Field Techniques Manual:
GIS, GPS and Remote Sensing

- Section C: Techniques

Chapter 11: Using GPS for Fieldwork

11 Using GPS for Fieldwork

11.1 GPS applications

The NAVSTAR system has great potential for high-resolution surveying. The way the expedition uses the system will need to be decided before leaving for the field. This decision will involve weighing the need for accuracy against the cost and encumbrance of a very accurate system. Though there is often a perception that only the highest accuracy possible should be considered, there are strong arguments for using cheaper, quicker and less accurate systems. The basic types of GPS available include: standard sets, standard sets with WAAS augmentation, differential and carrier wave differential. The cost increases for each of these technologies but the benefit to the expedition may be slight. When used correctly a standard waypoint fix is often enough for most types of fieldwork. The accuracy required can be determined by the type of project and the quality of the data it is to be referenced with.

The first decision to be made is whether the GPS reading is simply to locate the object of study so that it can be re-found by another expedition or whether the recorded point is scientifically important. If the reading is simply to guide a team back to a location, then a single GPS reading will normally suffice. If the reading is significant then the accuracy is usually determined by the accuracy of the data it is to be related to. Taking a differential reading at 1 m accuracy to compare to a Landsat scene at 30 m accuracy is not a valid scientific exercise. In this case a standard GPS reading is sufficient; this is shown in *Figure 11-3*. Similarly, if the GPS is being used in conjunction with a map then standard GPS readings are valid down to 1:10,000 scale. Only maps of 1:5,000 require any form of averaging or WAAS and maps of 1:2,500 require differential readings. Mapping to a higher precision than 1:5,000 is rare and the area covered would be small. Most expeditions cover larger areas at 1:25,000 to 1:100,000.

11.1.1 Types of fieldwork & surveying using GPS

The nature of an expedition's data will dictate the accuracy required. The information contained in Chapter 6 should help you achieve these results. In most cases the observations the expedition makes as part of the standard field work will take more than a few minutes. This gives time to collect ample GPS data for averaging. However, averaging is always better performed by hand not using the averaging features of the set which are notoriously poor. Achieving GPS accuracy should not be pursued to the cost of the expedition's field measurements. The field measurements should always be paramount and GPS accuracy should only be pursued if the situation dictates it.

Environmental change analysis: Measuring changes in the physical conditions of the ground often requires very detailed analysis. For these surveys, averaging, WAAS or even differential measurements are required. Averaging is a good method because it does not require the use of cumbersome equipment, especially when mapping in difficult terrain but it takes much longer. If time in the field costs a lot of money then hiring differential equipment may offset this. There are often political sensitivities to consider when using high resolution mapping equipment in some countries.

Geological mapping: To record the location of lithological units for future reference it is only necessary to record a location to standard waypoint accuracy. From this data the outcrop could be easily found. For recording individual rock units in a GIS the standard GPS accuracy is generally slightly too coarse and the time required for averaging makes this unsuitable. There may be many units at one location. For detailed work of this nature it is best to use a combination of GPS and traditional surveying techniques. The resolution required will be closely linked to the resolution of the accompanying data in the GIS. If a Landsat or ASTER scene is being used in combination with the collected data, then accurate marking of units may not be necessary, as they will not be shown on the image.

Habitat mapping: Mapping the habitat of animals or the location of observed animals is only usually necessary to the accuracy of standard GPS waypoints. The location of an animal in the field rarely needs to be more accurate than tens of metres because by their very nature they are mobile. For boundary mapping where a vehicle is used then an external antenna and a standard GPS is the best solution. Using a GPS in a vehicle without an external aerial is not ideal even when the receiver has a reasonable lock through the windscreen, because its view of the sky will be severely restricted. Some units do not have external antennas such as the Geko and ETREX range from Garmin. Care must be taken to read the specification of GPS units before selecting one. This research should not rely on the schematics in this manual that serve only as a basic guide. Check with the manufacturer's websites listed in Appendix 4.

Image rectification: Digital images often need to be given co-ordinates. This can be achieved from a map, by referencing common points or can be achieved in the field using GPS. The accuracy of the rectification will be affected by the accuracy of the data collected and commonly high precision data is required. However, the maximum rectification possible in imagery is related to the pixel size. For data sets such as Landsat TM and Landsat ETM+ multispectral, a good quality single waypoint will be sufficient. For more accurate data such as Landsat Pan or SPOT then averaging or WAAS might be more appropriate. For high-resolution satellite data, such as KVR, CORONA, or the new high-resolution IKONOS or Quickbird sensors, differential or carrier wave may be a consideration. These choices depend on the confidence that can be given to finding similar objects in the field as on the images. Where confidence in the control points is low there is no benefit in high precision or expensive data collection. This process is discussed in detail in Chapter 9 and outlined below in Section 11.6.

