Field Techniques Manual: GIS, GPS and Remote Sensing

- Section D: Planning & Practicalities

Chapter 13: Field Equipment

13 Field Equipment

13.1 Field-based applications

Until recently, much of the GIS component of expedition work may often have been conducted separately to the fieldwork component. The two were often seen as different skill sets, with different team members proficient in different disciplines. There is, however, a considerable advantage in being able to study GISci data *in-situ* and work with technologies in the field. At the very least in any modern fieldwork project, there will be digital equipment used for collecting data. This equipment will be vital to the expedition and due to the nature of most fieldwork will be irreplaceable when the work has started. Care and consideration must be given to making sure the apparatus performs to an optimum level for as long as possible. The ability to take GIS into the field means the expedition can respond more effectively to changes in the project plan and can be very cost effective. Failure to treat equipment with care and respect can be very costly to an expedition. The following chapter discusses how equipment can be used safely and reliably in often-hostile conditions. The Bogda Shan Expedition 2000 is used as an example through most of the chapter. The Expedition is described in detail in the appendix.

13.2 Field computing overview

Expedition computers are commonly used to store collected data and to plan a day's fieldwork. Fieldwork planning commonly involves the use of the GIS to view digital images and maps to help define and target fieldwork objectives. Having this capability is very useful, allowing large amounts of data to be collected more effectively, and facilitating changes if a fieldwork plan does not run smoothly.

The GIS can be used to conduct in-field analysis, but most of the computer modelling and interpretation is usually conducted after a fieldwork session has been completed. The ability to have access to computer facilities while in the field can be critical to many projects, but the field PC does not need to be a high specification machine. The field PC would normally be a relatively cheap low to medium specification laptop PC. Details for obtaining field equipment can be found in Section 13.11. The problem with field computing is that modern laptops are generally poorly equipped to deal with field use. Factors to note when considering using a PC in the field are those of protecting it from damage (either by drops, falls or poor weather conditions) and powering it. Section 13.4 describes the considerations for protecting equipment in inclement conditions and Section 13-5 describes considerations for powering the device when no mains AC power is available.

There are many other pit-falls that the team should avoid when relying on laptops PCs. One common problem is the ability to view the screen in direct sunlight as most screens are not suited for this task. Laptops are rarely used in very bright natural light so people are unaware of the limitations. In bright sunlight most laptop screens are unreadable. The team should check this before deciding to rely on the PC in the field. There are a number of technologies that help viewing in bright light. Many field hardened computers are available with transflective screens that are better suited to outdoor use. Other screen technologies include double bulb screens that are far brighter (but consume more amps) and high gloss screens such as the Sony X-Black screen that are brighter but in some conditions suffer from glare. Another important check is that the screen is not prone to damage. If a laptop screen is damaged in the field it can be a major issue for the expedition. An easy test for the reliability of a screen is whether the top of the computer touches the TFT screen when load is placed on it. To check, place your thumb on the plastic rim of the screen and apply a firm pressure between the thumb and forefinger. If the screen discolours around the pressure then the screen is prone to damage in the field. If there is no obvious discolouration then the PC is ideally suited to expedition work. The Bogda Shan Expedition 2000 used a Panasonic CF-25 Toughbook with an Intel 200 MHz MMX processor, 32 MB of RAM and a 2.1 GB hard drive. This PC was designed for outdoor use and was better at displaying data in sunlight but still not perfect. Though the laptop was technologically very dated its field design more than compensated for its technological limitations. More modern models are still behind the cutting edge; the CF-R1s use Intel M class chips running at 800 MHz and CF-50s use a 1.7 Ghz P4. The low specification of the CF-25 was acceptable for viewing images and planning workloads but slower machines should not be considered for modern GISci. The significant advantage of the Panasonic CF-25 despite its low processing power was the magnesium alloy weatherproof casing, which is an important consideration in cold or wet environments. The modern CF range is not the most protected laptop available but offer some degree of protection (see Section 13.3.1 for more details).

13.3 Data storage

The data the expedition collects will need to be stored. There is nothing wrong with recording information in a field book and, in many cases, that is where the majority of the notes will be made. The disadvantage of hand written information is that it's static, can not be manipulated, shared easily or backed up. To use the GIS to the best of its ability requires digital data to be available in the field. This data needs some form of storage.

13.3.1 Field PC for data storage

Digital images such as satellite scenes and scanned aerial photographs can create very large files. Though they can be printed and taken as hardcopies in the field, this limits their use. Hardcopies have a fixed scale, which restricts the data that can be seen and they cannot be digitally analysed. It is useful to have the data in digital form so that it can be integrated into the GIS. The size of the images can be up to several hundred megabytes, so storing and retrieving the data can be difficult and time consuming. Digital images can be successfully reduced in size, with acceptable loss of information, using tools such as ER Mapper's ECW compression algorithms (freeware data compression for images <500 MB), or free JPEG software (though most JPEG software will lose any co-ordinate information vital to a GIS).

Collected data is traditionally very small in size. Retyped field notes will generally be less than a few megabytes in size and downloaded GPS co-ordinates will also be very small. A recent mapping project conducted by the author used real time spooling of data from GPS receivers that generated very large volumes of raw GPS data but this still came to less than 20 MB of data after several days of collection.

These forms of data can be stored with ease on the hard drive of any laptop PC. Larger storage space is only required when storing digital images. These might be satellite or scanned air photographs, or photographs taken in the field with a digital camera. A Landsat scene is typically between 300 and 600 MB depending on the version of Landsat used and field photos from a digital camera may take 1 MB each (approx 2048 x 1536 pixel high-quality JPEG). Aerial photographs scanned into a PC will often create large files. A 600 dpi scan of an aerial photograph with a 20 cm pixel size resolution creates a 625 MB scene for each 5 x 5 km square, comparable in size to a Landsat 180 x 180 km scene. The Bogda Shan field PC was used to store around 900 MB of data and 750 MB of program files. On a 2 GB field PC this is a significant consideration. It does not take into account extra data acquired in the field, digital photographs or swap files generated by the PC while processing for which there should be a minimum of 200 MB.

Table 13-1 Storage space required for Bogda Shan Expedition.

Digital imagery	
1 full Landsat scene ETM+	590 Mb
2 processed Landsat subscenes	165 Mb each
2 high resolution Corona scenes	120 Mb

Programs	
Windows 98	200 Mb
Microsoft Office	200 Mb
Arc View	92 Mb
ER Mapper	271 Mb

This was a data storage total of about 1.6 GB, which still left ample room for storing GPS data gathered in the field. The data stored during the day in the GPS receiver memory was downloaded nightly onto the field PC and stored in Excel spreadsheets for import into the GIS. Over a period of four weeks fieldwork the GPS data set generated was 1.5 MB in size with an accompanying 1 MB Access database. The entire GIS project was described by a 1 MB file referencing all the stored image data and data tables. It is clear that the actual computer need not be of a high specification, and field protection is a much greater concern than processing power or storage space.

Table 13-2 Some typical sizes of geographical data.

Data	Unit	Storage space
Aerial photography	1 x 1 km	25 MB
Corona	1 x 1 km	8 MB
Landsat ETM+ subscene	1 x 1 km	0.01 MB
Landsat ETM+ full scene	1 x 1 km	0.2 MB

As well as the PC hard drive, the laptop can be used to store data on removable media such as floppy disks, optical disks (CDs and DVDs) and solid-state storage chips. The relative advantages of these devices are discussed in Section 13.10. Alternatively, there are several other methods for storing field data when a full-blown PC or laptop cannot be used.

13.3.2 GPS memory for data storage

Modern GPS units store 500 or more named waypoints with or without a graphical symbol. The name is often limited to less than 12 characters and is not useful in recording any significant quantity of information. For some purposes, however, it is entirely possible to generate a series of keys to accompany a waypoint. These keys could be referenced via a table in a notebook and a letter or number could be used to denote a photo or sample being taken at a particular point. A waypoint numbered as 23 at which photo 16 was taken along with sample 4 could be described by the waypoint name as w23p16s4.

Trackpoints cannot have names or symbols attached to them and must be backed up more frequently than waypoints. Trackpoints may be overwritten when the trackpoint memory has been filled making them a poor method for storing data. Trackpoints can be grouped into tracklogs (simplified trackpoints sometimes called routes) but this reduces the resolution of the track log to <50 points. To be certain that the data is safe requires backing up to a PC, laptop PC, PDA, data logger or by hand to a notebook. The sheer quantity of data stored can make written methods of backing up data inappropriate and so a digital medium is often required.

13.3.3 Data loggers for data storage

Data loggers are devices used to store large amounts of information in compact digital units. Several have been developed for GPS receivers and make convenient and portable methods for the storage of large amounts of GPS data (130,000 waypoints compared with 500 in a GPS unit's memory). Data loggers spool data from a GPS continually for 10 days and run on a 9V battery. They come with download software to transfer the data to a PC and make very useful pieces of equipment when downloading the GPS directly to a PC every night is not possible. They can be programmed to take NMEA sentence structure and time stamped location data. The Delorme Earthmate BlueLogger GPS can also store pseudo-range data for post processing.

13.3.4 PDA for data storage

PDAs (Personal Digital Assistants) are handheld computer units that have capabilities similar to desktop PCs but with reduced processing power and functionality. The market leader is Microsoft with the Pocket PC range accounting for just over 50% of the PDA market. The previous leader in the market was Palm One which still has a strong market share with the Palm series of handhelds.

The first Palm was released in 1996 and competed against PSION handhelds, which have subsequently become obsolete. Currently the two major types of PDA on the market today are Palm OS PDAs (those made by Palm-One or compatible with Palm OS software) and Pocket PCs powered by later versions of Microsoft's Windows CE called PocketPC (a scaled down version of the Windows 2000 kernel). Many third parties make models of each, with IBM, Qualcomm, Symbol Technologies and Sony making Palm compatible devices and Toshiba, Fujitsu-Siemens and Hewlett Packard/Compaq making Pocket PCs. In general, the Pocket PC is the more powerful of the two types but with this extra power and colour screen comes a reduction in battery time and robustness. Palm OS 3.5 supports only 256 colours models but newer models supporting OS 4 and OS 5 are on a par with Pocket PCs. Pocket PCs have up to 16,000 colours, making them more useful for displaying images. Palms have been around longer than Pocket PCs and have more shareware software developed for them. Both types can be integrated with GPS either through cables or via Bluetooth.

The basic memory on the units can be small: typically Pocket PCs will come with around 48 to 128 MB of which ~20 MB is used for applications. To ensure data is not lost when a battery expires and to allow more data to be collected, an SD card, CF chip, Memory Stick or MicroDrive should be attached. These have storage capacities from anywhere between 16 MB and 4 GB. They often represent very good storage methods if you can communicate between your hardware and the PDA. Bear in mind that many new PDAs do not have RS232 ports neither on themselves nor on their docking stations. This limits how effectively data can be transferred from a GPS to the unit.

Table 13-3 Approximate costs of data storage (discussed in detail in Section 13.12, Disaster recovery planning).

