The Development of Digital Field Data Collection Systems to Fulfil the British Geological Survey Mapping Requirements

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1. Introduction

Geological mapping with pen and paper is proving inefficient in many respects in the digital age. With this in mind, the British Geological Survey (BGS) instigated the System for Integrated Geospatial MApping programme (SIGMA) to improve the mapping workflow by evaluating and implementing effective digital procedures for baseline data review, geological data acquisition, and geological mapping and modelling. The project has developed digital field data capture systems to collect information for output to a Geographical Information System (GIS) and digital geological maps. BGS first explored the concept of digital field data collection in the early 1990's with the conclusion that the mobile computing hardware available at the time was not suitable.

An effective digital field data capture system will have a number of advantages over the conventional analogue recording systems. The first is to increase the efficiency of data collection and its subsequent manipulation, predominantly by reducing the time spent copying analogue field data to databases/GIS. The system design will ensure that all field geologists record the same range of structured data and also that mandatory or important information is not omitted. Drop-down menus and approved dictionaries are incorporated to standardise nomenclature. An additional advantage of a digital field system is that a GIS of baseline data (e.g. a series of historic topographic maps) can be uploaded onto the mobile PC, ensuring that new data are collected in the context of prior geological knowledge and with a wide range of other geographic and environmental datasets.

It should be noted that while we strive to guarantee corporate consistency and common standards by structuring our data collection, there must also be a degree of flexibility so that geologists are not unduly constrained. Moreover, when we replicate functions that are ideally suited to pencil and paper, such as drawing sketches, we must ensure that the digital solutions are fit for purpose and do not leave field geologists yearning for 'the old days'.

2. System requirements

The first step to developing a digital field data capture system was to produce a requirements specification that included the types of information recorded in the various mapping domains, as well as hardware and software specifications. The hardware platform running the application would have to meet the following requirements:

- Rugged – matches IP54 (protection against dust and rain) rating or better;

- Portable – must not weigh more than 3kg including the battery;
- Screen – must be readable in bright sunlight and gloomy conditions;
- Power – the batteries must last a working day, at least 8 hours;
- Ergonomic – i.e. easy to use, with a shoulder strap or carrying device;
- Cost –the system must be affordable, while fit for purpose;
- Connectivity – capable of linking to peripherals such as Global Positioning Systems (GPS) and Local Area Networks (LANs).

The software requirements focussed on compatibility with existing datasets/databases, applications and operating systems, while noting the necessity that the application must be stable and robust. Some specific examples of the needs of a geological recording system include the ability to link a GPS to a raster map background with data entry enabled at that point at the tap of a stylus. Lines or polygons drawn in the field should also be input using a drafting or sketch facility (as one would with a pencil on a map) from which a 'best fit' line can be generated later. Furthermore, advanced operations such as the ability to automatically convert gradient to angle of dip and vice versa, or to calculate bed thickness and vertical depths from dip and outcrop width data was also noted as a requirement. These advanced functions, not available with the paper-based system, are envisaged as a major 'selling feature' of a digital system to field geologists.

Having ascertained our hardware and software requirements, vendors were invited to demonstrate their products to us using samples of our own data. Suitable solutions were short-listed and obtained for development/customisation and testing purposes. We also maintained a watching brief on the rapidly developing mobile computing marketplace and endeavoured to evaluate any new appropriate technologies as they became available. We also realised that we are not the only Geological Survey working in this field so a year into our testing we convened a workshop on the theme of digital field data capture where delegates from across Europe and North America openly discussed their experiences. Abstracts, presentations and participant contact details are available online at http://www.bgs.ac.uk/dfdc/home.html.

3. The development process

A digital field data collection system cannot be developed without a data model. In essence, the data model is the backbone of the system and details the features collected in terms of each observation and its associated attributes. The geological data model is particularly complex with multiple one-to-many associations requiring a form of relational database to be implemented in the field data capture system.

BGS decided to develop two systems that utilise the same field data model. Having evaluated several hardware platforms, we chose a Personal Digital Assistant (PDA) application to replicate the conventional geological notebook. It encompasses pro-forma based recording of structured data that is commonly dictionary-constrained, and notebook based recording that encompasses freeform text and sketches (Fig. 1). This digital notebook can work as a standalone application, or (as is typically the case) in conjunction with a customised mobile GIS. The second system utilises a Tablet PC to integrate the notebook with additional field map functionality that includes the ability to sketch geological lines and annotate the map face with notes.