Detailed Boundary Mapping: Mapping political boundaries is often not substantially more accurate than a standard GPS fix. Small areas will on occasion require a more precise fix but this depends on the type of work conducted. For wildlife habitats it can be useful to know locations of reserves accurately but if the boundary is large, then averaging is not viable because of the length of time required to get a statistically meaningful fix. WAAS may help in these circumstances or differential GPS techniques. Modern surveying often requires high-resolution data and so are best suited to differential GPS work.

11.2 GPS care & power requirements

GPS receivers are generally robust pieces of equipment but the difficulty in repairing or replacing them in field locations means care must be exercised. GPS sets commonly work between –15°C and +70°C. This is as much a product of the operating conditions of liquid crystal used in the display as the operating conditions of the machinery. Battery life in these lower conditions can be lower but the GPS should function without ill effect. Below –20°C liquid crystal stops functioning and the display on the GPS may become irreparably damaged if held at this temperature for long periods of time. Specially designed GPS receivers equipped to function below these temperatures can be bought; examples include models from Silva that can extend the working to temperature to –25°C but much below this GPS receivers are of limited use. While working outdoors the GPS screen is prone to damage and plastic faced holders can be purchased to protect the receiver screen. These wallets can also give some protection to the receiver from poor weather conditions. Many GPS sets are splash proof but only newer models conform to waterproof standards (see Chapter 13). Modern sets are waterproof to 1 m for 30 minutes. Many of the newer Magellan models are waterproof and are designed to float.

Power requirements are discussed in depth in Section 13.6. However, it is touched on here for reader convenience. Most GPS receivers are powered by 1.5 volt AA batteries though Garmin Gekos use AAA batteries. Modern sets require two batteries though some older sets require four or even six. GPS receivers can be run in one of two modes, standard (continuous positional updates) and battery save (updates position once a second). For expedition use battery save mode is ideal and will yield around two days of field time per set of batteries. Generally standard rechargeables are not well suited for GPS units because of their voltage fall off and their lower overall voltage. Battery life might be less than a day with these sets, however, modern NiMh rechargeables with over 2000 mAh charges might last over three days.

11.3 Using GPS in non-ideal conditions

Section 6.9 describes the standard methods for improving GPS accuracy. These include WAAS, differential and averaging. This section looks at how the selected GPS should be used in the field to better ensure the chosen unit functions adequately. GPS receivers need clear views of the sky to operate. If placed in a pocket close to the body their view of the sky is impeded and the data collected will be of poorer quality. Care is also needed when using GPS in forested areas where canopy cover can disrupt the signal. These problems can be circumvented to some extent by using an external antenna. Many GPS receivers can take an external antenna via a small input socket on the rear or side of the unit. The external antenna can be attached to the receiver and extended to give a better view of the sky. Before selecting a GPS it is vital to decide if this is important for your expedition. Some popular models do not support external antennas. Units such as the Garmin ETREX range do not support this functionality. One use of an external antenna is to get the antenna off the ground and thus give it a clearer view of the sky by attaching it to a pole. If an expedition is planning to use a receiver under tree cover then getting the aerial just a few metres off the ground helps the signal enormously and cuts down on reflected signals from the forest floor. An aerial held up into the canopy or simply mounted on a backpack so signals are not obscured by an expedition member's body will benefit signal acquisition. One expedition-proven solution is to (1) place a bottle top (or other small metal object) on your head; (2) put on a baseball cap; and (3) put the magnetic antenna on top of the cap – it stays firmly in position, providing a low-cost, mobile mast. Another advantage of this system is that you can pocket the GPS while walking between sites, without losing a signal. For an example of how GPS was used in African rainforest see Dominy and

Duncan (2001). Signal reception is also a concern in vehicles, as GPS signals cannot travel though a metal body. To use a GPS receiver in a vehicle also requires an external antenna. If you are using GPS mostly in a vehicle, make sure you have an antenna-compatible model (e.g. Garmin 12XL or GPS 76 not an ETREX). More details on the use of vehicles in expedition work can be found in Sheppard 1998.

GPS receivers offer global coverage but the accuracy of NAVSTAR is greatly reduced at the poles. For northern polar expeditions, the GLONASS satellites may be a more viable alternative. GLONASS satellites orbit at up to 65° north/south, and give better polar coverage than NAVSTAR. Take care when switching between systems, as (1) most receivers are not dual constellation compatible, and (2) GLONASS operates in the PZ 90 datum, rather than WGS84. If this is not an option, NAVSTAR systems work at polar latitudes but their time to acquire and dilute will be greater.

11.4 Integrating GPS readings and historical maps

All NAVSTAR GPS work internally according to the WGS84 ellipsoid and datum. Because the expedition will no doubt visit areas with existing maps, these settings will need to be changed so that the data shown on the GPS screen is compatible with the map. Modern GPS support an increasing number of projections and datums but invariably at some stage the team will come across an unsupported map. In these circumstances the user can input a user defined datum into the GPS.