Device	Capacity	Cost *	Limitation	Notes
CF Card **	16 MB	-	Not widely available	-
CF Card	64 MB	£15	Requires Card Reader for use with PCs	Rewriteable
CF Card	128 MB	£20	Requires Card Reader for use with PCs	Rewriteable
CF Card	256 MB	£30	Requires Card Reader for use with PCs	Rewriteable
CF Card	512 MB	£50	Requires Card Reader for use with PCs	Rewriteable
SD Card	16 MB	-	Not widely available	-
SD Card	64 MB	£20	Requires Card Reader for use with PCs	Rewriteable
SD Card	128 MB	£30	Requires Card Reader for use with PCs	Rewriteable
SD Card	256 MB	£35	Requires Card Reader for use with PCs	Rewriteable
SD Card	512 MB	£65	Requires Card Reader for use with PCs	Rewriteable
USB Stick [#]	32 MB	£30	PC requires USB Port (not compatible with PDA)	Rewriteable
USB Stick [#]	64 MB	£15	PC requires USB Port (not compatible with PDA)	Rewriteable
USB Stick [#]	128 MB	£25	PC requires USB Port (not compatible with PDA)	Rewriteable
USB Stick [#]	512 MB	£55	PC requires USB Port (not compatible with PDA)	Rewriteable
CDR	600 MB +	~£5 for 10	Requires CD recorder / rewriter	Record Once (WORM)
CD RW	600 MB +	~£10 for 10	Requires CD recorder / rewriter	Rewriteable
DVD (various)	4700 MB	£3 - £5 each	Different formats. Ensure expedition DVD equipment can write to disc	Rewriteable

** Prices are approximate, early 2005. Some companies will sell cheaper than this, others will be more expensive. Mail order companies such as those listed in the popular monthly computer magazines will typically offer better value than high street stores. Prices will continue to fall and this list will become out of date. However, the list should show the relative costs of the media e.g. CF will always be ~75% of the price of SD and approximately the same price as USB data sticks.*
*** Using memory cards in a PC requires a card reader costing £15-£20 connecting through USB.*
[#] Most PDAs do not have mass driver support for USB memory, even if they have a USB connector.

The main disadvantage of PDAs is that they lose the information in their memory if their battery discharges. Information saved to a backup card is safe but data saved to the device will be lost. Given that battery life only gives 6-10 hours of continual use on some models, this is a major concern for expeditions. Pocket PCs are usually more susceptible to this than Palm devices, as the battery on Palms usually lasts longer. It is important to note how long the device can be kept on standby. Some devices will lose >10% of battery life per day even if they are not used. Other models will lose only 1 or 2% per day. This problem is discussed in Section 13.5.2 in relation to the lithium-ion battery supplied with the unit. As important as the primary battery life is the presence of a secondary battery. The secondary battery cannot run the unit but will protect data if the primary battery is removed or discharged. Without a secondary battery if the primary one is removed, the device will lose all data stored on the unit. Though the primary battery is rechargeable the secondary one is not and after discharging it will need replacing.

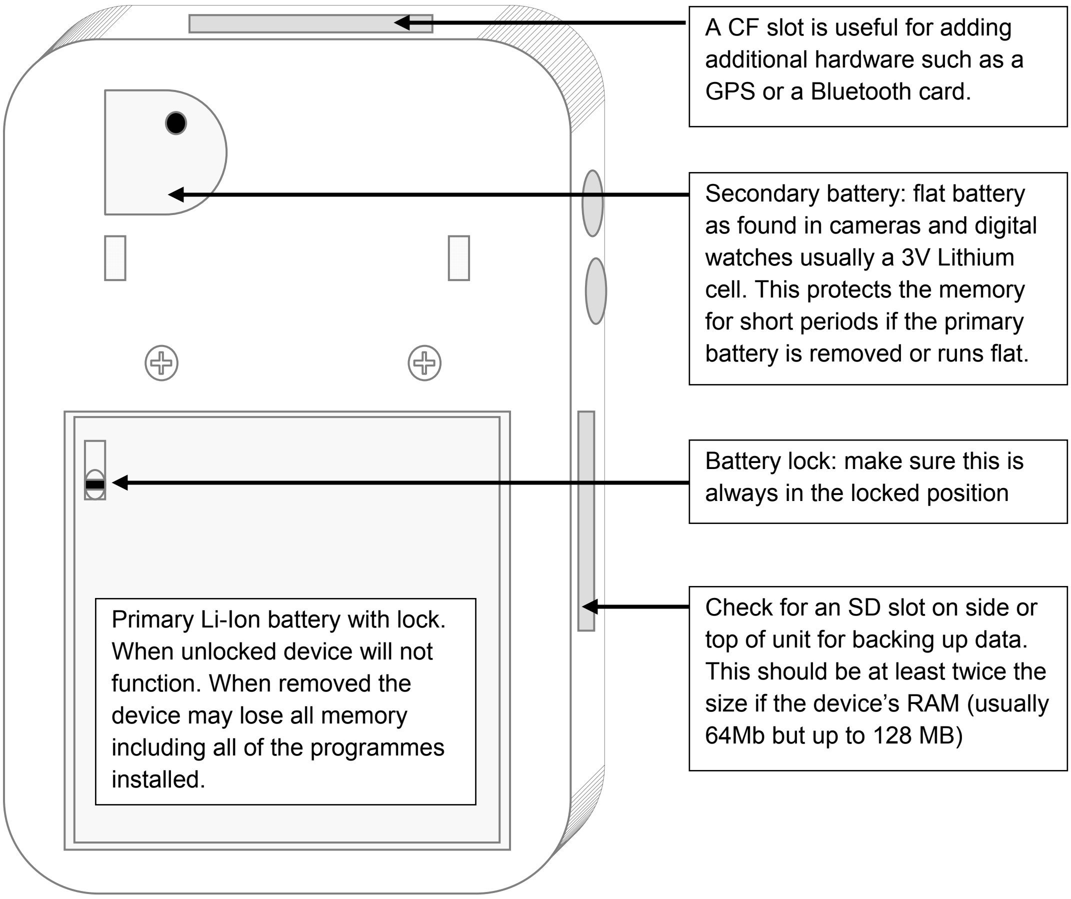


Figure 13-1 Key features at the rear of a Pocket PC.

A PDA is very useful for recording digital data and very quickly transfers it to a computer GIS. The real advantage of a PDA over a field slip is in the amount of time eliminated from the procedure of transcribing notes and uploading them. If digital data is required to be viewed in the field or if the GISci project has to be delivered very quickly on return from the field, then a PDA is an excellent way of speeding up this process. To be certain the data is protected the PDA needs to be equipped with some form of backup card like an SD or CF card. It is important to check the slots available in the unit before leaving for the field. If the unit only has one expansion slot and the expedition requires a Bluetooth card to be added then there will be no space left for a backup card. These factors must be considered before leaving for the field. The latest Pocket PCs also do not have an RS232 connection so it important that the PC or GPS is compatible with the USB connector on the PDA. Good units for the field include the Dell Axim X5 which is sturdy and features rubber casings that will protect the unit to a certain degree. It is also cheap, features SD and CF expansion and has a secondary battery. Battery life on the X5 is also excellent and it retains its charge well during periods of none use.

An important factor when selecting a PDA or field PC is the screen. Most PDAs and most laptops have screens that are designed to be seen in office environments or out of direct sunlight. In the field, where ambient brightness can be very high, many laptop screens are unreadable. This can be mitigated by using the device within a vehicle but using a computer outside is often impossible. This must be checked on the unit selected in advance. Not being able to read the screen renders any of these devices pointless and the expedition would be better off using field slips and paper notes.

13.3.5 The Internet & FTP sites

The previous examples have all included information for storing data locally. Though Flash cards and CD-ROMs are excellent storage mediums, they are still kept with the party in the field. If luggage is mislaid or equipment stolen all the data collected will be lost. By far the best and most re-assuring method for data storage is a periodic upload to the Internet.

Section 13.7 on field communications and Section 13.12 on disaster planning both go into this in more detail. The team should be aware of the ease of backing up data from the field via a mobile phone or sat phone or from the nearest town or city using an Internet café. This either uses a simple email to send the data to an email account or a file transfer protocol programme (FTP) to put the data into a folder on a remote computer or network. There are many cheap file stores available to the party and some of the common ones are listed in Section 13.12.1. The expedition should take the security of its data very seriously because this often underpins the goals of the expedition. As well as risk assessments for the tasks undertaken in the field the team must adequately consider the risks to their data and look for best practise methods to mitigate any loss.

13.4 Understanding device protection

Electronic devices, including GPS receivers, field computers and communication equipment are becoming essential for fieldwork. To maintain safe and reliable use in all conditions, both battery life and extreme weather performance are an essential consideration. The expedition must be prepared to supply either a sufficient number of standard batteries or use some other form of power such as deep-cycle lead acid batteries, solar power or a car battery.

Equally important as powering the devices is consideration for their protection. If the equipment is used for expedition critical information then it must be able to work in inhospitable conditions. The degree of protection offered by a device is often based on the type of equipment it uses. In general the fewer moving parts involved, the less likely the machine is to break from drops of falls. For this reason PDAs can sometimes be more rugged than laptops, due to the solid-state hardware employed. Most commonly, as discussed in Section 13.3.4, PDAs have severe limitations and their use should be carefully considered before selecting them for the field. Also, if in the fall the battery is jolted loose or the pins momentarily separate in the battery housing then the PDA will require a secondary battery to kick in. If there is not a secondary battery or if the battery has already been discharged due to a long period in the field then the PDA will lose all data in its internal memory. Storage cards such as SD and CF cards will not be affected but programs and data that can not be stored on to the removable medium, such as contacts, calendar information and some other file types will be lost.

When purchasing equipment it is important to ensure the equipment is complaint with a relevant hardware specification. Some units quote the US military specification MIL STD 810F which is a standard for field equipment. Another more common test is the IP rating (Ingress Protection) that takes into account the level of protection from moisture and solid contaminants. This chapter will look at the meaning of IP numbers, as these are the most common standards used for expedition hardware. The IP number is a two-digit value. The first digit is between 0 and 6 and represents the resistance to solid contaminants such as dust and other particles. The higher the rating the more protection the device yields. The second digit is for liquids and ranges between 0 and 8. A value of 0 represents no special protection (standard electronics) and the higher the number the better the protection. The highest levels 6 and 8 respectively represent complete protection. Table 13-4 describes the device protection afforded by each digit.

Table 13-4 Ingress Protection (IP) rating of electrical equipment.

1st digit	Description	2nd digit	Description
0	No protection	0	No protection
1	Protected from 50 mm or larger	1	Vertical dripping water
2	Protected from 12 mm or larger	2	Inclined and vertical drips
3	Protected from 2.5 mm or larger	3	Protection from spray from 60°
4	Protected from 1 mm or larger	4	Protected from splashes
5	Dust Protected	5	Protected from higher pressure water
6	Rarely used – complete device protection	6	Protected from heavy seas or high pressure hoses
N/A	N/A	7	Withstand total submersion at a stated pressure for a stated duration.

GPS receivers often quote the second digit to show how comprehensively they deal with water protection. Level 7 is usually quoted as 1 m depth for a brief period, which is what most new GPS receivers can withstand. This number is often found at the end of the GPS specification. For example, the Garmin ETREX is IEC 529 IPX7 where X7 represents the IP level 7-submersion factor. Level 8 is sometimes quoted and this would be protection from a sustained submersion. A common score for hardened laptops is IP54. This offers near complete protection against dust and particulate contaminants and complete protection against particles over 1 mm in size with protection from sustained water from splashes or torrential rain from any angle.

