

GDA (Geologic Data Assistant), an ArcPad extension for geologic mapping: Code, prerequisites, and instructions

by Evan E. Thoms and Ralph A. Haugerud

Geological Survey Open-File Report 2006-1097

Use of product or trade names in this report does not constitute endorsement by the Geological Survey

Table of Contents

Introduction

Download GDA

What you need to know

Required hardware and software

Windows CE / PocketPC PDA

GPS unit

ArcPad

Software on the laptop or desktop

GDA

Outline of GDA

GDA data structure

Base map and compilation geology

Setup instructions

Initial setup

To start a new project

Each time you start ArcPad

Data Safety

Incorporating GDA data into a desktop GIS

Customization

References Cited

Introduction

GDA (Geologic Data Assistant) is an extension to ArcPad, a mobile mapping software program by Environmental Systems Research Institute (ESRI) designed to run on personal digital assistant (PDA) computers. GDA and ArcPad allow a PDA to replace the paper notebook and field map traditionally used for geologic mapping. GDA allows easy collection of field data that include:

- Station location as determined by GPS, map inspection, or as a bearing and distance offset from an existing station
- Map unit and related lithologies
- Outcrop characteristics
- Structural orientations

- Contacts, faults, and other linear features
- Information about samples
- Information about photographs
- Extended free-form text
- Sketches
- Miscellaneous map annotation

This report provides a link to [downloadable code](#), describes the [required hardware and software necessary to use GDA](#), describes the [GDA data structure](#), gives [setup instructions for GDA](#), describes [moving data from GDA into a desktop GIS](#), and discusses [customization of GDA](#). To use GDA efficiently will require an intermediate knowledge of computer systems and, most importantly, good file management. GDA does not have to be used in conjunction with ESRI's ArcMap, but knowledge of that program is useful for customizing certain GDA files and viewing shapefiles. [Haugerud and Thoms \(2004\)](#) discuss rationales behind some of the choices made in building GDA.

Note that the GDA code includes HTML help files that discuss setup and use of the software. Much of this report is copied from the GDA help files.

Download GDA

There are 2 downloadable GDA packages from which to choose depending on the intended host system.

- For installation on a **Windows PC**, download [GDA_PC_Install.zip](#). This package contains the loose files and a simple DOS batch file to copy them to the appropriate directories. This is also the package to download for further development of GDA in ArcPad Application Builder.
- For installation on a **Windows CE** device, download [GDA_For_PPC.cab](#)

Get a copy of this documentation as [zipped html](#) or [PDF](#).

What you need to know

To use GDA, you should have some familiarity with your PDA, with ArcPad, and with some basic principles of GIS.

First, use your PDA. Learn how to open programs and switch between them. Experiment with the several different methods of text input, to find what works best for you. Learn how to change screen brightness. Poke around in the system settings. Windows CE has changed significantly with each release. Our experience is primarily with WinCE 3.0; if you are using a later version, some of our PDA-related advice may be wrong.

Configuring the communications link between the PDA and an external GPS receiver can be challenging. The instructions that work for our hardware and operating system are likely to be wrong for your setup. You will have read your manuals (this may not help much) and experiment.

Second, look through the ArcPad user manual (available [here](#)). Pay attention to the layer metaphor, the notion of an active layer, the limits of ArcPad symbolization, and how a map projection can be defined.

Third, you should have a basic understanding of map projections and datums. You should appreciate the distinction between the contents of a spatial database and the symbolization of those contents on a map or

computer screen.

Required hardware and software

Windows CE / PocketPC PDA

ArcPad, and thus GDA, runs on the Windows CE 3.0 (or greater) operating system, also known as the PocketPC operating system. It can also be installed on Windows-based desktop, laptop, or tablet computers. It does not work on Palm or Linux devices. Most WinCE computers are adequate. When selecting a PDA, pay particular attention to display readability, communications capabilities, battery life, the quality of the digitizer, memory capacity, and speed. We are currently using Hewlett-Packard iPAQs with 400MHz processors, 64MB memory, and 240 x 320 pixel 16-bit color daylight-readable displays.

Extra battery

An extended-capacity battery, or an expansion pack with an additional battery, is desirable. You would like to have enough power for continuous operation throughout a 14-hour field day. When using a GPS it is especially useful to set your PDA to never shut off. One reason for this is simply efficiency, but the other is that turning a PDA off without first disconnecting the com port often causes the PDA to lock up so that it can only be reset with a soft reboot. The largest drains on the battery are the intensity of the backlight and the length of time it is on, so set your backlight to dim to nothing after a short period of inactivity.