To transform the WGS84 co-ordinates to a custom set of parameters the GPS needs to know at least 5 pieces of information. These are the difference between the radius of the WGS84 and the custom ellipsoid (da), the amount by which the ellipsoid is flattened (df) and a three dimensional co-ordinate for referencing the ellipsoids together (dx,dy,dz). Usually df will be a very small number, typically < 0.00005. Therefore some GPS units will require reciprocal flattening. For example, if the expedition was working in SE Asia using a GPS in conjunction with maps using an Indian datum such as Indian Vietnam 1960 on the Everest 1830 datum then the GPS may not have all the necessary parameters in its database. In this case it is comparatively simple to research the required parameters and input them. A search on Google for example will invariably point you in the correct direction. An example of how the WGS84 readings can be converted for a SE Asia expedition by the GPS is shown below in Figure 11-1.

The Everest 1830 ellipsoid has a radius of 6,377,276.345 m against the WGS84 measurement of 6,378,137 m. The difference between the two is 860.65 metres so this is the da reading. The flattening of the Everest model is a factor of 0.003324449297 compared to the WGS84 figure of 0.003352810665. This gives a difference of 0.000028. Because this is such a small figure sometimes df is calculated as 1f-1/f (300.8107 - 298.2572 = 2.5445). The Cartesian co-ordinates dx, dy and dz are fixed figures and for referencing WGS84 and Indian Vietnam 1960 are 198, 881 and 317 respectively. To input these into the GPS consult your manual, navigate to the settings page and select the option for projections. Enter them as shown below. Once this has been done all the GPS readings will match up with your map. As mentioned in Chapter 6, the GPS is not perfect at its calculations and when working outside of WGS84, it can add another 5 m to the inherent errors.

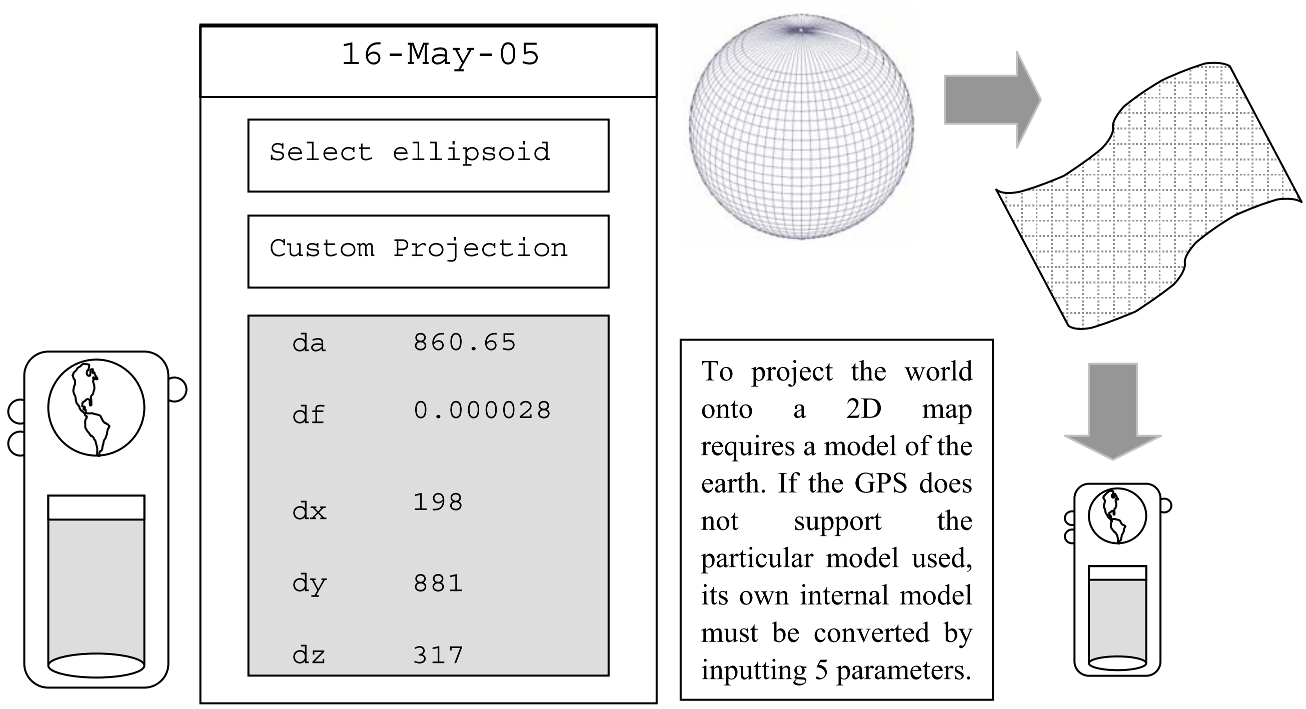

Figure 11-1: Inputting user datums into a GPS.

The five parameters above may not fully describe the map projection. Ideally the GPS also requires a meridian or origin (central meridian), a scale factor and information about any false northings or eastings.