If a greater degree of protection is required than the device inherently supports, then there are various companies specialising in added protection for field equipment. Several digital camera manufacturers make plastic housings for their cameras so they can be used underwater. The housings are usually device specific do that the buttons on the casing line up with the buttons on the camera. These housings are designed for diving but equally protect in areas where splashes to the camera are likely, such as water based expeditions or those conducting coastal or river research. Digital cameras are very susceptible to water damage. Similarly, older GPS units may not be IPX7 compliant and greater protection may be sought for these units. PRO Sports produces AquaPac equipment for housing digital equipment that may be damaged by water or other climate conditions. A heavy duty water proof covering for a GPS can be bought for around £30 and will protect a GPS, mobile phone or similar device. The AquaPac will also allow the GPS to be used below the typical temperatures where the screen would fail. The unit can still be accessed through the covering and this could be a solution for expeditions needing GPS readings in cold climates (Figure 13-2).

Figure 13-2 PDA protection casing. PDA supplied by MapAction.

Water is a major concern for any electrical device and even very small quantities of water can be enough to disable a device. Fortunately, water damage is often temporary and even when damage appears more serious, long term problems can often be avoided through rapid and carefully applied mitigation procedures. One of the common problems associated with water damage is the short-circuiting of contacts within the device. Some of the most vulnerable contacts are those associated with any external buttons. One device that is both susceptible to damage and critical to expedition safety is a mobile phone. Mobile phones are discussed in detail in Section 13.8 but they function as a good generic case study for devices that are susceptible to damage. When damaged by water a mobile phone will usually stop working almost immediately. The expedition must act quickly to reduce the risk of permanent, irreparable damage. The damaged kit should be disassembled into its constituent parts and dried separately. When re-assembled the kit will normally work well. The expedition should make sure that it has a small set of screw drivers to do this.

Figure 13-3 Disassembling a mobile phone to prevent water damage.

13.5 Powering field equipment.

The most important factor when considering the care and use of electronic equipment in the field is battery life. Most equipment used in modern GISci will require some form of electricity. If the expedition is operating from a basecamp where a stable electricity supply is available then this is less of a problem but powering the devices becomes more difficult in the field. Before entering a discussion on specific batteries it is worth understanding the terminology of power requirements.

Batteries supply a current (amps or A) at a specified potential difference (voltage, volts or V). The battery is rated to describe how much charge is stored within it. This stored charge is called the amp hour (Ah) rating and is sometimes expressed as milli-amp hours (mAh) where 1000 milli-amps is equal to 1 Amp hour. Amp hours are a measure of how many hours the battery can deliver the required charge. For instance, a 3 Ah battery can deliver 3 A for 1 hour or 6 A for ½ an hour. This does not hold for all currents as a 3 Ah battery will not supply 12 A for ¼ of an hour as this would likely be too high a current for a small battery. Some batteries are designed for high currents over short periods and the most common type of this battery is the lead/acid car battery. Car batteries are designed to deliver very high currents for short periods to start the car but are unsuited to longer continuous use.

A device requires a fixed voltage to work. The voltage supplied by a battery should remain constant or 'flat' for the length of the batteries life; in reality it will never behave like this. In all cases, the voltage will fall off when the amps get lower. Though this happens in all batteries, the gradient of fall off should be as shallow as possible. This is why some batteries stop powering a device well before the estimated amp-hour limit. Cheaper batteries and rechargeable batteries suffer from this more than expensive batteries do and this compounds their often low Ah rating.

Often more than one battery is used at a time in the device. In the case of GPS receivers, the unit may require two, four or even six batteries. When multiple AA batteries are used they are usually configured in series to increase the voltage not in parallel to increase the charge. For GPS receivers the amp-hours of the batteries are not added only the voltage. Therefore, four AA batteries rated at 1.5V with 2 Ah gives 6V at 2 Ah not 6V at 8Ah.

On occasions, it is essential to know the power consumption of the device (also called its wattage). This is a description of the current used at a specified voltage and is found by multiplying volts and amps (Power = current x volts, or P=IV).

Most field devices run from some form of battery, either standard 1.5V AA batteries in the case of GPS receivers or from rechargeable Li-Ion batteries in the case of field computers, PDAs and phones. The following sections look at the different types of battery and how they should be used to maximise their performance.

13.5.1 Battery life from standard AA batteries

For field use there are five different types of standard AA battery that can be used with the field equipment. These different types are shown in Table 13-5 and discussed in more detail below. Occasionally some devices will require a different type of battery such as AAA batteries (slightly smaller than AA and thinner) or 9V rectangular batteries.

Table 13-5 Different battery types.

Battery type	Common name	Size	Voltage	Approximate (mAh) *	Approximate power
Lead / acid	Lead / Acid	AA	1.5 V	600	0.9 watts
Nickel cadmium	NiCad	AA	1.2 V	1000	1.2 watts
Alkaline	Alkaline	AA	1.5 V	1000 – 2000	2.3 watts
Lithium	Lithium	AA[#]	15 V or 3 V[#]	2000	3 watts
Nickel metal hydride	NiMh	AA	1.2 to 1.5V	2300	2.75 watts
Alkaline	Alkaline	AAA	1.5 V	1120	1.68 watts
9V alkaline	9V	9V	9 V	560	5 watts

** Amp Hour ratings for batteries are highly variable across different manufacturers. These are rough guidelines. Also, bear in mind that the voltage drop off means that the full capacity will never be discharged because the device will stop registering the voltage before the battery is fully exhausted.*

*** The Amp Hour rating for standard alkaline batteries is never quoted, generally because of the voltage drop off. The expedition should budget for a value in the range of 1500 mAh.*

[#] *Lithium cells are sometimes supplied as compact units designed to replace 2 AA batteries. If this is the case, then the configuration of the batteries in the device is an important issue, i.e. the batteries must lie side by side and cannot be staggered. Not all lithium cells are supplied like this and some are standard AA shape.*

Lead/acid style batteries are cheap but are not suited to the high-energy drain of equipment such as GPS sets and will last less than a third the time of alkaline batteries. Similarly NiCad, though having the advantage of being rechargeable, last for even shorter periods. NiCad batteries also run at lower voltages and are often not powerful enough to run high drain equipment. Alkaline batteries are the standard type used in field equipment but their life is substantially reduced at temperatures below 5°C. In conditions approaching or below freezing lithium batteries are recommended. Modern Nickel Metal Hydride (NiMh) batteries are on the market that have acceptable voltage levels and very high Amp Hours. Modern NiMh batteries are rated at up to 2300 mAh compared with between 1000 and 2000 mAh for alkaline AAs (commonly around 1500 mAh). The disadvantage of NiMh batteries is that they are very expensive at around £25 GBP for a pack. NiMh 2300 batteries will last 1 ½ times as long as a standard alkaline battery. Similar to NiCads the voltage of NiMh is still usually lower than standard alkaline batteries so care must be taken to test any 4 battery device receiver thoroughly before equipping the expedition. Some expedition devices may require AAA batteries: these are rated at 1.5 V like AAs but have a smaller mAh rating. It is often desirable to keep the type of battery consistent through all expedition devices. This means that batteries can be shared between equipment in the case of battery failure.

A GPS receiver is a typical device used in the field on AA batteries. GPS manuals recommend alkaline batteries and often quote their receivers at around 22-24 hours continuous use in battery save mode. This is generally on the high side and realistic use and handling of the set may see this drop to a little over 16 hours (approx. two days field time). The rechargeable NiCad batteries give about three-quarters of a day’s use in the field (~5 hours) but obviously have the advantage of being rechargeable off a lead/acid car battery or solar panel. With the use of a lead/acid battery or solar cell these batteries can be recharged daily, however, the voltage fall off is worse with rechargeable batteries than with other batteries. This means that towards the end of the charge even though they have enough amperage they do not have enough voltage to power the device. This is compounded by the number of batteries a GPS requires. Four battery receivers fair worse on rechargeables than two battery ones. This can be used to reduce weight for a team but is often a false economy. Most rechargeable do not deliver as high voltage as standard alkaline AAs. For a two battery GPS this is not a problem but some GPS receivers require four AA batteries. Four batteries are more common in older models and the difference in voltage between four rechargeables and four AAs is often too great for the GPS. This is shown in Table 13-6.

Table 13-6 Effect of differing voltages on electrical equipment.

Battery requirement	Standard AA batteries	Standard rechargeables	Voltage explanation	Acceptable Performance
1 battery	1.5 V	1.3 V	0.2 V - no real difference	✓
2 battery	3 V	2.6 V	0.4 V – no real difference	✓
4 battery	6 V	5.2 V	0.8 V – significant difference	×

To calculate the battery life of the device used requires knowledge of the current it pulls against the current stored in the battery. Standard alkaline batteries are rated around 1000 to 1600 mAh so it is possible to get an approximation of the length of time the batteries will last in the field. A GPS unit pulls about 100 mA. This is increased by around 10-15 mA if an external antenna is attached. Many GPS receivers have a back-lit screen that can be enabled, sometimes by pressing the power key for a short length of time. This reduces battery time significantly and should only be used for very short lengths of time. The current pulled depends on the unit, the size of the screen and the exact settings used but adds around a further 40-50 mA to the current. If an electronic flux-gate compass is enabled then the current is increased by another 40 mA. WAAS also increases battery drain considerably and both the electronic compass and WAAS should be disabled if they are not needed. Therefore, a GPS would last for around 10 hours in standard mode using 1000 mAh batteries reduced by around 1 hour by adding each option above. Realistically, using good quality 1600 mAh AAs battery life could be between 16 hours and 8 hours depending on the options selected. Modern 2300 mAh NiMh batteries would last for closer to 23 hours with most options turned off which would give around three days field time for a GPS in battery save mode. This is shown in Table 13-7.

For subzero temperatures, lithium AA batteries are better than alkaline AAs. Lithium batteries carry up to three times the charge of alkaline batteries and weigh less. Their charge is affected far less by the cold, making them a good choice for cold weather environments. Turning the set off for periods can also extend battery life, however, this does carry the caveat of waiting for a warm fix and for the data to settle.

Table 13-7 Current pulled by differing devices.

Device	Standard AA batteries	Approximate current	Approximate battery life using 1600 mAh AAs
GPS in battery save mode	2 * 1.5 V	100 mA	16 hours
GPS as above with aerial	2 * 1.5 V	110 mA	14 hours 30 minutes
GPS with aerial and backlight	2 * 1.5 V	150 mA	10 hours 30 minutes
GPS with electronic compass	2 * 1.5 V	140 mA	11 hours 30 minutes
GPS with Bluetooth	2 * 1.5 V or 3.3 V Li-Ion	110 mA	14 hours 30 minutes

If the GPS is to be used in a vehicle then powering it through the 12V adaptor inside the vehicle is a good method for cutting down on batteries. A power adaptor is usually sold separate to the GPS for around £20 GBP. They connect via the PC connector on the back of the GPS. If this is important to the expedition then check the GPS has an adaptor for this. Basic models such as the Garmin Geko 101 do not have PC connectors and can not be used in this way. It is also worth checking that the vehicle has a 12V adaptor because some older models that may be used on expeditions do not.

13.5.2 Battery life from standard lithium ion battery

Standard laptops come with a single rechargeable Li-Ion (lithium ion) battery rated at around 3600 mAh. This gives an operating time of 1 hour at 3.6 Amps running at 10.8V. The actual current pulled by the computer varies with the application. A typical test of amperage pulled by different computer functions while running off the battery is shown in Table 13-8.