Extra non-volatile memory

Use a Compact Flash card, Secure Digital card, or other non-volatile memory for mapping project workspace. This provides storage for large raster images and guards against data loss when, inevitably, you forget and let the PDA battery run down. We use expansion packs that provide both a Compact Flash slot and an additional battery. Be aware that unless you store programs in a non-volatile space on your PDA, ArcPad will evaporate from memory if the battery dies. As a backup in the field, keep a PC nearby from which you can re-install ArcPad.

Bluetooth

Bluetooth (a short distance device-to-device radio protocol) is excellent for communication between the PDA and a GPS unit. Cable connections between GPS and PDA are fragile, inconvenient, and hard to make waterproof.

Screen protector

Protect the PDA screen from abrasion with a self-adhesive replaceable plastic screen protector (check Office Depot or a similar supplier.)

Case

The PDA probably won't survive a 4-ft drop onto bedrock. Get a rugged case that provides significant shock-

proofing. Consider third-party cases (such as Otterbox) as well as cases available through your PDA manufacturer. Such cases can also be waterproof, with a clear vinyl window over the PDA screen--but if you retain this window, omit any additional screen protector.

3rd-party stylus

A third-party stylus with a pocket clip or lanyard is handy. Multifunction instruments that combine a stylus with a pen or pencil (or both) are available for under fifteen dollars.

GPS unit

Standard recreational-grade GPS provides nominal XY accuracy of 10 meters (with averaging) at a cost of \$100-300. We find this sufficient. For increased accuracy use a WAAS-capable GPS unit, or a differential GPS unit, at substantially greater cost. Note that ArcPad provides an excellent GPS display: all one needs is a screenless GPS receiver that can send standard NMEA 0183 signals to another device.

GPS satellites broadcast at a wavelength that does not pass through the human body, so a pocket is not a good place from which to use a GPS unit. Instead, put it in the lid of a backpack, on the top of a staff protruding from a pack, or fastened it to your hat. Another option is to use a small external antenna on a hat (google on *GPS Pathfinder Pocket Antenna Cap*) while keeping the receiver in a pocket or on a belt clip (if you can tolerate the necessary connecting cables).

Communications between the GPS unit and PDA are a potential problem. If a cable connection is to be used you may have to purchase appropriate cables for both GPS unit and PDA separately, and you may have to join them with a male-to-male adapter and null modem connector as well. See the ArcPad user manual for good instructions on following this route. Duct tape will transform the cables and adapter into a single, stronger, unit. The data-cable fitting on many PDAs is weak. One can mount the PDA in a rigid windowed box with a short data cable that leads from the PDA to a more substantial fitting anchored to the box and worry less about breaking the connector, but you will still be trussed up like Gulliver among the Lilliputians. A wireless connection (e.g. Bluetooth, see [above](#)) is better.

Compact flash card GPS units arguably provide the most robust connection. There are no cables, no risk of losing the signal due to distance from the receiver (as there is with Bluetooth devices), and since the GPS unit draws current from the PDA battery, there is no worry of having the unit die before your PDA does. They can also be swapped in and out of the compact flash slot with fewer com port hassles than the Bluetooth units. The main disadvantage with this method is that you are likely to lose the GPS signal as you hold the PDA near your body while entering data.

We use credit-card sized Bluetooth GPS receivers such as that sold by Socket Communications (<http://www.socketstore.com/product.asp?sku=2542622>). These 16-channel receivers can be bought for less than \$230. They weigh 2 ounces and the replaceable and rechargeable battery lasts 9 hours, more than adequate for working out of a vehicle with a cigarette-lighter recharger available. For a long day on foot carry an extra battery or mobile recharger, such as the iPowerPak by Data Nation (<http://www.data-nation.com>) or Mobile Power Pack by Socket.

In recent tests with a Bluetooth GPS unit and a Bluetooth-ready iPAQ h2200, we have found the Bluetooth Manager to be much improved over older versions, causing us to lean even more strongly toward that system.

ArcPad

ArcPad is a simple GIS program for the PocketPC, optimized for collection and display of map information while mobile. It has fewer symbolization and database capabilities than the average desktop GIS, can be customized to a limited extent using XML and VBScript, and has an excellent GPS interface.