11.5 Integrating GPS and other GISci data

GPS data is often useful for navigation purposes but often it will need to be stored and referenced later. If these data are stored in the GPS memory, it will often need to be accessed or downloaded to a computer. Most GPS receivers come with a cable interface to connect between a computer and the receiver, but the cable is often an additional product and can be quite expensive. Some of the more expensive GPS receivers come with free cables making them a more economical solution. It is very important that the cables are compatible with the hardware the expedition is using in the field. Most GPS receivers use a unique connector that plugs into a serial (9 pin male RS232 port) on the computer. It is important to check that the computer has a relevant port because many new PCs and laptops are only shipping with USB connectors. A USB to GPS cable can be purchased in some cases but this is rarely free with a receiver. A serial to USB converter can be obtained but these often need drivers to emulate a virtual COM port. These cables cost between £6 and £25 GBP depending on length and whether a driver is supplied. An example of this type of converter is shown below in Figure 11-2. Converters can be obtained to change 9 pin serial into 25 pin serial, which at first glance appear to be compatible with a parallel port. Parallel ports are faster connectors used commonly with printers and are available on most PCs. The converter cannot change the serial signal into a parallel one so these do not usually work. It is vitally important to check that all equipment communicates successfully before leaving for the field. There is also an advantage in keeping expedition kit as similar as possible between all members. This is especially true of GPS where manufacturers use different proprietary connectors on the back of all units. If a cable is lost or damaged and the expedition kit is similar between all members then another member's cable can be substituted in to continue downloading and using a receiver. In addition, with the complexity in setting up a receiver, there is a time benefit in not having to learn each receiver's start-up process. When using a more exotic form of GPS receiver it is vitally important to apply stringent tests with all field equipment. Units that communicate via Blue Tooth do not always send their data stream out in a standard NMEA 4800 bps signal. Units such as the AnyComm GPS 600 shown in Chapter 6 are ideal for expedition work in that they are field hardened, but communicate using 38,400 bps. Some software will not cope with this form of data possibly rendering the equipment useless to the expedition.

Figure 11-2 Serial - RS232 9 pin male to USB converter. The RS23 serial connector is shown on the left and the USB connector is shown on the right. The RS232 connector receives the female GPS connector and transfers the data through the USB port of the PC.

Software is also not included and this is an additional purchase. Several shareware or freeware products exist to download the data into a PC and these are discussed in detail in Chapter 14. When a GPS outputs its data to a PC, usually as an ASCII text file, it can be imported into a spreadsheet or database file. This data can then be input into a GIS for spatial analysis. The data held in the spreadsheet or database is usually in a series of columns consisting of latitude, longitude, elevation and additional information. What data the GPS makes available for downloading is not a constant across all units and models. Many units do not download elevation data for tracklogs and this can seriously compromise an expedition that requires this data. Most modern receivers will download elevation for way points but only X and Y can be taken for granted. The type of data output from the unit can be vital to an expedition so it is important to check the output strings with the manufacturer before purchasing the unit. A good tool for downloading data is GPS Utility. This can export the data as *.dbf or as Arc Shape Files that can be uploaded very quickly into a GIS.

Once the data has been output from the unit it can be overlain onto other data in the GIS. Though this is a comparatively simple task and usually quite accurate, understanding the exact relationship between GPS data with other data stored in the GIS is more complex. The GIS system used for collating the field data can be configured to be as accurate as the co-ordinate system used (i.e. metres for UTM, decimal degrees for latitude and longitude etc.). However, the correlation of data within this system will not always be of this accuracy as shown in Figure 11-3 and described in the text below.