Table 13-8 Tests conducted on field computer. Figures show mean A at 10.8V for Panasonic CF25.

Status	Amps
Idle	1.7 Amps
Low level processing	1.9 Amps
Booting	2 Amps
High disk usage	2.05 Amps

For normal usage, downloading, processing, and uploading data, the PC will average a current of 1.9 Amps. On a 3600 mAh battery this will give a performance life for a standard Li-Ion cell of:

Run time = Amp hours/Ampere = 3.6 / 1.9
= Approx. 1.9 hours, about 1 hour 55 minutes

Due to inaccuracies and potential idle time, we can round this to two hours of continuous use. Various battery designs exist but the optimum performance is achieved with Li-Ion. Older NiCad (nickel cadmium) batteries are now rarely used due to memory effects. Memory effects involve a reduction of battery capacity when the battery is not discharged fully before recharging. A second alternative, NiMh (nickel metal-hydride) has no memory problems but exhibits inferior performance such as shorter battery life compared to new Li-Ion batteries. The advantage of NiMh over Li-Ion is its resilience to low temperatures. Li-Ion batteries have poor reliability in cold conditions and are prone to failure at temperatures below 0°C. Therefore for the mountain expeditions or those in cold climates a NiMh would have been preferable. It is recommended that to protect against failure and to extend battery life, additional battery power is provided by either a second battery or other rechargeable mechanism. As MHz clock speeds have increased in laptops their battery requirements have also increased. In some instances, it is worth the expedition looking at the processor requirements and opting for a lower speed to increase the battery life. This may involve buying older second hand PCs. The disadvantage with second hand laptops is that batteries can sometimes have a short life span (2-4 years) and therefore second hand units may have damaged batteries that require replacing. Intel produces Centrino and Dothan processors that are designed to pull smaller amperages than standard chipsets. Some Centrino processors can run for 3 to 5 hours on a single charge, significantly more than the 1.5 to 2 hours supplied by a laptop running a P4 processor. Lithium Polymer batteries (Li-Pol) give better performance by size and weight than Li-Ion but the difference is not significant. Li-Pol are becoming popular on the new Palm-One PDA units including the modern Zire and Tungsten range.

Ensuring a good power supply for the expedition PDA is vital due to the device's volatile RAM. As discussed in Section 13.3.4, the PDA will lose all its memory if the battery discharges. A typical Pocket PC PDA is supplied with a Li-Ion battery rated around 1000 mAh to 1400 mAh but they can often be fitted with high performance batteries rated around 3500 mAh. These batteries are usually expensive (~£100 GBP) and add significantly to the weight and size of the unit. Palm-One units are usually supplied with smaller batteries rated around 840 mAh or 900 mAh. However, their battery drain is significantly less than that of a Pocket PC and the battery will usually last longer. A rough rule of thumb for PDA battery drain is that in normal operation the unit will pull around 100 mA per 100 MHz clock speed. Therefore, a 126 MHz Texas processor Tungsten E from Palm-One would pull a current of around 126 mA and last just under 7 hours continual usage on its 840 mAh battery. A 400 MHz PXA 250 Pocket PC running on a 1400 mAh battery would run for less than 4 hours. The X-Scale processors from Intel used in many PDAs are designed to vary the processor speed (and therefore battery consumption) depending on the task being performed. Pocket PCs running Pocket Windows 2003 can take advantage of this but older versions of Windows cannot. In those cases, software such as Pocket Hack Master can be used to force a change in clock speed. This can reduce the clock speed to conserve the battery or increase speeds to increase performance. Over clocking is not recommended as it significantly reduces battery life and may damage the unit. Also very few applications need high processor speeds.

The above rules are not hard and fast rules and depend on the way the device is used and, most importantly, the level of brightness on the screen. A screen set to maximum brightness will almost double the charge pulled. Using a wireless communication like

Bluetooth will add another 50-60 mA. These rules give a good approximation for most PDAs but the expedition equipment should be fully tested before leaving for the field. In addition, in conditions below 15°C the battery life will fall away and perform significantly worse than in the optimum 15°C to 40°C range.

PDAs should also be fitted with a secondary battery. It is better if this is a separate cell but some PDAs simply reserve part of the primary battery for backup purposes. This is of little use if the primary battery is physically removed either by accident, for cleaning or replacing. A secondary battery is easy to check for, as shown in Figure 13-1. The secondary battery is usually a CR flat coin type battery (CR2032). These deliver a nominal 3V and hold 220 mAh charge. The length of time the secondary battery will protect the device for depends on the amount of charge required by the unit to keep the volatile SD RAM active. This can be anywhere from 1-10 mA and so could be from 4 to 40 days from the primary battery or between 1 and 10 days from the secondary. If the secondary battery is a CR flat battery then it will not be rechargeable. The Dell Axim X5 discussed in Section 13.3.4 takes just over 1 mA whereas some older units such as the Toshiba E740 take closer to 10 mA. In the case of the Dell Axim X5 the primary battery will last around 30-40 days without charge, with an additional 8 or 9 days supplied by the secondary battery before all memory is lost. The Toshiba E740 has no secondary battery and so would only last around 1 week before the memory is lost. Calculating or estimating this in advance is vital because the device will hard reset if left for longer than this period, a real problem if a lengthy travel to and from the field is required.

Larger Li-Ion batteries can be purchased that can be used to power multiple devices. The Socket Mobile Power Supply available from *www.socketcom.com/product/AC4009-541.asp* can be used to power multiple devices and has a 7.2 Ah rating. This would be useful for charging equipment or running PDAs for a longer period of time. A Dell Axim x5 would run for a total of 18 hours using this equipment. The device is bulky and heavy but can be clipped to a member's belt for continuous use or kept at basecamp to charge equipment. The specifications claim the battery can recharge a PDA 10 times per charge or recharge a mobile phone 15 times.

13.5.3 Battery life from solar panels

One method of alternative power is the use of a solar panel. A general solar panel design for powering laptops uses two photovoltaic cells. The solar panel apparatus is usually housed in a strong waterproof casing with hardened specifications inline with 'ruggedised' field PCs. The panels themselves are coated to be weatherproof and withstand small impacts. These panels are connected to a voltage controller, which comes as a standard part of the equipment. Calculations suggest that the recharge of a laptop PC during the course of one full day of bright sun light would allow just over one hour of PC use a day.

Table 13-9 Battery life generated by a full day of recharging from a solar panel that delivers 0.29 A per hour of direct sunlight.

Solar panel performance	Approximate current	Results
Over an 8 hour period	0.29 A * 8 hours	2.32 A @ 18 volts
Run time of PC if charged from a solar panel	2.32 / 1.9	1 hour 13 minutes

A modern solar cell designed for expedition work is made by ICP Global Technologies Inc. Their iSun Portable charger is a solar power device capable of delivering up to 2.2 amps that can be used for powering GPS units and PDAs. The current is generally too small to directly power a laptop computer, which requires a minimum of 2 amps because the generated amperage is dependent on the brightness of the sun. However, the unit could be used to trickle charge a laptop battery, as shown in the battery life worked example above. The units can also be daisy-chained together and two units working together could be used to run a laptop. The units are weatherproof and can be used outdoors, though they are not certified as being waterproof and should be protected from extreme conditions or submersion. Their temperature range is between -40°C and +80°C and this should be sufficient for most expeditions. More information can be found at *www.isunpower.com*. In September 2003 the units were retailing for $80 US and available from some retailer in the UK for around £35-£40. They have subsequently become slightly more difficult to locate and at the time of printing (early 2005) are retailing for closer to £50. The expedition should try to shop around to get the best price.

For more heavy duty use and for powering more equipment Maplin produce a 45 watt solar panel costing £349.99 from *www.maplin.co.uk*. This unit consists of three 15 watt panels. This is a much larger more powerful power source but is consequently far more expensive. The iSun is a more practical solution and is shown below in Figure 13-4.

Figure 13-4 Garmin ETREX GPS and I-SUN charger.

Other useful tools for conserving battery power include windup torches. Windup torches can be useful pieces of field kit and offer 16 minutes of light after a 60 second turn. They can be further wound to offer up to five hours of battery life. Windups can alternatively be charged from the mains or from a car battery.

13.5.4 Battery life from lead acid batteries

Alternative recharge methods include lead-acid car batteries, which perform better than solar panels but are not designed for deep cycle operation (i.e. draining to empty and recharging). These batteries are rated between ~45-50 Ah and are designed to generate high amperage over very short periods but not to drain. If a vehicle is available to the expedition then its battery can be used for powering equipment. If a vehicle engine is switched off the 12V adapter can supply power to run a field PC for over two hours but running for too long only on the battery can flatten it. Car batteries do not perform well if they are discharged (deep cycled) and starting the vehicle will be problematic; flat batteries require jump starting from a second vehicle. To negate this, the vehicle's ignition should be started for 10 minutes every hour.

An alternative to lead/acid vehicle batteries are deep cycle lead/acid 'leisure batteries'. Deep cycle leisure batteries do not offer the same current, operating at a maximum of 10-20 amps, but for similar size and weight may be of higher Ah rating. Equivalent deep cycle batteries may offer performances of 80 Ah with deep cycle discharge performance. The Bogda Shan Expedition used a 100 Ah deep cycle, sealed, lead-acid battery purchased in China from the Xinjiang Seismological Bureau. Battery life was never fully tested but gave over 14 hours of continuous use on the Southern side of the Bogda Shan. Calculations suggest that for the operations used in the field the battery should have yielded over 40 days of use. The main factors to be considered when selecting between lead-acid batteries and solar cells are their weight and dimensions. Deep cycle batteries are sealed and easier to transport than car batteries but are correspondingly heavier and more awkward. Battery weight can be over 10 kilograms and they can measure over two feet in length. This makes them significantly more difficult to transport than boxed solar panels and two people may be required to carry them. The Bogda Shan Expedition used camels and horses to transport the equipment to campsites, so battery weight was not significant concern, but where animal or vehicle transport is not available, large deep cycle batteries may be impractical. The following example shows how long a 100 Ah battery could sustain PC given typical expedition power requirements.

Table 13-10 Battery life from a lead acid battery.

Co-ordinate download from GPS:

  Download co-ordinate information from GPS: 10 mins.
  Process co-ordinate information in GIS: 25 mins.
  = (1.9 A x 10 minutes) + (1.9 x 25 minutes)
  = (1.9 A x 0.16 hours) + (1.9 x 0.417 hours)
  = <u>1.10 Ah per day</u>

Other field equipment needs: phone charging to maintain communications:

  5 hour charge every 3 days @ 0.255 A
  = 5 x 0.255 = 1.275 Ah per 3 days
  = <u>0.425 Ah per day</u>

Expedition planning using satellite imagery on laptop:

  30 minutes computer time each evening
  = 1.9 A x 0.5 hour
  = <u>0.95 Ah per day</u>

Number of expedition days using a 100 Ah battery life:

  1.10 Ah + 0.425 Ah + 0.95 Ah = 2.475 Ah per day
  100 Ah / 2.473 A per day = approx. <u>40 days field time</u>

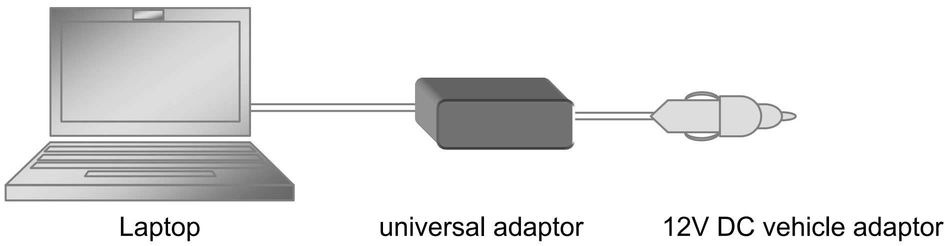
The conclusion is that a deep cycle lead acid battery should give about 40 days of operating time in a remote location. If a car can be reached during this period the battery can be recharged. Completely discharging a standard car battery can be detrimental to its operation and therefore deep cycle cells capable of complete discharge are recommended.