ArcPad can be obtained from ESRI (<http://www.esri.com/software/arcpad>) for about \$500. A free evaluation copy that times out after 20 minutes may be downloaded from the web. GDA will not work with versions of ArcPad earlier than 6.0.1 We are using ArcPad 6.0.3. We have not experimented with this version of GDA on ArcPad 7.

Third party file browser

The file browsing program that comes with the Windows CE, File Explorer, does not, by default, show file extensions. Editing the registry to force file extensions to show is an option available to the advanced user, but it is risky. The safest remedy is to install a third party program that shows extensions. PEFile, by Vieka, is a cheap and reliable solution. Seeing file extensions is important because there are many files associated with GDA which have names that differ only by their extensions. Many can be edited in a text editor on the PDA by temporarily changing the extension to '.txt'.

Software on the laptop or desktop

ArcGIS/ArcView

ArcGIS or ArcView will make it easier to define symbolization, such as the colors of dots that correspond to different map units. See the ArcPad manual for advice on this. (Note that you can also do this with a text editor, carefully copying, pasting, and editing the .xml file for the layer. Colors are in RGB, 0..255 gamut for each component. Search for "VALUEMAPRENDERER".)

ArcGIS provides tools for reformatting data for digital base maps. You may need to reproject rasters to the projection of your field project. ArcGIS will export an entire map project to ArcPad. Note that you may have to tile large raster images to avoid the 50MB input-image size limit on the MrSID converter that is shipped with ArcGIS. See the ArcPad documentation.

You will almost certainly need ArcGIS or ArcView to make a completed geologic map from the data you collect with GDA.

Excel (or OpenOffice) or Access

You will need to edit .dbf files that constitute some of the picklists. This is conveniently done on a PC with Microsoft's Excel. The Calc program in OpenOffice.org works equally well. CDBF (google for it) works well. Another solution is to create an Access database containing all of the picklist tables and export them as needed in .dbf format. Let us know if you find a DBF editor that runs on a PDA!

Text editor

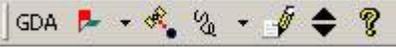
A text editor that works gracefully with plain ASCII files is handy for minor modifications of layer definition (.apl) and VBScript (.vbs) files. On a Windows platform, WordPad and Notepad are fine. Many other

editors are available. Avoid using Microsoft Word because it may add hidden and extraneous formatting tags that are not recognized by GDA.

GDA

Outline of GDA

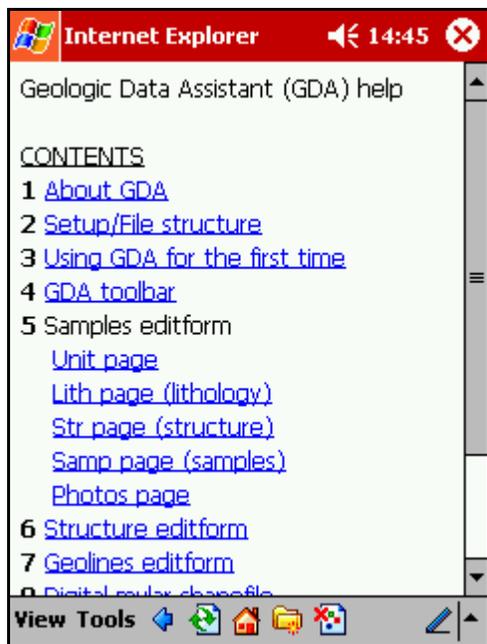
GDA consists of 4 sets of files:

1) The GDA toolbar  and events that occur when buttons on the toolbar are tapped are defined by XML and VBScript files `GDA_1.0.apa` and `GDA_1.0.vbs`. From left to right, icons when tapped effect the following:

- Make station layer active (tap location on screen to add station). Drop-down menu item for plotting a station with bearing and distance from the currently selected station.
- Add station at GPS location
- Make geolines layer active (draw line on screen to add data). Drop-down menu item to draw a line with a polyline tool.
- Make mylar layer active (draw line on screen to add data)
- Show Edit toolbar
- Show GDA Help

2) GDA modifies certain aspects of ArcPad's behavior with XML and VBScript files `ArcPad.apx` and `ArcPad.vbs`.

3) GDA help is provided by HTML help files in folder `GDAHelp`.



