Field Techniques Manual: GIS, GPS and Remote Sensing

- <u>Section A: Introduction</u>

Chapter 1: GIS, GPS, Remote Sensing and Fieldwork

1 GIS, GPS, Remote Sensing and Fieldwork

The widespread use of computers has led to the development of new technologies, collectively known as geographical information sciences (GISci), for mapping and monitoring features on the surface of the Earth. Foremost for exploration and fieldwork among these technologies are: *geographical information systems* (GIS), which can take digital datasets and produce maps showing features of interest in matter of seconds; the *global positioning system* (GPS), which allows positions to be determined to ±10 m anywhere on the Earth's surface; and methods of observing features from a distance, such as photography or infra-red scanning, known as *remote sensing*. These GISci techniques complement the surveys and sampling that are at the heart of scientific exploration (Figure 1-1): they greatly enhance the types of fieldwork that can be carried out, reduce the amount of time needed for many tasks and improve the quality of results.

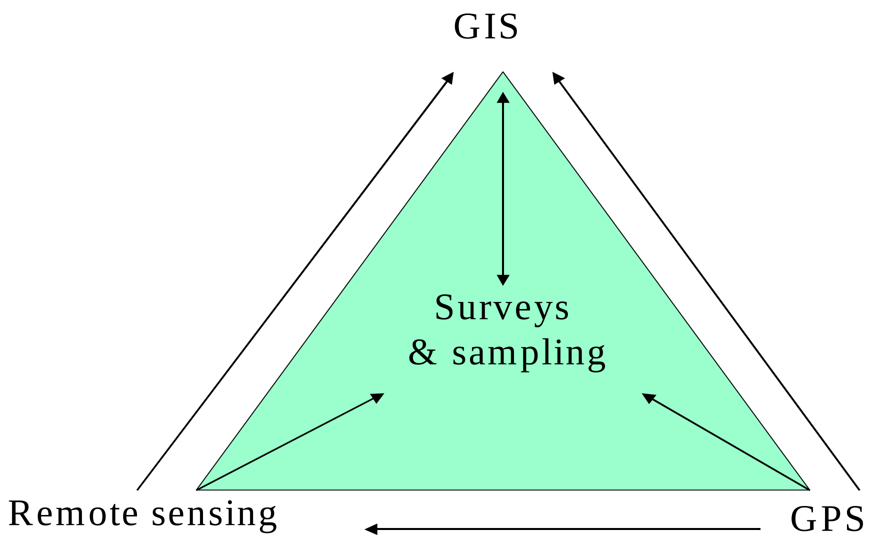

Figure 1-1 Geographical information sciences and expedition fieldwork.

A fundamental objective of most exploration is to observe and record information about the part of the world being studied, for instance by field surveys, photography, or questionnaires. The development of ever-cheaper and more powerful computers, GIS software and GPS kit, along with low-cost satellite pictures of the Earth, has greatly improved the potential of expeditionary fieldwork to record, analyse and present data that may help us to improve conditions on this beleaguered planet.

Remote sensing provides us with a means of recording the distribution of features on the surface of the Earth and changes in those features over time: it is often the only source of new data about a region that will be available to you, prior to you going there to collect field data. Your GPS will tell you where you are in your study region and allows you to input your sample locations into a GIS. A GIS is a means of combining existing data and new data from fieldwork or the interpretation of remotely sensed images. GIS-generated maps greatly reduce the original amounts of data and can be designed to focus on specific themes of interest to your research.

This manual aims to provide expeditions with details of fieldwork techniques, from 'traditional' compass-based surveying, through to the use of GIS to show GPS-located sites on satellite images displayed on a laptop screen in, say, Amazonia or the Himalayas. There are many ways in which geographical information sciences can help with fieldwork projects, these are just a few of the possible applications:

- *Logistics:* planning routes and navigation
- *Research:* mapping vegetation, wildlife, urbanisation, soils and geological features
- *Monitoring:* data logging of fire extents, forest loss, river channel changes
- *Conservation applications*: assessing biodiversity, park zonation, impact assessment
- *Technology transfer:* training local technical staff, donating hardware and shareware
- *Education:* maps for displays, involving schoolchildren with fieldwork.