13.5.5 Power adaptors and inverters

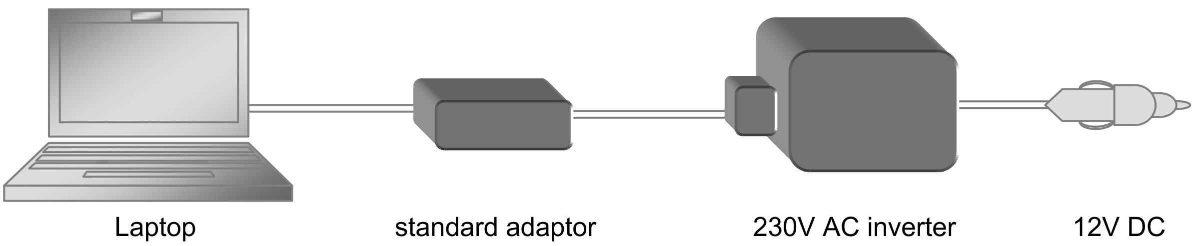
Field PCs bought in Europe can be run from 230-240 V mains power supply. They usually come with an external power supply to transform the 230 V AC to a smaller DC voltage (perhaps 10 – 20 V). Commonly field equipment will need to be used in areas away from mains power. In these cases, power can be supplied from a vehicle that can output 12 V DC. 12 V DC straight from the vehicle is not usually practical for directly running a device. Therefore, the best solution is to keep an inverter available for powering the equipment. An inverter takes the 12 V DC and changes it up to 230 V AC. This standard 'household' current can be transformed back to DC using the PCs external power supply.

There are methods for taking the 12V DC straight into the PC without using the step to AC. If the expedition can be certain of the electrical needs of the equipment then this is an ideal solution. However, taking power from the vehicle straight to the device, even through a transformer, can irreparably damage the equipment. Universal adaptors for changing the 12V DC to a laptop's required DC only work if the output is exactly what the laptop requires. If the voltages are different, the field laptop will be damaged. Due to this risk, it is sometimes preferable to go through an inverter. The other advantage of an inverter is that they can then be used to power any AC device, such as a battery charger, cellular phone, sat phone or PDA. Both inverters and universal adaptors cost around £50-£70. These two methods are shown in Figure 13-5.

Figure 13-5 Methods for powering a field computer from a vehicle:



Method 1: Universal adaptor replaces computer transformer and changes 12V DC into 15V DC required for a laptop. Method reduces cables and is easier to use in the field. This method requires that the adaptor is completely compatible with the field PC. It is not recommended because the field PC can be damaged by this method. Other forms of universal adaptor are discussed later.



Method 2: Power inverter is used to change the 12V DC into mains 230V which can then be used with the laptop power cable supplied with the computer. This method has more cables but is safer for an expedition.

When selecting an inverter the unit must be capable of handling the load required by the equipment. This needs to be calculated before leaving for the field. Load or power consumption is measured in wattage. This is sometimes printed on equipment; however, occasionally the power consumption is only listed as amps and volts. If wattage is not present, it can be calculated by multiplying the amps and volts: Power = (Current * Voltage) or P=IV.

Laptops draw currents in the region of 0.4 to 0.7 A at 230 V giving a power consumption between 90 W and 160 W. The current is different to the current listed in Table 13-8, as that showed current from the internal battery not from a 230 V electricity supply. To run a standard laptop from a 12V battery usually requires a 140 W power inverter. Some more powerful modern laptop PCs may draw more power than a standard 140W inverter can easily supply. In these cases, a 300 W unit may be required but that is unlikely and 140 W should suffice. The disadvantage of using a higher wattage inverter is the cost (which can nearly double from approx. £50-£70 for a 140 W to over £120 for a 300 W) and the weight and dimensions (over 2 cm and 100 grams heavier for a 300 W). The other problem with the units is that even when they are not plugged into an appliance, they draw power from the car battery. A 140 W unit draws 0.3 A and a 300 W unit draws 0.4 A. This could quickly flatten a car battery if left plugged in without starting the engine.

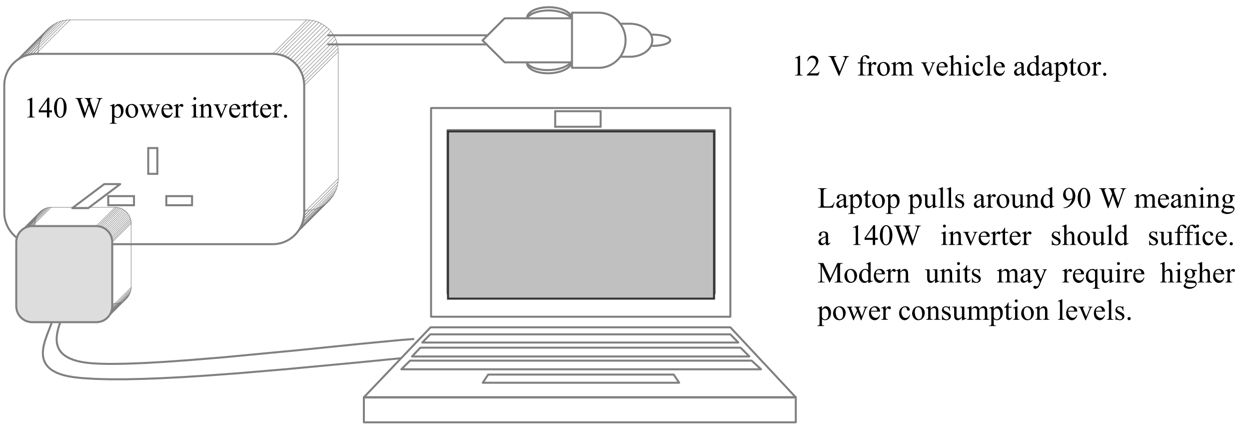


Figure 13-6 Schematic layout of equipment required to power a laptop in the field

Adapters can be purchased for GPS receivers that change the 12 V DC vehicle supply into 3 V DC for the unit without the requirement for an inverter. These are often not interchangeable between units so care must be taken to ensure that the unit is compatible with the power supply lead.

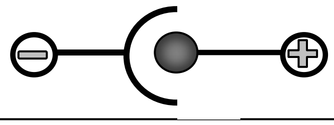
When on an expedition, being in the field limits the repairs you can do and the replacement kit you can obtain. A prudent measure when using equipment with DC adaptors is to purchase a universal adaptor plug. Though these plugs should never replace the manufacturer’s own plug and transformer supplied with the electrical equipment, they are a useful backup tool if things go wrong. Universal adaptors come with a selection of different sized input jacks to plug into various computers, mobile phones etc. Adaptors also have a switch to select the most applicable output voltage. They then change a 240 V electrical current into the current matching the device. You may also need a travel adaptor to change a 3-pin UK plug into the configuration used in your host country. Figure 13-7 shows the details on the back of a Toshiba standard transformer for a UK E800 PDA.

Figure 13-7 Reading electrical equipment requirements.

Input 100-240V @ 50-60 Hz

Output 5V @ 3A

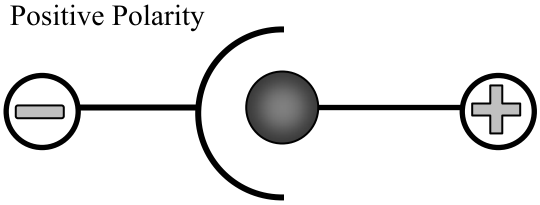
The diagram in the bottom right shows the polarity of the input jack, either positive or negative: in this case it is positive.



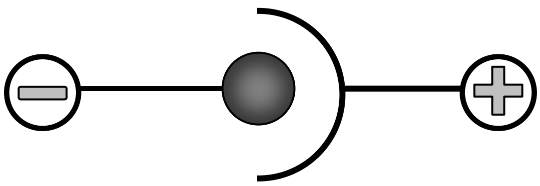
Ensuring you set your adaptor correctly and safely is of paramount importance. On the end of the adaptor where the multi-sized input jacks clip in, there are usually two thin metal prongs. The way the prongs are attached to the jack determines its polarity.

Determining the polarity of equipment

Positive Polarity

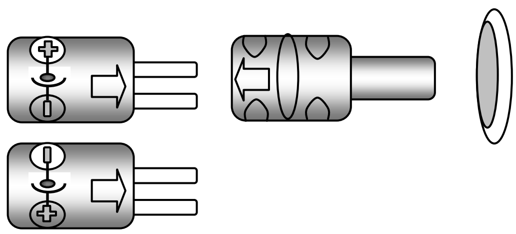


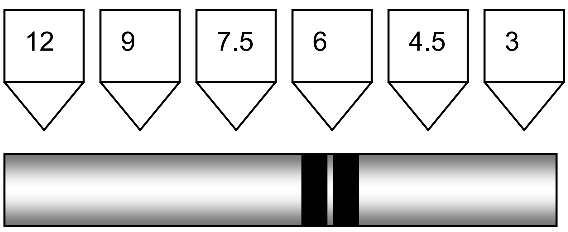
Negative Polarity



An electrical device connects to a power supply via a male-female adaptor plug. The male tip comes from the power supply and is either positively or negatively charged. This plugs into the DC input jack of the equipment

The polarity of the adaptor must match that of the equipment. Use the key on the left for determining the polarity. Connect the universal adaptor with the correct setting.





The Universal Adaptor is set here to 6 Volts

Power

Figure 13-8 Configuring a universal adaptor.

When using electrical equipment there are some basic standby kit you should have with you. Items that are common in towns may be unavailable in rural areas or in the field. You should not let a simple electrical failure end your GISci work and a little planning should help mitigate these incidents. The tables below show some of the more important back up equipment required.

Table 13-11 Basic field equipment requirements.