4) GDA data for a mapping project reside in a single user-designated project directory. Multiple mapping projects require multiple project directories. Each project directory contains files for the 4 data layers

described below, a collection of .dbf files that define picklists, per-station files of notes and sketches that may be created while using GDA, and an ArcPad.apm file (written by ArcPad each time work is saved) that defines active layers, pathnames, current map extent, and controls some symbolization. Empty copies of the data files are stored in a Templates directory that resides at the same directory level as the different project directories. A mapping project directory will also commonly contain a projection file, a subdirectory with base map layers, a subdirectory with compiled geologic data layers, and archive subdirectories.

GDA data structure

GDA adds 4 editable data layers to a project: stations, structure, geolines, and mylar. Most data layers have 5 files: 3 files with extensions shp, dbf, and shx that constitute a shapefile, an ArcPad XML layer-definition file with extension .apl, and--except for the mylar layer--a .vbs file that contains VBScript code called by events defined in the layer definition file.

Stations

Stations is the primary point data layer. Within it are recorded all station locations and much of the data associated with them. Adding a new station brings up an edit form that controls almost all point attributes and allows editing of associated tables for Samples, Photos, and the structure layer. Attributes of points in this layer are:

Unit page (see image)					
<i>Attribute</i>	<i>Format (type, N bytes)</i>	<i>Editform label</i>	<i>Definition</i>	<i>Vocabulary</i>	<i>Where is vocabulary defined?</i>
STAID	Char, 16	Form caption	Station identifier	Generated automatically from Geologist, date, time	na
MAPUNIT	Char, 30	Unit	Geologic map unit (formal or informal, may be at any stratigraphic level)	Open Varies per project Self-updating Default is value at last station	Units_1.0.dbf Corresponding symbolization is defined in Stations_1.0.apl
CERTAINTY	Char, 10	Certainty of unit identification		Open Definite, probable, tentative	Stations_1.0.apl
HOWLOC	Char, 10	How located	How station is located	Open Inspection, Offset, Other	Stations_1.0.apl

				<i>Set to GPS if location by GPS button</i>	
OCQUAL	Char, 8	OC quality	Nature of outcrop	Open Good, poor, rubble, soil, none	Stations_1.0.apl
OCDIAM	Char, 5	OC min diam	Minimum diameter of outcrop	Open 0.1m, 0.5m, 1m, 2m, 5m	Stations_1.0.apl
SCALE	Char, 8	Map scale 1:	Denominator of map scale at time station is located	Automatically generated	na
GEOLOGIST	Char, 2	Geologist	Used to calculate StationID	Open	Geologists_1.0.dbf
DATUM	Char, 15	Not visible on form	If the current station was located by offset coordinates from another station, this field stores the ID of that 'datum' station.	Automatically generated	na
Lith page (see image)					
LITH	Char, 100	Lithology	Short lithologic description	Open Self-updating	Units_1.0.dbf
MINGRNSZ	Char, 10	Min grain size	Use to describe the minimum size of clasts, crystals, blasts, etc.	Udden-Wentworth scale.	GrainSizes_1.0.dbf
MAXGRNSZ	Char, 10	Max grain size	Use to describe the maximum size of clasts, crystals, blasts, etc.	Udden-Wentworth scale.	GrainSizes_1.0.dbf

The Lith page also has two buttons called ADD NOTE and ADD SKETCH which can be used to create and edit text or graphics files, respectively, related to the current station. For instance, when the ADD NOTE button is tapped during the attribution of a new station a file is created that is named with the station ID and given a .txt extension. The file is then opened with the first line consisting of the current date and time and you may add as much text as needed to describe the station or related attributes. During successive visits to the station, tapping the ADD NOTE button will open the original file and prepend the date and time of the visit.

The file extensions associated with these two buttons are `.txt` (ADD NOTE) and `.psw` (ADD SKETCH). By default, WinCE devices will use Pocket Notepad to open files with a `.txt` extension and Pocket Word to open those with a `.psw` extension. We chose Pocket Word for the sketch files only because it has a rudimentary drawing toolbar and it is available on all WinCE devices. There are a number of graphics programs designed for PDAs that will far exceed Pocket Word's drawing capabilities for a reasonable price. If you install one, you will need to change the GDA code so that the files created by the ADD SKETCH button are given an appropriate extension. Open `Stations_1.0.vbs` with a simple text editor such as Notepad and search for 'SketchPath' within the AddSketch subroutine. Change the string "`.psw`" to the extension associated with the graphics program you want to use.