1.1 Organisation of this manual

There are four parts to this manual: data, techniques, planning and results. The first set of chapters examines the various types of *geographical data* and the *geographical frameworks* fundamental to mapping. The main types of geographical data used on a fieldwork-based project are illustrated in Figure 1-2 and fall into two categories: (i) externally produced maps, images, photos and databases; and (ii) data collected by the expedition, using surveys and sampling. Data stored in a GIS can be manipulated, integrated or combined with other data sets for research or management purposes. The merging and statistical analysing of spatial (map-based) data sets provides new opportunities to formulate and test hypothesis on the organisation and functioning of the socio-economic or geo-ecological system being examined.

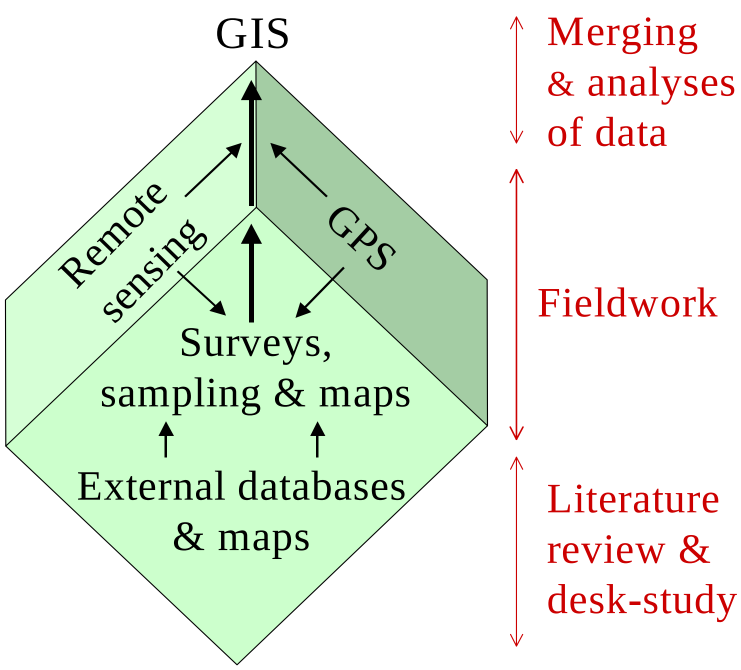

Figure 1-2 Data sources for expedition fieldwork. The arrows in the diamond indicate how data from one source can feed into another.

For data to be used in a GIS, they first has to be geo-referenced or 'fixed' in geographical space. The Geographical Framework chapter examines the various ways in which this can be done, and associated problems. Geo-referencing uses co-ordinates to locate points, with longitude and latitude being the fundamental system. Certain assumptions need to be made about the shape of the earth and these must be made clear in any GPS or GIS co-ordinate system, in the form of a spheroid and a datum. For most purposes in GIS and on paper maps, a flat ‘x,y’ co-ordinate system is far easier to deal with than a spheroidal ‘longitude, latitude’ system, so a further step is introduced to the geographical framework, that of map projections.

The next set of chapters provides detailed reviews of *GISci techniques* that are of use to expeditions, moving from geographical information systems (GIS) to remote sensing and photogrammetry, before considering surveying and the global positioning system (GPS). GIS has been in use for several decades and is having a pervasive impact on the conduct of expedition fieldwork. Burrough & McDonnel (1998) define a GIS as “a powerful set of tools for collecting, storing, retrieving at will, transformation and displaying spatial data from the real world for a particular set of purposes”. Some outstanding textbooks on the application of GIS have recently been published (Burrough & McDonnell 1998, Johnston 1998, Heywood *et al.* 1998, Wadsworth & Treweek 1999, Longley *et al.* 2001). Expedition fieldwork will almost always involve the production of some form of map, both from field surveys and from the interpretation of features on images from aircraft and/or satellites, often using geomorphological and ecological mapping. GIS allows the integration and analysis of spatial databases, as well as providing a means of producing high-quality cartographic outputs.