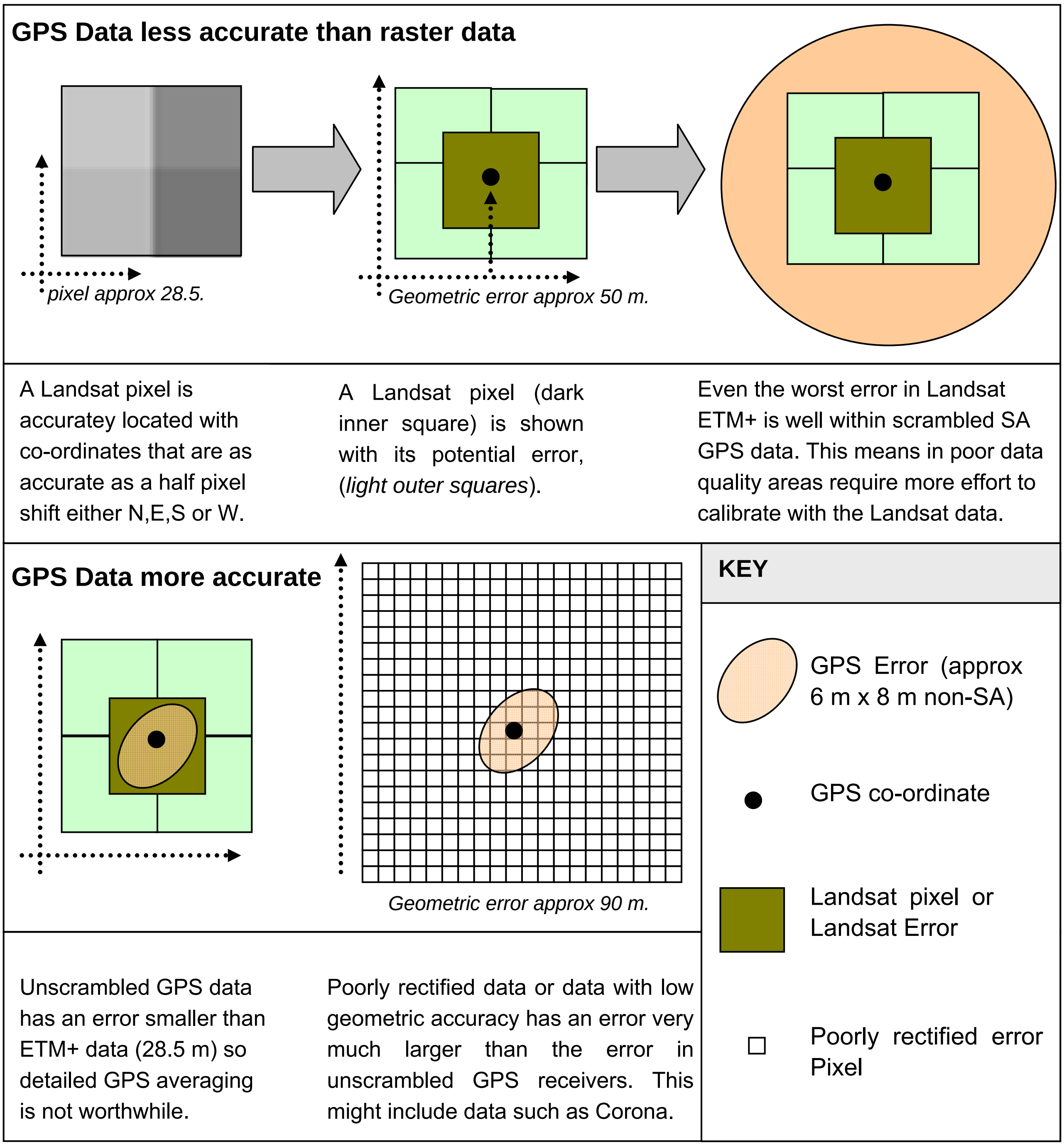

Figure 11-3 Approximate error ellipses when correlating data in a GIS (shown to scale).

The GPS data will have an inherent error, and the digital data (maps or images) will also have an error. The error in placing a location on an image is determined by the geometric accuracy of the data. This is a measure of the difference between the co-ordinate given to a point on an image and its actual co-ordinate location. Modern digital images generally have a very high geometric accuracy with only small amounts of shift. Landsat ETM+ imagery has a geometric accuracy better than 50 m, commonly quoted to be about one pixel (Landsat website). The Landsat ETM+ data is commonly supplied georeferenced with corner co-ordinates given in a separate text header file. The high quality geometric accuracy of modern digital images means the errors in overlaying the GPS points are controlled mainly by the error of the GPS technology used. When Selective Availability was an issue, this error would have been of the order of 100 m, considerably larger than the error in the projected Landsat data. The disabling of this scrambling has increased the accuracy by an order of magnitude. Current accuracy when using 12 channel sets is of the order of one pixel (10-15 m) in Landsat ETM+ panchromatic and is similar to the inherent error in Landsat data. For older data such as analogue data that has been scanned into a computer, the error is controlled by the quality of rectification. In the Bogda Shan study the CORONA data has an error of ± 90 m. This was compounded by the 15 m accuracy of the GPS sets giving an overall error of over 200 m.

In the top two images in Figure 11-3, the dark green central square represents the Landsat pixel. This pixel has a geometric error meaning it could be shifted to any of the light green outer pixels. When using scrambled GPS data the Landsat error is less important than the GPS error. When using unscrambled data (any GPS reading after May 2000) the Landsat error is more important than the GPS error. This has a bearing when selecting the type of GPS to use in the field (i.e. standard, WAAS or differential). Even high resolution data, such as the Corona, shown in the bottom left, which apparently looks like very high resolution, quite often has an error much larger than the GPS error, meaning standard sets are still compatible with high resolution data.