Other pages of the Stations form allow editing of subsidiary tables (dbf files) for Samples and Photos. Fields in these tables and the associated entries in the Stations edit form are shown in the tables below.

Sample page (see image)					
Attribute	Format (type, N bytes)	<i>Editform label</i>	Definition	Vocabulary	Where is vocabulary stored?
STAID	Char, 16	not shown	ID of station at which the sample was collected.	Automatically generated	na
SAMPID	Char, 16	<i>Listed in Samples from this station</i>	SampleID	Automatically generated	na
PURPOSE	Char, 30	Purpose	Type of analysis to be performed on sample	Open Self-updating	Samptype.dbf

Photo page (see image)					
<i>Attribute</i>	<i>Format (type, N bytes)</i>	<i>Editform label</i>	<i>Definition</i>	<i>Vocabulary</i>	<i>Where is vocabulary stored?</i>
STAID	Char, 16	not shown	ID of station at which the photo was taken.	Automatically generated	na
PHOTOID	Char, 15	<i>Listed in Photos from this station</i>	With care, can match camera filename	Calculated from Prefix and No. Self-incrementing	na
TOPIC	Char, 100	Topic	Subject of photo	Open No pick list	na

WIDTH	Char, 8	Width	Width of field of view	Open No pick list	na
DIRECTION	Char, 5	Direction	View direction	Open N,NE,E,SE,S,SW,W,NW,down	Stations_1.0.apl

With properly configured symbolization (see [Symbolization](#)), points in the Stations layer can be shown as dots whose color corresponds to MAPUNIT.

Structure

Structure is a point layer for storing and plotting orientation data (bedding, foliation, lineation, etc.) Such data are stored in a layer separate from the Stations layer so that they can be plotted. A point must first be added to the Stations layer before orientation measurements can be recorded. Structure data are added from the Str page of the Stations form (see [image](#)).

As each measurement is added to the Structure layer, GDA programmatically copies the coordinates of the station point to the Structure layer. Multiple structure measurements may be added at a single station.

Features of the Structure layer are described in the following table:

<i>Attribute</i>	<i>Format (type, N bytes)</i>	<i>Editform label</i>	<i>Definition</i>	<i>Vocabulary</i>	<i>Where is vocabulary stored?</i>
STAID	Char, 16	not shown	ID of station at which the structural observation was made.	Automatically generated	na
STYPE	Char, 30	Type		Open	StrucTypes_1.0.dbf Corresponding symbolization is defined in Structure_1.0.apl
QUALITY	Char, 1	Poor observation (checkbox)		Closed Unchecked (default)=F Checked =T	na
AZI	Char, 3	Strike/Trend	Azimuth (strike, trend) in degrees, 0=North, clockwise Follows right-hand rule: for N-S strike, AZI=0 for E dip, AZI=180 for W dip	0..360	na

INC	Char, 3	Dip/Plunge	Inclination (dip, plunge) in degrees, 0=horizontal, 90=vertical (down), -90=vertical (up)	-90..90	na
DATE_	Date, 8	not visible	Date of measurement.	System date	na

The table below shows the contents of `StrucTypes_1.0.dbf` as it is distributed in GDA. The Text field shows the value that will be stored within the `STYPE` field. Note that `Structure_1.0.apl` contains instructions for `STYPES` in addition to those listed below; these can be added to `StrucTypes_1.0.dbf` and will be symbolized. Addition of other values to `StrucTypes_1.0.dbf` will require that you update the symbology defined in `Structure_1.0.apl` (see [Symbolization](#)).

<i>TEXT</i>
upright bedding
overturned bedding
bedding no top
bedding, horizontal
joint
fault
slickenlines
striae
foliation
schistosity
cleavage
lineation
stretching L
mineral L
intersection L
foliation, horizontal

dike
fold hinge

Geolines

Geolines is a line layer for contacts, faults, shorelines, and other linear features. Attributes of lines in this layer and their characteristics are:

<i>Attribute</i>	<i>Format (type, N bytes)</i>	<i>Editform</i>	<i>Definition</i>	<i>Vocabulary</i>	<i>Where is vocabulary stored?</i>
DATETIME	Char, 24		Date and time of observation	Automatically generated	na
LTYPE	Char, 30	LineType	Geologic line type	Open	Geolines_1.0.apl
PRECISION	Char, 20	Precision (m)	Precision of line location	Open 1, 2, 5, 10, 25, 50, 100 default is 0, should be understood as NODATA	Geolines_1.0.apl
SCALE	Char, 20	Map scale 1:	Denominator of map scale at which line is digitized	Automatically generated	na

The table below shows the contents of `LineTypes_1.0.dbf` as they are distributed GDA. The `LINETYPE` field shows the value that will be stored in the `LTYPE` field. If these values are changed or more are added and you wish to have new values symbolized properly, you will have to update the symbology (see [Symbolization](#)).