<table>
<tr><th>Equipment</th><th>Use</th><th>Cost</th></tr>
<tr><td>AC DC Inverter</td><td>Run AC equipment directly from a vehicle by scaling 12V up to 230/240 AC Voltage.</td><td>£70 - £150</td></tr>
<tr><td>Universal DC Adaptor</td><td>Run any DC device by scaling a 230/240 AC Voltage to any DC voltage.</td><td>£5</td></tr>
<tr><td>Fuses (5 amp)</td><td>Fuses are a very common item, but can be difficult to obtain in the field. Because of this an ample supply should be kept close to hand.</td><td>> £0.50</td></tr>
<tr><td>UK ⇒ Country AC adaptor</td><td>Convert UK manufactured equipment (3 pin plug) to the country of the expedition’s type.</td><td rowspan="2">£1-£5</td></tr>
<tr><td>Non UK ⇒ UK AC adaptor</td><td>Convert items manufactured outside of the UK to a 3 pin UK plug type. Useful for purchasing items outside of the UK and using them on return from the expedition.</td></tr>
</table>

<table>
<tr><th>Power Supply</th><th>Use</th><th>Cost</th></tr>
<tr><td>NiMh Rechargeable Batteries</td><td>Use 2100 or 2300 NiMh batteries to power GPS, Digital Cameras etc.</td><td>£20
(for four)</td></tr>
<tr><td>Standard AA alkaline batteries</td><td colspan="2" rowspan="2">Use if the NiMh cannot be recharged. £4 (for four) AA. Use branded makes such as Duracell or Energizer. Avoid Zinc.</td></tr>
<tr><td>Standard AAA alkaline.</td></tr>
</table>

Standard Kit	Use
Black electrical tape	Useful for patching cables and offering some degree of waterproof protection to a device.
Set of screw drivers (check compatibility)	Check you can take apart any equipment and service any parts you need to. This can save a lot of time in the field.

13.6 Caring for GPS receivers

GPS receivers are most commonly powered using 1.5 V AA batteries. Some units such as the Garmin Gekos use AAA batteries. Battery life can be increased by the use of battery save mode. Battery save mode reduces the refresh time of the receiver and only receives satellite data once a second. There should be no reduction in performance by using this option. Continuous operation for two field days (total +16 hours) per set of alkaline batteries with the receiver in battery save mode will be typical for most expeditions. Tests on rechargeable batteries show that they give half to three-quarters of a day’s use (~5 hours).

GPS units being used in vehicles can usually be powered directly from the vehicle battery, ideally via a 12 V adapter and a suitable power cable (available for most GPSs). Older vehicles in some parts of the world will not have modern adaptors, so if you know the car battery output and the required GPS input, then connection can be made by direct wiring with suitable fuse protection.

Operating conditions for GPS receivers are rated from -15°C to 70°C. If the GPS is to be used at the lower extremities of these temperatures such as subzero temperatures, lithium batteries are better than alkaline ones. Lithium batteries carry up to three times the charge of alkaline batteries and weigh less. Their charge is also affected far less by the cold, making them a good choice for cold weather environments.

13.7 Field communications & remote data access

In remote locations if communication from the field is required, expeditions are limited to satellite phones or cellular phones compliant with the Global System for Mobile Communications (GSM) standard. Current satellite phones are usually low bandwidth, high cost devices but offer access from most latitudes. The most popular type of satellite phone works on the Iridium network. The Iridium network uses 66 low earth orbit (LEO) satellites to allow communications anywhere in the world. GSM is cheaper but works within given cells, rarely more than twenty to fifty kilometres from a transmitter depending on line of sight and other factors. Such transmitters are usually only located in highly populous areas. Maps of estimated transmitter range for most countries are easily obtainable from network service providers. The Bogda Shan Expedition relied solely on GSM compliant communication. Signal strength in the valleys was most commonly zero, but was improved at higher elevations, even over 100 km from populous areas. Even though GSM is becoming more widely distributed no expedition should rely on its use and careful consideration should be given to field communications.

For a GSM phone to be able to '*talk*' to a cell it must be compatible with the frequency of the cell. There are essentially three frequency bands broadcast according to GSM standards. These frequencies are GSM 900 (900 MHz), GSM 1800 (1800MHz) and GSM 1900 (1900MHz). Any one phone would originally have been configured to communicate with one frequency. Since the mid 1990s handsets have been developed that can switch between frequencies. These are referred to as dual or tri-band phones. In the UK both GSM 900 and GSM 1800 are used by the main service providers. GSM 900 is used throughout mainland Europe and the Asia-Pacific region. GSM 1800 is also used throughout Europe and in Australia. The third band frequency, GSM 1900, is used in North America and will be introduced in Latin America and Africa.

If coverage is available, access to online databases and datasets is possible but limited to the capability of the handset. Most handsets operating on the GSM network offer 9.6 Kbs connectivity (note Kbs means Kilobits per second compared to KBs which is kilobytes per second, the same notation applies to Mb and MB). GSM speeds compare poorly with a standard V.90 landline connection that offers up to 56 Kbs. Some high-speed WAP enabled phones extend to 14.4 Kbs. GPRS (General Packet Radio Service) uses GSM to combine channels to provide an upper limit of 144 Kbs. This technology is sometimes referred to as G2.5. There are two different types of GSM 2.5 technology. The highest implemented G2.5 technology is the High Speed Circuit Switched Data (HSCSD), which allows communication speeds up to around 40 Kbs both up stream and downstream. In areas of limited coverage, these speeds will fall below quoted maximums. The other form of GSM is an always-on data connection where data volume rather than connection time governs the cost of the service. This form of GSM is much more localised in availability and ranges in speed from 28.8 Kbs to 36 Kbs and is sometimes, erroneously, called GPRS.

Where higher speed access is required, the most significant increase will be the introduction of Universal Mobile Telecommunications System (UMTS), also known as G3 or 3G (Third Generation). G3 will offer maximum throughput of 2 Mbs but in most common installations runs at 384 Kbs in areas of good coverage; it is still unclear how many countries will implement the service. Many phones that are 3G enabled are currently being sold with the data communication parts disabled. Very few service providers currently allow data to be transferred through the UMTS network. As of the time of writing the only data implementation of UMTS in the UK is the Vodafone 3G Mobile Connect PCMCIA card for laptops. This is rated at up to 384 Kbs in areas of good signal strength but rapidly falls off towards modem levels in poorer coverage. Obviously, this type of data is only available in a few major cities worldwide but could be useful for a team to upload their data during periods when the expedition passes through a city. Remote access via satellite phones does not rely on a country's adoption of a given technology. Satellite services of significance to expeditions include Teledesic (*www.teledesic.com*), and EUTELSAT's Hotbird satellite (*www.eutelsat.org/home/index.html*). These are moderately fast services operating at around broadband speeds.

A third alternative, SkyBridge (*www.skybridgesatellite.com*), will use 80 satellites offering 20 Mbs downstream and 2 Mbs upstream connectivity with 30 millisecond (fibre-like) latency, contrasting geostationary earth orbit's 500 millisecond latency, due to their 913 mile low earth orbit. SkyBridge's 435 mile radius footprint gives continual line of sight to at least one satellite for latitudes –68° to +68°.

Any of the systems described would offer high-speed access in remote areas but the future implementation of the technology is still uncertain and expedition access will be controlled by their cost. Iridium currently offers two data packages with global access but they are rated at 2.4 Kbs and 9.6 Kbs significantly below the specification of either GSM or the newer mobile data rates. The take up of sat phones in Africa is currently being encouraged. An initiative called "Go Africa" from Telenor Satellite Services is the cheapest method for getting access to satellite communications in Africa. The system uses Motorola 9505 handsets on the Iridium Network and offers a 40% discount over any other sitcom solution.

13.8 Field concerns with cellular phones

Standard cellular phones are powered by rechargeable Li-Ion battery operating at around 3.6 volts similar to those discussed in Section 13.5.2. Battery time between charges varies according to the handset used. Typically, you can expect between 7 and 14 days of standby in areas of good signal strength. In remote locations signal strength will often drop to near zero or zero. In these environments, cellular phones increase signal strength in an effort to boost reception from transmitters: in such conditions battery life will drop below three days. Actual usage times vary but talk time of three hours in good signal areas, will drop to two in areas of poor to medium signal strength. Calculating the projected battery life of a mobile phone is more difficult than with a PDA. The phone's battery will be listed in the same format (usually sub 1000 mAh) but battery drain is not constant. Older monochrome phones pull less than ½ mA when in standby mode and somewhere nearer 150-200 mA when transmitting (dependant on the reception quality). Modern colour phones pull closer to 1 mA in standby and similar levels when transmitting. Some large screen phones have higher currents with smart phones and UMTS (3G) phones pulling closer to 10 mA. Obviously additional features such as GPS and Bluetooth built into the phone will increase battery drain. GPS often adds around 5 mA and Bluetooth adds another 5mA. Most phones do not lose their memory when discharged but modern phones can be difficult to keep well charged in the field. Phones such as the Motorola A835 with AGPS (Assisted GPS, a method of using additional radio signals to keep the GPS working indoors) will pull over 15 mA on standby, which on a 980 mAh battery only gives just over two days stand by.

Small solar panels are readily available that are designed for mobile phones. These units are often more compact than those shown in Section 13.5.3 and fold in two making them light weight methods for powering the device. They charge both 3.6 V NiMh and Li-Ion phones. However, the units are often manufacturer specific and only suited to certain mobile phones. As such, if many electrical items are being taken into the field such as GPS receivers, PDAs and battery chargers then it is better to take a multi-purpose solar panel rather than a device specific one.

It is important to check that the phone used on the project is compatible with the cellular frequency of the host country visited for the GISci project. Even if the phone is compatible it will only work if your service provider has enabled the handset to talk to different cells. This has to be done before leaving for the field by contacting the service provider and requesting roaming to be enabled. There is usually no cost for this service but it must be switched on before leaving for the field. Enabling this after you have left is very difficult. Calls, however, can be very costly when phoning from abroad and bear in mind that you will also be charged a portion of the call cost for receiving calls to a handset while abroad. These costs should be investigated thoroughly before leaving for the field, as they can cause severe problems when returning home.

As with most electrical equipment, phones are equipped with LCD screens. The usual problems persist with these when used in inhospitable climates. The screen will cease to function if kept below 0ºC for any period. In addition, units are not generally waterproof though some more rugged units are available. Rugged units include the Nokia 5140. The Nokia 5140 is compatible with a clip on GPS attachment. It should be noted that the colour screen on most new phones is usually not suited to expedition work. Modern colour screens are very difficult to read in bright daylight and monochrome screens are often a better choice. The more additional features a phone uses the more it will drain the Li-Ion battery.

13.9 Photographic equipment and geo-tagging

Photographs add immense value to an expedition. A brief note is included here on their role in a GISci focused expedition. For inclusion in a GIS the images must be in a digital format. This could be film that is scanned into a computer or an image from a digital camera. Digital cameras are becoming more powerful and better suited to expedition work all the time and have many uses that an expedition might find valuable.

Digital cameras can be configured on the fly with the ability to change ISO settings, exposures etc. quickly between shots. Some of these settings would require complete film changes in standard film cameras especially where film speed need altering. Digital cameras also allow the photographer to view the image immediately to be certain the picture has come out. The author has been on an expedition where an entire six-week field project's photographs were rendered unusable because the ISO dial on the expedition camera had been knocked onto the wrong setting. All the developed pictures came out bleached white, an unfortunate event that would have been avoided with a digital camera.

A digital camera records data onto an array of CCDs. This is similar to the remote sensing platforms discussed in Chapter 5. Cameras are rated with a Mega Pixel (MP) value to describe their resolution. Basic entry-level models are rated at 2 MP but 3 MP make good all round cameras. Higher resolution 4-6 MP models make excellent cameras but may be too expensive with little appreciable gain for the expedition. Higher resolution models exist beyond 10 MP that are reserved for specialised professional applications. The expedition should be aware that a MP rating does not fully describe the quality of a camera. Other features such as lens quality and size of CCD etc. will also affect the final image. It is worth noting that CCDs are significantly less responsive to light than film. As a result digital images are good in bright light but require a powerful flash in dim conditions or appear 'noisy'. In addition, unless the camera has a large CCD array then resolutions above 3 MP can be very noisy because the same amount of light is being used on a higher number of CCDs. In this case, a 3 MP camera is often preferable for low light conditions. Table 13-12 shows the X and Y resolutions of these camera types.