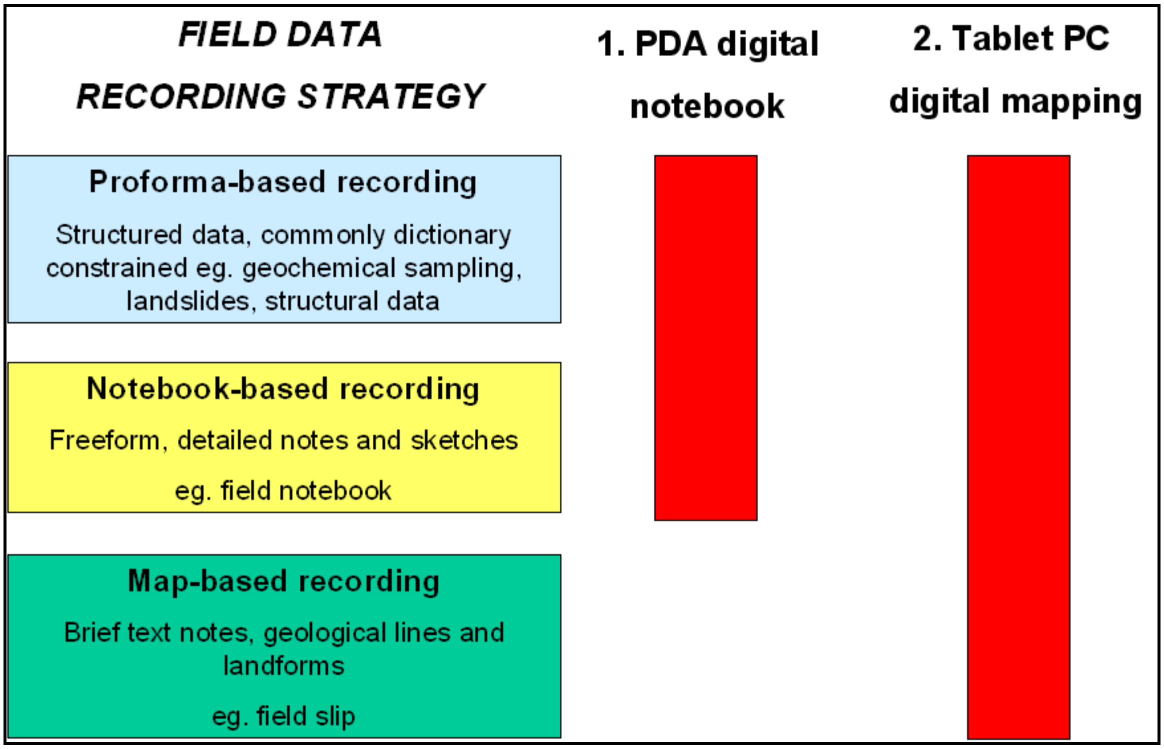

Fig. 1. BGS field recording strategy using PDAs and Tablet PCs.

The multiple one-to-many complexities of geological data necessitate a relational database, and this is handled on the PDA using a BGS bespoke application written in encapsulated Visual Basic (eVB) while the Tablet PC system is being designed in MSAccess. The geologist will use either the digital notebook or the integrated mapping application depending on the mapping project, the geological domain and the specific requirements.

Field trials started in Greenland in the summer of 2001 and have continued within mapping projects in the UK and elsewhere. The trials are designed to test the beta applications in various geological domains. Significant advances in hardware and software have meant that the current system uses a different hardware platform and GIS software to those first tested in 2001.

4. An outline of the digital notebook and fieldslip

The PDA 'notebook' application runs on a HP iPAQ platform and uses ESRI ArcPad 6.0.3 as the front end. Raster base maps, be they topographic or geological etc., can be uploaded, and a customised toolbar enables points, lines and polygons to be drawn on the map face. Observations are not entered using the ArcPad forms programmable in VB script using ApplicationBuilder as it cannot fulfil the needs of the complex data structure we require. Instead, we use a bespoke BGS eVB application that contains hard-coded links to maintain the data structure in the field in a compact database format (CDB).

