upside down (always a slight possibility in a Jeep but the least of my concerns). I also drilled an extra hole in the fixed base to allow the locating pin (and therefore the whole mounting arm, base plate and powerbook) to be rotated about 15 degrees to the left. This position can only be used when there is no passenger but it allows full access to the heater/air conditioner controls and centre outlets as well as the radio/cassette player.

GPS Receiver

My GPS receiver is a Garmin CX12. This is an excellent 12 channel receiver with a colour LCD display (backlit) which can store 1000 waypoints. The Garmin CX12 is clipped into the Garmin swivel mount which is in turn screwed to the right hand side of the transmission hump just under the bottom edge of the dash.

I made a stainless steel tube with the bottom end cut at the same angle as the floor beside the transmission to fill the gap under the outboard side of the swivel mount. A long self-tapping screw fits through the tube and into the floor. I used a sharp prick punch to make the holes in the floor for the mounting screws. Hint: never drill through carpet as the drill bit will snag the carpet and tear it.

The Garmin mount feeds both power and data into the back of the receiver via one plug fixed in the Garmin swivel mount. The Garmin receiver is easy to reach in a right hand drive Jeep. In a left hand drive it would probably need to be located so as not to interfere with access to the transfer case shifter.

Antenna

For the best reception I fitted a Garmin GA27 remote antenna onto the engine hood. The GA27 antenna is a small black lump and is fairly unobtrusive. This antenna provides good satellite signal strength, even in valleys with steep sides (or in cities with tall buildings).

I drilled 2 small holes through the hood for the mounting screws and one for the cable. I made a 2.5mm thick rubber gasket the same shape as the antenna and fitted longer screws than those supplied to allow for the thickness of the gasket, the hood sheet metal and the washers I used. I also used black silicone sealant to make sure it was weather proof.

The underside of a Wrangler hood is fitted with insulation. To hide and protect the cable I placed it between the insulation and hood sheet metal, leading it out at the back edge and down to a hole in the firewall, The antenna cable is 2.4m long, easily reaching from the engine compartment, through the firewall and up to the GPS receiver. I placed the cable inside split plastic shielding so it cannot be damaged easily.

Cables

To connect the GPS receiver to the Powerbook is simple, by using Garmin's data/power cable (PN 010-10165-00) and Keyspan's PDA adapter (PN USA19). One end of the Garmin cable plugs into the back of the CX12 and the other end has an RS-232 female DB9 plug.

The Keyspan PDA adapter plugs into the serial plug and has a USB plug at the other end to plug into one of the Powerbooks USB ports. Keyspan's free USB Serial Assistant 2.1 software seems to work perfectly with MacOS 9.0.4. Keyspan make several adapters to connect USB Macs to serial devices (PC's as well).

Software

The moving map software I selected is GPSy Pro. It costs \$149 US and works with nearly any data output capable GPS receiver. It displays current location, speed, heading, navigation data and satellite visibility. It allows the calibration of any scanned map or raster image at any scale (even distorted maps). Up to ten points can be used for very accurate calibration of maps in a large range of common file formats including PICT/GIF/JPEG.

Once the GPS receiver is turned on and has acquired a 3-D fix, the GPSy Pro application can be launched and a calibrated map file opened. I have aliases of my calibration files in a folder in the Powerbooks Apple menu. The calibration files point to the actual map files. Serial communication is turned on from GPSy Pro's preferences control panel. Select 'locate repeat' from the GPS Link menu and your position is instantly displayed, overlaid onto the map you have selected. I have mine set to update once per second.

The software displays the users location in any of 125 defined datums using a range of coordinate systems. GPSyPro can also upload and download waypoints from compatible Garmin, Lowrance/Eagle and Magellan GPS receivers. The 89 page user manual (supplied as an Adobe Acrobat PDF document) is well written and comprehensive. See the GPSy site for more information on this excellent software.

The maps I have used so far are 1:250,000 scale topographic, colour raster images from AUSLIG (Australian Surveying and Land Information Group) and are available on CD-ROM. I am using Disk 1 which covers Tasmania, Victoria and New South Wales. I believe 1:100,000 and 1:25,000 scale maps are planned for release by AUSLIG on CD-ROM in the near future. Meanwhile I have scanned my own 1:100,000 scale paper maps. It takes a few minutes to calibrate a scanned map once you know the co-ordinates of some known points on the map.

The software displays the ground track of the Jeep (in a range of user selectable widths and colours) in real time as I drive. Waypoints can also be displayed in a range of colours and sizes.

With this system the Jeep can be in a featureless region at night, in fog or rain, and correctly display the Jeep's location, where it has been and where to go to reach its destination.

Variations

This system would work with any Powerbook (or PC laptop with suitable software) with sufficient RAM and an active matrix display. I experimented with an old 5300cs Powerbook but the passive display is not bright enough for daylight use.

GPSy Pro 1.16 uses a minimum of about 6.2MB of RAM with virtual memory turned on. A Powerbook with 64MB of RAM would be quite adequate. It will run on any Mac CPU from a 68020 up to a G4. A Powerbook with a G3 CPU (Wall Street, Lombard, Pismo, iBook) is ideal, as large map files can be opened by GPSy Pro quickly. For example on my 333MHz G3 Powerbook an AUSLIG 1:250,000 map saved as an 8MB tiff loads in about 4 seconds.

If your Powerbook is pre USB, an adapter cable to connect the Garmin serial cable to a standard Apple mini DIN serial port is available from GPSy. It is also available bundled with the GPSy Pro software at a discounted price. GPSy also have a basic version of the software but this only uses three calibration points on maps and is not really accurate enough for use with large scale or distorted maps.

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If you have any questions about this project contact Ian Cossor at ijcossor@hotkey.net.au
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