Table 13-12 Resolution of typical camera types.

Camera	Resolution	File size (compressed)
2 MP	1600 x 1200	600 KB
3 MP	2048 x 1536	900 KB
5 MP	2560 x 1920	2 MB
7 MP	3072 x 2304	3 MB

The sizes of print shown in Table 13-12 are at high print quality and sizes can be increased with slight loss in clarity as discussed below and shown in Table 13-13. The file sizes quoted are for a camera employing JPEG compression, a feature all cameras employ. A 3 MP image stored as a TIFF or BMP would take up around 9 MB but saved as a JPEG it would only take around 1 MB. JPEG compression does reduce the quality of the print but the difference is barely detectable in all but the highest levels of JPEG compression. It is therefore generally not worth using a RAW or TIFF format even if the camera has one. Lowering the level of compression increases the print size slightly but vastly increase the file size. This trade off is rarely worth it because the team may find uncompressed images are too large for most purposes and take too long to backup and store on the web. Certainly, as far as presentation graphics on a website are concerned, images should rarely be more than 100 KB. The team should check all these factors before leaving for the field.

Larger sizes should be reserved for printouts while images on the web and in presentations should be smaller. Printing out high quality images can be difficult and time consuming so it is important to understand how the quality of output is affected by the image size. Printers are not rated in Pixels but in dots per inch (DPI). A DPI rating for a good photographic quality inkjet printer might be 4800 x 1200 DPI. Because a printer cannot print every possible shade of colour that can appear in a photograph (16.3 Million), it improvises this colour by mixing dots of coloured ink from its printer heads. Typically the colours magenta, cyan and yellow are used for the primary colours, with a second head supplying either black or a three colour mix for flesh tones including pink, pale blue and black. The actual DPI rating of a printer is the quoted resolution divided by the number of colours in the colour head. In the case of most printers this would be (4800 / 3) x (1200 / 3) = 1600 x 400. The required DPI to fool the human eye is considered to be 300 x 300. So modern printers easily achieve this but older printers may struggle. There are also many issues regarding ink quality and paper quality that influence the final product. To equate the MP rating of cameras to a final image size on paper a factor of 300 DPI should be used. Unfortunately, because of JPEG compression the actual acceptable output size is slightly smaller and Table 13-13 summarises the resultant outputs.

Table 13-13 Output sizes of typical cameras.

Camera	Output size (perfect)	Output paper size (perfect)	Acceptable size
2 MP	4” x 3”	small photograph	large photograph
3 MP	6” x 4”	standard photograph	large photograph - A4 page
5 MP	7” x 5”	large photograph	> A4 page
7 MP	8” x 6”	large photograph	< A3 page

All data for a GISci project needs some form of co-ordinates. Typically for photography the co-ordinates will be transcribed in a field notebook. More recently, the text strings from a GPS memory have been used to reference where a photograph was taken as shown in Section 13.3.2. These text strings can encode photograph numbers but they are cumbersome and better methods exist for encoding co-ordinates. Some modern cameras are entering the market with connections for a GPS or soon with GPS modules. The method these modules use is to encode the co-ordinates in the embedded header file of the digital photograph. The digital pictures, even when stored as JPEGs, have data referred to as an EXIF format embedded in them. The EXIF format has a string reserved for co-ordinates and the GPS modules populate them. Using a GPS module is an excellent way of attaching co-ordinates to a picture but it is expensive and there are cheaper methods. All digital cameras record the time the image was taken. Similarly, GPS receivers record the time that a waypoint was taken (it should confirm that either the trackpoint or waypoint downloads time from the expedition receiver and although this is common, it should not be assumed). Software can be used to match the GPS co-ordinate to the photograph using matching times. This can then assign the photographs a co-ordinate to relate them into the GPS. One software package for this method is Robo-Geo found at *www.robogeo.com/home*.

13.10 Selecting the expedition hardware

In advising expeditions on the hardware required, it is often difficult and unhelpful to talk in detail about requirements without mentioning manufacturers, models and suppliers. This discussion should, however, not be taken as a complete summary of every product on the market and where a company name is mentioned it should be assumed that other similar companies exist that supply equally capable systems. In all cases, research should be conducted to look into the current situation before purchasing any equipment. This information is only accurate at the time of writing (2004-2005).

Hardware must be purchased that will survive in the climate and conditions that the expedition is visiting. For most expeditions, cost will be a significant factor in selecting project kit. However, if mission critical expedition equipment fails in the field the cost to the team could be substantial. A device failure may mean vital data cannot be collected and may even cause the project to fail or have to be temporarily abandoned. Insuring against this by using the correct equipment is a valuable and cost effective strategy. Field hardened equipment is very expensive but worth the cost. It is better to try to obtain this equipment second-hand or through a sponsor, such as a University, than to use hardware that is prone to failure.

If an inhospitable climate is a significant consideration, either with temperature extremes or with issues of water or dust near the computer, then hardened laptops are required. For extreme temperatures Itronix laptops can operate between –20 °C to 60 °C and can be extended to work at lower temperatures down to ~-30°C with additional battery save hardware. Itronix PCs significantly lag behind standard PCs and laptops in processing power but are becoming more powerful all the time. There are several laptops available from Itronix, older models have included the Itronix GoBook Pro and GoBook II and their most up to date model available in late 2004 is the Go Book III. The Go Book Pro featured a 700 Mhz PIII-M processor, 256 MB RAM and 20 GB IBM hard disk. The GoBookII featured a 12.1-inch screen and a faster processor. The current model meets and exceeds the MIL-STD 810F standard and comes equipped with a 1.8 Ghz processor and up to 2 Gb of RAM. The screen is touch sensitive and uses 'Outdoor Viewable Transmissive' to make it more readable in direct sunlight (a major problem with most laptops). These specifications will continue to become obsolete but field hardened laptops will typically stay 18 months behind the most powerful laptops available. These Itronix PCs are very strong and will survive metre drops onto concrete and have IP54 ratings. The drawback of these models is the price, which is around £4,500 for the current models. Older Itronix kit features solid-state storage but both GoBooks use a single spindle drive encased in shockproof gels at the heart of the PC. More details can be found at *www.gobookmax.co.uk*. The current models use 5,400mAh lithium ion batteries with inbuilt battery conservation software that allows the CPU to run at 25, 50, 75 and 100 percent power. On its lowest setting, the GoBook lasts for up to 3 hours 20 minutes of continual heavy usage or 5 hours at lower usage settings. The Itronixs PCs also now have wireless 802.11b and Bluetooth for increased connectivity options while in the field as well as a GSM and GPRS card for field communications.

The Panasonic range of Toughbooks has a long pedigree in the area of hardened laptops but more recent models are not as sturdy as some of the older models. They are, however, significantly faster than other hardened laptops with speed ratings that are more inline with standard laptop PCs. The modern Panasonic range is also much cheaper and depending on the model retail for between £1500 - £2000. A recent test in Computer Shopper (November 2003) reviews a range of hardened PCs and the reader can find more information on different manufacturer's equipment from this review (see *www.computershopper.co.uk*).

Figure 13-9 Field PC and wireless GPS unit. The GPS shown here has no LCD screen and can communicate wirelessly via blue-tooth. The advantage of this is that the GPS unit can be used in conditions below 0℃. The Panasonic CF-27 can also be used in inhospitable conditions without risk of damage.

When selecting a PC it is vital to make sure it is compatible with the equipment you will be taking into the field. If the PC is required to run from a car it must have an inverter to take the 12V DC and change it to a power supply compatible with the laptop. If it is to be used with a GPS unit it must be compatible with the connector on a GPS, usually an RS232 connector.

While all modern laptops feature similar battery save settings most are generally unsuitable for fieldwork due to either their fragile nature or the power overheads from most high mega-hertz chipsets. Lowering power consumption helps, using techniques such as the GoBook's speed reduction or Intel's Speedstep, but it is unrealistic to budget for over 2 to 2½ hours usage from one battery on a standard PC. This combined with the expense of new laptops means older models are generally more suited to expedition work.

In general, slower processors will draw less current from the battery. If battery life is a significant consideration then the expedition should look for products powered by lower consuming processors such as those using the Transmeta Crusoe or Intel Centrino chips. Lower specification machines may last between four and six hours. The IP rating of these machines should be checked because they are not designed for use in inhospitable regions. In a hot dry environment a low IP rating for moisture might not be a major concern. Try to match the kit you obtain to the conditions of your expedition.

GPS receivers must also be targeted to the conditions on the expedition. If the expedition will be under tree cover an external antenna is vital. The capabilities of this antenna should always be tested in a local forested environment before leaving for the field. If the conditions will be cold (around 0°C) then a receiver such as the Silva Multi Navigator should be considered. If the conditions are below this then special care needs to be taken. A GPS without an LCD screen is often preferable with a link to a device that can be kept sheltered and protected. Three common models are shown below in Figure 13-10. A better method still, is to keep the GPS entirely sheltered and only use an external antenna. This would take the GPS down well below zero.

Figure 13-10 GPS Receivers: Basic ETREX, Silva MulitNavigator, AnyComm GP600. The ETREX has an operating range of 50°c to 0°c, The Silva 50° to -15°C and the AnyComm 60°c to -20°C. For temperatures beyond this a GPS using an external antenna is the best solution but that requires the unit to be stowed somewhere protected from the elements and generally negates the use of waypoints.

The Bogda Shan Expedition used many of the technologies listed above. Because vehicles could not be driven to the basecamp a deep-cycle lead-acid battery was carried to the camp. This battery provided power for the entire time in the field. The GPS sets performed adequately in all conditions and the use of the field hardened Panasonic Toughbook meant that data was less vulnerable to loss or corruption. The GPS sets all performed well, but for the high altitude mountaineering sections, the ETREX was the preferred device. The small size and internal antenna make it the easiest to handle. The casing is also ruggedised giving good shock resistance and waterproofing. These factors help make new models like the Garmin ETREX range or Magellan meridian series the most suitable devices for difficult terrain.

13.11 Purchasing equipment

As explained in Section 13.10 there are many alternatives to buying expedition equipment, including borrowing from a university department or renting equipment. In some cases, purchasing equipment it the only valid option. In this case, the expedition will no doubt have to put a significant effort into obtaining equipment as cheaply as possible. This section briefly looks at some methods for reducing the cost of expedition hardware.

A complete set of GPS receivers for all members, combined with field hardened computers, professional photography equipment and PDAs for field recording is an ideal scenario but is made impossible by the immense cost (several thousand pounds). Instead, there are some methods that can be used to reduce the cost. The expedition laptop might be the most expensive part of the equipment required. Computers get faster and more capable all the time; however, there is not a need to use the fastest PC when in the field. The Bogda Shan expedition used a Panasonic CF-25 laptop running at around 200 MHz (see Section 13.2 and Figure 13-9). Though this was not ideal in all case it was acceptable for most uses. Recently CF-27 have been appearing as refurbished laptops in some mail order catalogue listing for around £200 GBP + VAT (SterlingXS June 2004). These are excellent computers for field use even though they have limited processing power by today's standard. The CF-27 is about 4 years old but would have cost £3,500 in mid 2000. The CF-27 runs an Intel 266 MHz MMX processor with 168 MB Ram and a 4 GB hard drive. These computers make excellent tools for expedition use. Second hand machines can often be picked up on auction sites from the Internet such as EBAY (*www.ebay.com*). These sites are useful but bear in mind that Li-Ion batteries have a very limited life so do your best to check before purchasing that the batteries still work.