Collecting images of Earth surface features, using aircraft or satellites, is a key aspect of *remote sensing*. Multi-spectral scanning instruments work in the visible and infrared part of the spectrum, whereas radar techniques use the microwave part, providing us with a unique capability to ‘see’ through cloud cover. Remote sensing has seen a rapid increase in computing power and software for image processing, allowing users to deal with growing volumes of data and more sophisticated image processing (Drury 2001, Gibson & Power 2000, Lillesand & Kiefer 2000, Mather 1999). An important stage of processing remotely sensed data for mapping is *classification*, which allows images to be more readily related to ecological and geomorphological features. Supervised classification requires the user to specify what classes are present and to identify homogeneous ‘training’ patches of each class: pixels (picture elements) are then allocated to one class or another, based on the unique *spectral signature* of each class. Surface areas of various land cover classes can be calculated by counting the number of pixels per class over the area of interest. A specialist aspect of remote sensing concerns collecting precise and accurate measurements from photographs, termed *photogrammetry*. With aerial photography being the most widely used form of remote sensing (Petrie 1999), a basic knowledge of photogrammetry is useful for most expedition fieldwork. The widespread use of flatbed scanners, allowing digital copies to be made of airphoto prints, and the advent of relatively low cost digital photogrammetry software, has allowed changes in land cover types and landforms to be mapped in detail, using airphoto archives that may cover the past 50 years. The costs of remote sensing vary considerably, depending on the technique and image processing, and are in the order of US$ 60 and US$ 1 per kilometre square for airborne and satellite images, respectively. Some archive imagery is now being made available free.

The *global positioning system* (GPS) is an American military navigation system, parts of which are available to the general public, that uses a network of satellites to locate GPS receivers positioned anywhere on the Earth’s surface. As most GPS receivers are light-weight, portable and cheap (some costing less than $100), GPS usage has become a key aspect of expeditionary fieldwork. Accurate ground control is essential when mapping using remotely sensed data, as remotely sensed measurements can only be as reliable as the ground truth on which they are based. In 2000 the USA improved the accuracy of standard GPS signals, from ±100 m to ±10 m, greatly improving the ground-truthing of medium-scale satellite imagery, such as the widely-used Landsat data. Differential GPS (dGPS) can now readily provide centimetre to metre detail in field survey locations: this has helped to improve the accuracy of land cover mapping. Many GPS receivers are also data-loggers: you can devise a code system for a given set of features, use the GPS to locate those features, then plot and analyse the resulting features’ locations by exporting the GPS data into a GIS.

The *expedition planning and management* chapter highlights how organising a successful scientific expedition takes a lot of planning, which in turn requires a lot of time: allow at least one year, preferably two, to get your ideas from the drawing board to fruition. Each stage in the ‘life’ of an expedition involves different types of data, and associated problems, many of which are highlighted in the questions below:

Planning:

- what is the overall aim or goal?
- what objectives do you hope to achieve?
- are there any maps or previous studies of your study area?
- which surveying and sampling techniques are appropriate?
- does the project have appropriate staff and equipment?
- how much time (and money) will the project require?

Fieldwork:

- where are your study areas located?
- how precise are your maps?
- how should field data be collected and stored?
- how will laptops, GPS units, etc, be powered in remote settings?

This handbook, plus the listings of websites given on the handbook’s CD, will help you to find the answers to many of the questions posed above. A number of expedition training courses are also available, foremost among which are those run by the RGS-IBG’s Expedition Advisory Centre (EAC).

The final set of chapters focuses on the fruits of your expeditionary labour, the *results* of your fieldwork. An expedition GIS allows you to start data entry, analysis and even presentation - in the form of maps - during your fieldwork, speeding up a process usually reserved (often with some dread) for after returning home. The main benefit, however, can be for local people involved in data collection, data analysis and the useful application of expedition findings.

The last part of the manual gives *examples* of the sorts of exploration fieldwork that you could follow using geographical information sciences. A wide range of applications are covered: from archaeology, ecology and geoscience, to natural resource management and socio-economic studies. Some more detailed case studies are also included, illustrating ways in which GIS, GPS and remote sensing can aid fieldwork in remote settings.

There is an ever-increasing range of topics that you could examine, especially with regard to risks from natural hazards, threats to biodiversity and the depletion of natural resources. Good luck with your endeavours!