Index level information is automatically populated where possible (e.g. from a linked GPS) and then the eVB application is 'fired up' to create forms that are used to enter the data (Fig. 2).

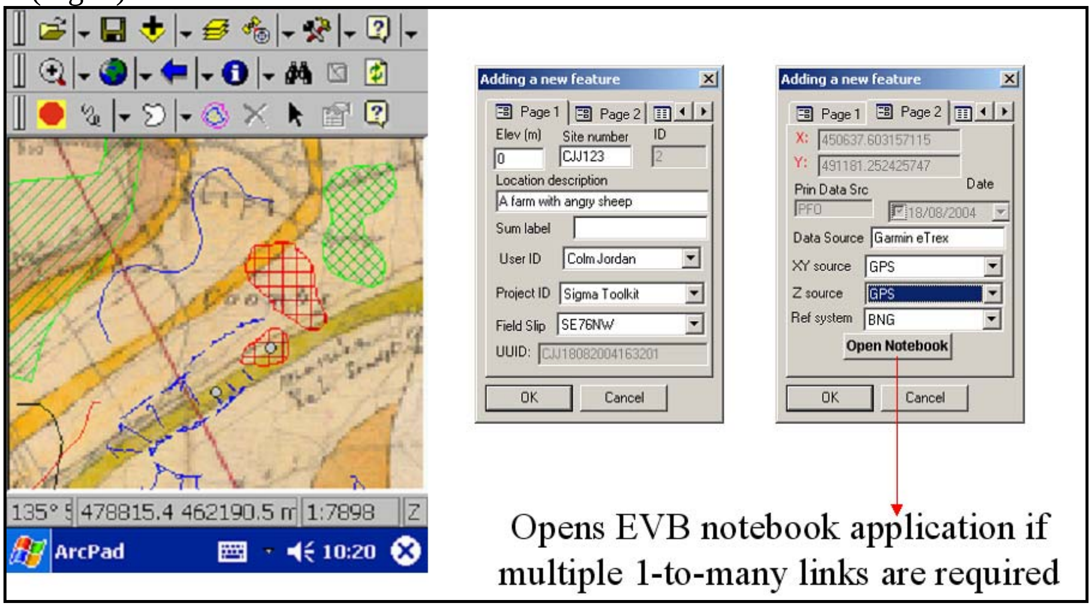

Fig. 2. Field notebook interface.

Forms are compiled dynamically within the eVB application depending on what is being recorded. For example, if a geologist chooses to record structural measurements, and wishes to record planes rather than lineations then the associated dropdown list of options will change. Subsequently, if a fault/fracture is to be recorded the form will fill with the measurement fields that are required to record this type of data (Fig. 3).