A very tempting plan for obtaining equipment is to purchase it over the Internet from a non-UK company. Field equipment in the US often costs a similar dollar value to the sterling value, i.e. a £1000 PC might cost around $1000 in the US. Depending on the current exchange rate this can look very tempting. At the time of writing the exchange rate is 1.9059 dollars to the pound. This appears to nearly half the cost of equipment. However, there are some important considerations. Equipment brought into the UK is subject to three possible taxes: customs import duty, excise tax and value added tax (VAT). This coupled with the added expense of shipping across the Atlantic means the equipment is not as good value as might have been thought. Import duty is a complicated issue. Import duties are variable and range from 0% through to over 10%. For example, a PDA has no import tax but a PDA with calculator functions incurs a 3.7% tax. The expedition can check possible import taxes by visiting *www.hmce.gov.uk*. To determine the actual level of tax requires an 8-digit TARIC code. This can be found on the website and allows a full quote to be calculated. For expedition surveying equipment the code takes the form 90 – 15 – XX – XX and general taxes are around 3.7%. This duty is imposed on all goods over £7. Excise duty is not applicable for expedition imports and applies to alcohol, tobacco and some other closely monitored imports. VAT is calculated at 17.5% on top of the cost of the goods + shipping + import duty and is charged on goods over £18. As an example, an ETREX Venture GPS retails in the UK for around £114.38 but only $124.95 in the US. This appears at first glace to convert to a price of $124.95 / 1.9059 (current exchange rate at time of writing) = £65.56. The actual difference in price is described in Table 13-14.

As can be see in Table 13-14 there is still a benefit from importing goods but the time delays in obtaining them (some companies wait an additional five days before dispatching international orders) and the problems in returning goods may make the process unsuitable. Some retailers may be difficult to contact in the case of the goods needing to be returned and UK laws will be of little help if the equipment is not fit for its purpose. US goods also come with US power adaptors; converters will need to be bought to run them in the UK.

Table 13-14 Import taxes on imported GPS equipment.

Item	cost from UK	cost from US ($ / £)
Device	£ 114.38	$ 124.95 = £ 65.56
Shipping	£ 5.00	$ 30.00 = £ 15.74
Subtotal	£ 119.38	$ 154.95 = £ 81.30
Import Duty @ 3.7%		£ 3.01
Excise (N/A)		£ 0.00
VAT		£ 14.76
Total	£ 119.38	£ 99.06

An important note in a discussion on importing GISci equipment is the need to declare the equipment correctly to customs. There is a possible temptation to use a slightly different code to avoid the import duty. This is illegal and should not be done. Some exporters may state on their website that goods will be labelled to pass favourably through UK customs (either through a change to the goods description or by undervaluing the goods). You should be aware that as the designated importer, under British law you are responsible for the labelling and declaring of goods even if all this is handled by the shipper in the US. If a declaration is found to be incorrect you may be liable to financial penalties and criminal prosecution and the goods can be forfeited. It is essential any imports are declared accurately.

13.12 Disaster recovery planning

13.12.1 Data backups

All systems are prone to failure and a recovery plan is essential in any field operation. The first and most critical factor in data-disaster recovery planning and mitigation is to keep a backup of your data. A backup should consist of all the files in the GIS and be kept separate from the hard drive storing the GIS. Ideally, it should be located away from the basecamp. Many of the data storage devices discussed below are listed in Section 13.3. A rough price guide can also be found in Table 13-3.

A simple backup procedure is to use a floppy disk to copy key data from the host PC to a temporary storage medium. The disadvantage of a floppy disk is its limited storage space (<1.44 MB) and its susceptibility to corruption. Floppy disks are not robust and should not be recommended for use in the field. Alternative storage medium include recordable and re-writable CDs (CD-R and CD-RW). The advantage of CD based technology is that they can store between 550 and 700 MB depending on the type used. A CD is generally more robust than a floppy disk but the disadvantage is that they require a more specialised drive. Also if the disk is not 'closed' after a recording phase a standard CD-ROM will not be able to read the data on the disk.

The storage space for a GIS is often actually quite small. The point and shape data files are often only a few KB in size. The Bogda Shan Expedition discussed in Section 17.1, generated very large quantities of GPS data. However, the total size of the database was only 988 KB. This would quite easily fit onto a floppy disk. The image files were much larger at just over 1 GB. Image files could easily be backed up before the expedition so making additional backups as the expedition progresses is commonly not necessary. Other storage mediums include DVD RAM, DVDR and DVD Recordable, all of which are different standards of DVD recording. These allow about 4.7 GB of storage onto a single sided, single layered disk.

Other types of data storage include USB key ring datasticks. These very small devices clip into the USB slot of a PC and act as a removable hard disk. When used on machines running Windows 98 SE, Windows ME, Windows 2000, Windows XP, or any Apple Mac using OS9 or OS X they are auto detected and require no software. The sticks come in sizes from 16 MB up to 2 GB. Larger sticks are becoming available all the time. They form a robust and convenient way of storing data. USB devices are powered through the USB port by the computer they are attached to. They commonly draw a 94 milli-amp charge from the battery.

The problem with floppy disks, CDs, DVDs and memory sticks is that they are still generally storing data locally. A much better method is to use a none-local storage medium. As described in Section 13.3.5, the best none-local storage area in general, is the Internet. If an area of the Internet is prepared in advance then data can be uploaded and protected. The most common way of doing this is to use FTP (File Transfer Protocol). FTP is built into Windows by default, and the common programme used is Telnet. More user-friendly programmes can be downloaded. One example is Cute FTP. The main disadvantage of using non-local storage is that it requires connection to the Internet, which requires some form of telecommunication. The most common form would be a phone line. In the field, where this is not available, a mobile phone may suffice or an Internet café might be located in a nearby town.

Different types of connections are discussed in Section 13.7. A basic field configuration for lightweight FTP can be seen below in Figure 13-101. If the party intends to use FTP on a Pocket PC they should ensure the device has an FTP client. This is not always available as default and software may need to be downloaded or purchased to make it operational. There are a number of free FTP clients, including Robust FTP 3.0, available from many of the download sites such as *www.pocketpccity.com*.

Figure 13-11 A possible FTP / HTTP field configuration using small apparatus.

There are many cheap file stores available and not all can be listed here. One company of note is the US online storage specialist Streamload (*www.streamload.com*), which will allocate 10 GB of free storage space to a user. This can be accessed when the expedition wants but with a monthly limit of 100 MB of transactions. Alternatively, unlimited storage with a 1 GB transaction limit starts at $4.95 a month. If such large allocations are not required, the team should check whether they have free webspace from an Internet Service Provider (ISP). ISPs often allocate between 5 and 30 MB to a user for personal webpages. This might be an acceptable size for storing GPS data and field notes. All FTP links require an upload via a phone line. Some Internet cafés might not support FTP and the cost for dialling into an ISP from abroad may be prohibitive. In these cases, it might be easier to look at using an email account. Email accounts can usually be accessed from anywhere, especially ones with Internet portals. A good example of free email through the Internet is Hotmail. Hotmail offers free email storage of 250 MB or a paid for service of 2 GB for £14.95 a year. Hotmail cannot be used as a standard FTP site but users may feel more comfortable emailing data to a secure location rather than relying on FTP. There is a 30 MB per email limit on Hotmail's paid account but there is no limit on the number of emails that can be received in a month. There are many other similar email services to Hotmail. These include Google's GMail (not publicly available at time of going to press) offering 1 GB and Lycos' email services offering between 1 and 10 GB of space. These can be found at *gmail.google.com* and *www.lycos.co.uk* respectively.

13.12.2 Data recovery

If data on a disk becomes corrupted then there are some basic techniques that can be used to salvage information. A hard disk and floppy disk work in similar ways. The sectors on the magnetic disk store data. If these are corrupted, it is often possible to move the data to recover most of it.

The first step is to scan the disk for errors. Scanning the disk can often show that there are problems. Microsoft has a scandisk tool built into all versions of Windows and DOS (typically accessed as: My Computer ⇒ C:\ ⇒ Properties ⇒ Tools ⇒ Check Now).

The recovery option will attempt to take the data on those sectors and save them to a text file. Though this may result in a loss of the exact data type it should allow the basic information to be put back together. Another effective method, especially with floppy disks, is a disk defragment. This too is included in Windows and DOS (My Computer ⇒ C:\ ⇒ Properties ⇒ Tools ⇒ Defragment). Defragmenting moves the information on a disk into continuous sectors; the intention is to speed up disk access times by making the information contiguous. However, it also has the effect of moving information away from corrupted sectors. This can be an effective method for recovering data from a floppy disk. If a hard disk is very badly damaged by water or fire, specialist companies can normally still recover the data. These services can be expensive but save the expedition having to re-do work to recover lost information.

13.12.3 System recovery / repairing catastrophic system failures in the field

Sometimes data cannot be recovered form a hard disk. If the disk is in a stable and undamaged state (i.e. there are no bad sectors detected by scandisk or the number of bad sectors is not increasing with time) then a restore should be possible. It is always advisable to take a copy of the Operating System disk with you, as well as a boot disk containing basic boot files such as command.com, config.sys, and autoexec.bat. Ensure these files contain generic CD drivers such as atapi to get the PC started. The bootdisk should also include basic DOS programmes such as scandisk, format and fdisk. If the hard disk is damaged and contains bad sectors then replacing it is preferable. When replacing the hard disk, not just the GISci data but all operating system files will be lost requiring the system to be re-loaded. This is also true if the field PC has to be completely replaced by another unit.

A complete restore is only possible if all the GISci data has been taken out into the field on disks. This will require creating disks for all the imagery etc. before venturing into the field. It is also advisable to have all manuals either printed in hardcopy or stored as documents (PDF) to help get the various parts of the GIS project up and running. There are a number of standard programmes that should be taken into the field to help you with this task. The Operating System disks are essential; even if a restore is not needed, you may require additional programmes/drivers from the original disks. Other software of vital importance is a copy of an Office Suite (such as Microsoft Office/Works, Star Office etc.), Adobe Acrobat Reader, WinZip and a FTP client. There may be other software specific to your expedition that you should carry with you. These additional programmes will include the disks for the GIS software and any supporting software such as GPS Utility. These will be essential to ensure that data can be restored or for the field PC to be replaced. A simple method for restoring the system is to use a utility such as Norton Ghost to ghost the main disk of the computer. Ghosting creates an exact copy including the boot record. If a ghost is taken at regular intervals it should be possible to very quickly get the expedition PC back to a workable state.

When using a PDA in the field it is possible to install some of the programs to the removable media cards. After a battery discharge the unit will hard reset back to its factory standard state. This is a state where only the operating system and key operating system applications are installed. To re-install the additional expedition software such as ArcPad or GPS Tuner requires the PDA to be reconnected to a computer and have the files transferred back across. To mitigate this some software can be installed to a CF or SD card. These cards retain their memory after a battery discharge. This is one method for ensuring the PDA can be brought back up to speed as quickly as possible in the case of a system failure.