During the Bogda Shan Expedition (see Section 17.1), which used receivers after the end of SA scrambling, the correlation of the point and image data was most significantly affected by the inherent image error with Landsat, or the limits of rectification with Corona. The maximum offset for a series of points measured in the field was measured in metres and found to be a function of GPS error and image error. The GPS error is calculated as the sum of atmospheric and local effects as discussed in Chapter 6. This error is referred to as dilution of precision or DOP.

$$\text{Correlation Error} = \frac{\text{GPS DOP} = (\text{Atmospheric} + \text{Local Effects})}{2} + \frac{\text{Image Error}}{2}$$

This error describes the error when plotting a point onto the image. It does not take into account the error of locating an object in the image and giving this a location. When trying to overlay data about a specific point in an image, the spatial resolution of the image must be taken into account. For example, the Bogda Shan Expedition tried to map the movement of the front of a glacier over a 40 year period using various datasets. The Expedition recorded co-ordinates for the front of the glacier and tried to calculate the movement based on the co-ordinates of the GPS against the image. Because the pixel size of the image dictates the accuracy, this can be combined with the error in correlating the two datasets. The overall error is given by:

$$\text{Correlation Error} = \frac{\text{GPS DOP} = (\text{Atmospheric} + \text{Local Effects})}{2} + \frac{\text{Image Error}}{2} + \frac{\text{Image IFOV}}{2}$$

For GPS to Landsat that might mean a correlation error of:

$$\text{Correlation Error} = \frac{15}{2} + \frac{50}{2} + \frac{28}{2} = 7.5 + 25 + 14 = 46.5$$

This means an approximate error of 45 m was introduced when correlating the data. Any GPS reading of an object on the Landsat image would have a 45 m error so for the Bogda Shan Expedition the glacier would have had an error of ± 22.5 m for the Landsat data. The Corona data was substantially worse because the image error was so much higher. Although the spatial resolution of Corona is so much better, the actual measurements taken are significantly worse due to the poor control on rectification. The accuracy of the data in Corona would have been of the order of ± 60-100 m depending on the rectification process. This is described in the following section.

11.6 GPS receivers for creating expedition maps

Digital images can be used as accurate and useful expedition maps. In some instances, the purpose of an expedition might be to create a map. GPS are excellent tools for either making maps on their own or making maps in conjunction with digital images. When used on their own GPS receivers can be used to map out linear features using their tracklogs to a very high degree of accuracy ~1:10,000. This might be useful when visiting an area whose road network is poorly mapped or not known. Using the GPS while doing a day's reconnaissance would give a quick and accurate map of the road networks.

Figure 11-4 The use of vehicles in rapid reconnaissance and map making. When first arriving in the field a vehicle can be used to quickly assess the area and produce a rough basemap.

If the aim of the expedition is to create small maps and use them in the GPS then it may be in the team's interest to acquire a GPS with a larger screen and better resolution than some of the smaller units. If maps, such as the one shown in Figure 11-5, are used in the GPS, then a unit such as the GPS76 from Garmin may be preferable to a unit such as an ETREX.

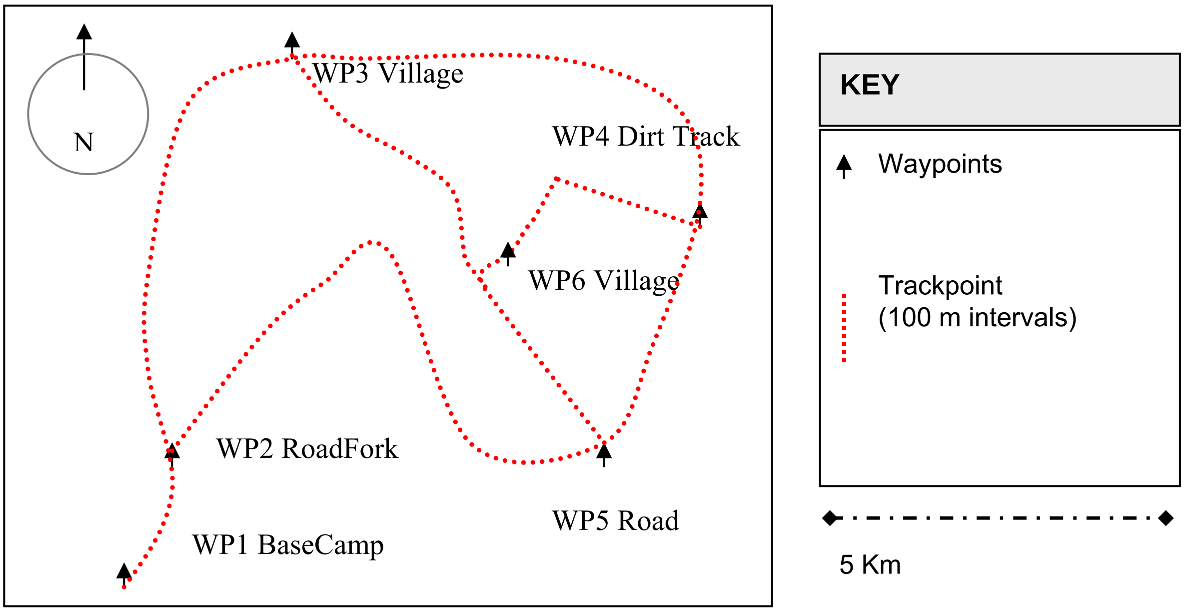

Figure 11-5 Schematic point plot of GPS Data showing road and tracks in a study area annotated with way points. This type of information can be displayed from the GPS screen or it can be downloaded into a Utility such as GPS Utility or downloaded and plotted into a GIS.