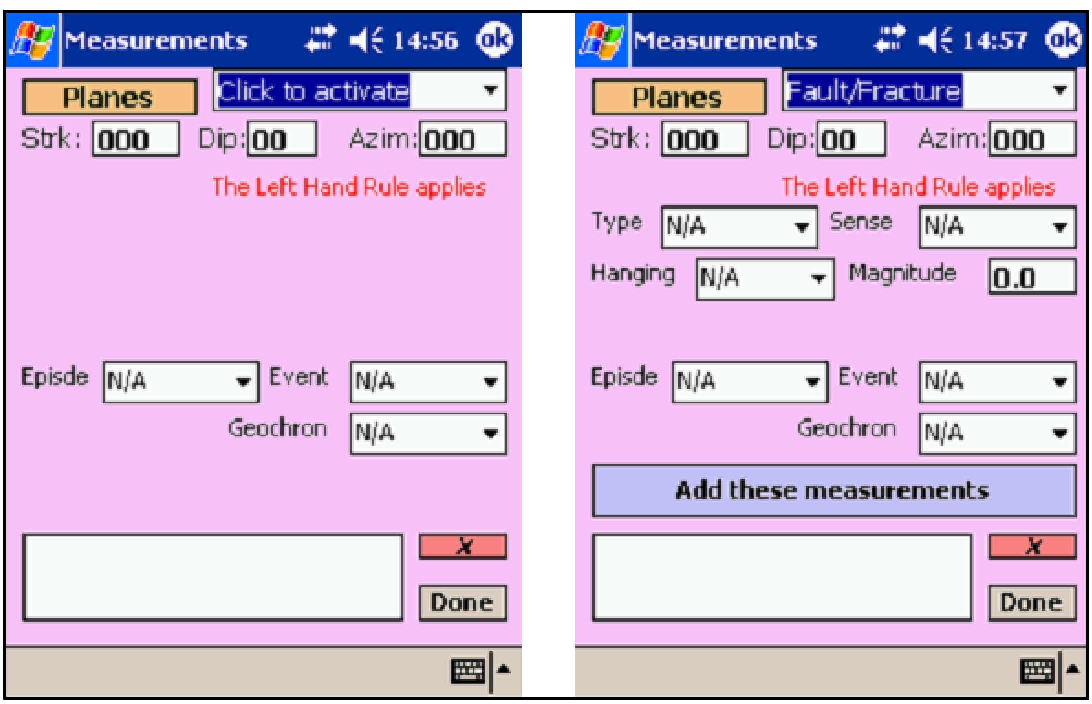

Fig. 3. Example of a dynamically compiled form to record structural measurements.

A simple tool has been implemented for line and polygon drawing. Rather than attempt to collect complicated or attributed linework in the field, we use streaming to replicate the style of sketching that one does with a pencil on a paper fieldslip. We have six line styles including: Bedrock Inferred, Bedrock Observed, Corrections, Form Lines (geomorphology), Superficial Inferred and Superficial Observed. When drawing a polygon the geologist has a choice between four colours with five fill styles. The concept is not to produce publication standard linework on the PDA but to create draft lines that are later digitised or imported into a BGS customised ArcMap application where the lines are properly attributed and topology added.

The complete digital notebook toolkit supplied to geologists includes a PDA with rugged cases, a Bluetooth GPS, a digital camera, rechargeable batteries and charger, multi card reader and Bluetooth adaptor for laptops that are not enabled with Bluetooth. All of these are supplied in a rugged padded case.

The significant drawback of the current system is the difficulty in editing data in the field. Despite this, field tests have shown that digital field data capture using the digital notebook (on a PDA platform) can significantly improve data collection and allow easier transfer of data into corporate databases.

At the time of writing, the digital fieldslip is still under development. Having evaluated several hardware platforms, the system is being developed on ruggedised Tablet PCs running MS Windows XP for Tablet Edition. Two screen sizes are in use; one is 8.4” diagonal while the other is 10.4”. The front end is ArcGIS9 and the relational data will be held in MSAccess. Having previously been constrained by the size of the PDA screen and the need to work with a CDB compact database format, we are able to redesign the interface and include new functionality. The move to MSAccess will mean that the difficulty of editing data that existed on the PDA can be overcome. Furthermore, the fact that the Tablet PCs combine the functionality of a PDA and a laptop will mean that there will be less hardware to maintain and most users will not need to learn how to operate a CE operating system in addition to the ‘normal’ MSWindows OS that they are used to.

Finally, some BGS projects do not require a relational database in the field, and their field workers do not need to draw lines or polygons. These projects are simply interested in collecting pro forma information at a point and inputting those data to a flat database structure. A ‘simple’ ArcPad customised application has been designed for these projects, running on PDAs. In this ‘horses for courses’ system, the field workers will choose the correct ‘fit-for-purpose’ digital tool for the job.

5. Summary

The BGS has tested many hardware platforms, operating systems, proprietary GIS packages and various peripherals. We have also customised existing software and written our own in an effort to develop an efficient digital field data capture system. Substantial efforts have also been focussed on designing and documenting a field data model because this inevitably forms the basis of all the data collected in the field.

One application has been developed in the form of a ‘digital notebook’ to replicate the data recorded in conventional notebooks, while another is being designed to incorporate the digital notebook with a digital fieldslip. The notebook runs on PDAs with ArcPad linking to a bespoke eVB application, while the fieldslip is designed to run on Tablet PCs using heavily customised interfaces to ArcMap v9 and MSAccess.

6. Acknowledgements

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