Figure 11-5 shows how GPS data can be used on its own but GPS readings are most useful when they can be combined with some form of digital data. Alternatively, analogue data may exist that needs to be corrected to turn into a map. The process of georectification is described in detail in Chapter 9. The information here is purely to illustrate how a GPS should be used when collecting field data to be fed into a GIS or image processing program for rectification purposes. Commonly digital imagery that has no co-ordinates is rectified off high quality maps. However, in many of the areas an expedition team may aim to visit, maps might be poor quality, restricted or simply non-existent. Three results of a rectification exercise are shown below to illustrate the power of using GPS in the field for image rectification. The Bogda Shan expedition rectified data using image-to-image rectification. The Landsat ETM+ data was used to correct the Corona data. This was the best that could be done before leaving for the field because Chinese maps were not available. Each pixel had an error of ~± 80 – 90 m in X and Y. This is shown schematically in Figure 11.6 for errors in the X co-ordinate.

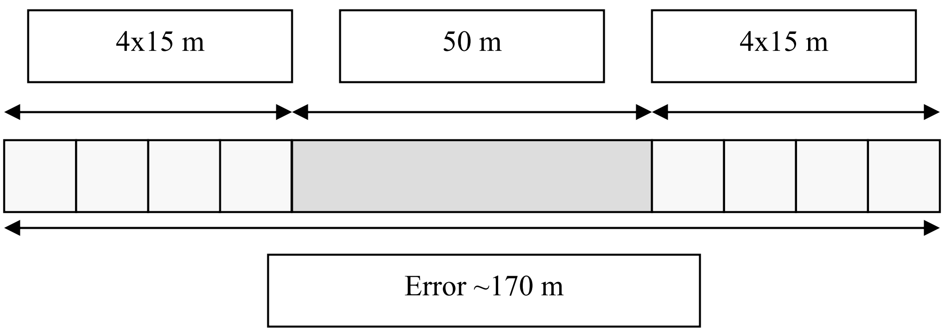

Figure 11.6a Errors generated from rectification (in X dimension using Landsat ETM+ data).

A far better method is to take a GPS unit and map the co-ordinates reported from the receiver to the scanned data (this can be seen in Appendix 2). GPS receivers can be used to rectify data to a much greater degree of precision. By locating areas in the field from the CORONA data and recording the co-ordinates for that location allows georeferencing in the field. If the team could find a visible outcrop in the field to within a 10 pixel square on the CORONA imagery, the error would be equal to the GPS error ~20 m (3σ error) + error of 10x10 pixels locating pixel in the image.

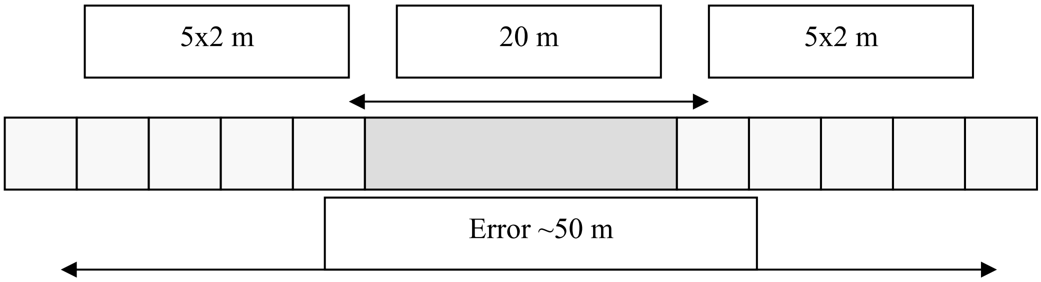

Figure 11-6b Errors generated from GPS rectification (in X dimension)

This method gives an error of ± 25 m, which is an improvement of three times on the current method. This is already a conservative estimate of GPS resolution and it is possible to improve GPS confidence to significantly better than 20 m with averaging, pseudo range, dGPS, or WAAS. By using one of these methods the error in rectified digital data could be reduced to about 25 m (± 12 m).

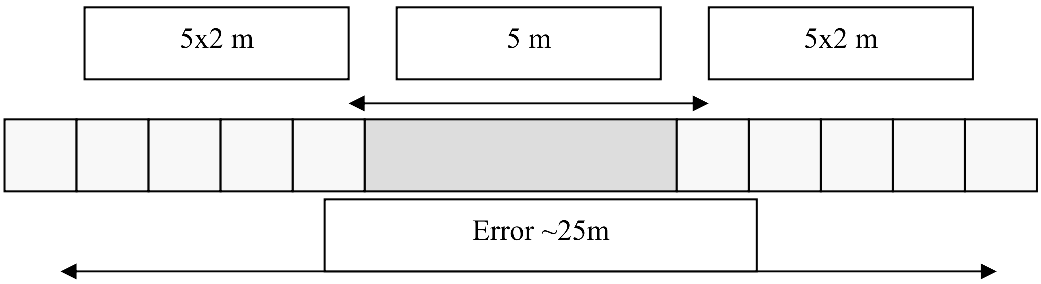

Figure 11.6c Errors generated from processed GPS rectification (in X dimension).

The better the correction used, the better the final product. If an accurate map is being constructed then the only realistic method is an averaged GPS position or a WAAS enabled GPS receiver.

Table 11-1 Characteristics of satellite image data.

Type of data	Resolution of image	Comparable Scale
Landsat	28.8 m	1:100,000
Landsat ETM+	15 m (panchromatic)	1:75,000
Corona	2 m – 10 m	None (no co-ordinates)
Rectified Corona (Landsat)	2 m – 10 m	1:200,000
Rectified Corona (GPS)	2 m – 10 m	1:50,000
Rectified Corona (Averaged GPS)	2 m – 10 m	1:30,000
Rectified Corona (dGPS or WAAS)	2 m – 10 m	1:25,000

These examples show that GPS receivers are an excellent method for rectifying raw images and making base maps for expeditions. An example of how to use GPS data for rectification purposes is shown in Appendix 2.

11.7 GPS receiver models

Several companies manufacture GPS receivers and a 'catalogue of common sets' is shown in Appendix 4. The accuracy of similar channel models is not substantially different between the companies. The two major manufacturers of entry-level sets are Magellan and Garmin. Traditionally Magellan is more commonly associated with marine navigation and Garmin with recreational hiking or aviation. Both companies provide basic, cheap sets that would be ideally suited to an expedition. Other companies such as Silva, Trimble, MLR and Lowrance also produce receivers but many of these are for more specialised pursuits. In general, all models are created to the same standards and more expensive models will not give better results. Magellan has made some significant steps forward with the Meridian and Sportrack ranges. These offer a very reliable WAAS service (where WAAS coverage is available) and a more powerful active antenna that offers the best civilian performance available under canopy cover.

The list in Appendix 4 is by no means exhaustive and may not include recent firmware updates. When considering purchasing a GPS unit consult the manufacturer's website to determine the exact specifications or cheap mail order companies such as GPS Warehouse (*www.gpsw.co.uk*) or Expansys (*www.expansys.co.uk*). The following costs are accurate as at June 2004 from mail order companies. High Street stores may be more expensive. Costs of GPS receivers rose slightly in 2002 and stayed fairly static throughout 2003. A price drop of around 10-15% came in mid 2004. For larger orders it may be worth considering purchasing abroad and paying import duty on units, as this is often cheaper than buying in the UK (for a fuller description of this see Section 13.11). The features list gives an idea of the features of each GPS but is not exhaustive. If a feature is not listed it is not an automatic indication that the GPS does not have it.

All the units listed in Appendix 4 are 'standard' types of receiver meaning they have an antenna, locally based software for calculating a position and some form of LCD screen for displaying the result. There are other types of receivers available including Bluetooth, PDA and CF cards and AGPS receivers. These more exotic units are often built for in car navigation or other specific tasks. When purchasing these units for an expedition, make sure they are not sold with included navigation software because this will double the cost of the unit. The first type of GPS specifically built for a PDA was the NavMan GPS500 built for the original Compaq IPAQ. This used a jacket to slot over the IPAQ. Subsequent PDA GPS units have used more generic interfaces and the current most popular method is Bluetooth. Bluetooth GPS include the Navman GPS 4460 and AnyCom GP 600. The GPS 4460 has a 30 hour battery life and the AnyCom lasts for around 16 hours. Some PDAs are shipping with integrated GPS antennas. The Mitac Mio-Digi-Walker has a GPS antenna built into it. This saves some money by not having to purchase the individual units. The Mitac unit runs a 300MHz PXA255 with 64 Mb of RAM. These units may be useful to an expedition but PDAs are expensive compared to standard GPS units. Also GPS are finding their way into mobile phones with units such as the Motorola A835 having chips integrated into them and Nokia 5140 supporting GPS clip on antennas. Care must be taken when looking at a mobile phone GPS because often the phone lacks the processing power to calculate a position. The data is actually received from the satellite and sent via GSM to a central computer for processing. The data is then sent back to the phone, sometimes with a map of the current location. This means the phone GPS will only work where there is GSM coverage and the service provider often charges for the position calculation (approx. 10p per use). An example of this is shown below.

Figure 11-7 The use of Assisted GPS on a smart phone. This can give reasonable accuracy even in areas where normal GPS signals do not reach. However, it is expensive and poorly suited to most expeditions. A better solution for areas of poor signal strength is an external antenna connected to a standard receiver or a SIRF III 20 channel receiver.