<i>LINETYPE</i>
contact
fault
outcrop limit
scratch boundary

till bed
peat bed
ash bed.
bedding trace
fold
anticline
syncline
marker bed
dike
vein
scarp

Mylar

Mylar is a layer of unattributed lines, included to provide flexibility. Use Mylar for map ornamentation, text written directly on the map, or other annotation. Note that in most cases any information in this layer must later be translated into a form that can be queried by machine.

Base map and compilation geology

ArcPad allows GDA to use a wide variety of base materials, including previous geologic data. The primary limitation is symbolization. Only one raster layer may be used at a time, as ArcPad does not support transparency.

Setup instructions.

Initial setup

Establish an ActiveSync connection between the PC and the PDA.
Install ArcPad on the PC:

Use the default installation folder suggested by the setup wizard, i.e. 'C:\Program Files\Arcpad'

On the PC, Start>Programs>ArcPad>Install ArcPad application for Windows CE
 On the PC, Start>Programs>ArcPad>Install ArcPad font for Windows CE
 On the PC, Start>Programs>ArcPad>Install VBScript Runtime Library for Windows CE

Install GDA:

Both the .bat and .cab files assume you installed ArcPad in the default directory!

Download the appropriate GDA package for your system and unzip the file.

For installation on the PC, double-click on GDA_PC_Install.bat.

For installation on the PDA, copy GDA_For_PPC.cab file to any folder, make a copy (.cab files disappear once unzipped), and double-tap the file.

Choose 'No' to any dialogs asking you to retry installation of a font file.

The default locations after installation are shown below. If you have chosen to install ArcPad in a non-default folder, you will have to move the files from the unzipped GDA_PC_Install.zip file manually.

<i>Location on PC</i>	<i>Location on PDA</i>
C:\Program Files\ArcPad\AppletFiles GDA_1.0.apa GDA_1.0.vbs	\Program Files\ArcPad\Applets GDA_1.0.apa GDA_1.0.vbs
C:\Program Files\ArcPad\SystemFiles ArcPad.apx ArcPad.vbs	\Program Files\ArcPad\System ArcPad.apx ArcPad.vbs
My Documents\GDAProjects\ GDATemplates\	\My Documents\ GDATemplates\
C:\WINDOWS (or WINNT)\Fonts esri_7.ttf	\Windows\Fonts arial.ttf esri_7.ttf (ESRI Geology

After installation on a PC, move the My Documents\GDAProjects\Templates folder to another drive and folder if you wish; the other folders must remain within the ArcPad installation folder.

After installation on a PDA, move the My Documents\GDATemplates folder to a non-volatile storage card and make a copy of it for each project.

Configure PDA to communicate with Bluetooth GPS unit.

These are general instructions for making contact with a Socket Bluetooth GPS unit on an

internally enabled bluetooth PDA. If you use a different GPS unit these instructions may not apply.

Make sure the GPS unit is fully charged.

Power on the GPS unit. The status LED will blink blue.

Power on the PDA.

Turn PDA Bluetooth radio ON (Tap blue and black icon in the lower right corner of PDA screen).

Tap Bluetooth icon (now blue and white) and open Bluetooth Manager.

Perform a Bluetooth device discovery to find the GPS unit.

Pair and bond with the the Bluetooth GPS unit. Use the passkey 0183 if prompted. You only need to discover, bond with, and pair with the GPS unit the first time you use it with your PDA.

Start ArcPad and check the settings below before attempting to enable the GPS.

Configure ArcPad

Start ArcPad.

Open ArcPad Options (crossed wrench and hammer: top toolbar, 2nd icon from right, select Options...) and configure Protocol and GPS pages.

With the Socket GPS communicating via internal Bluetooth on an IPAQ H3900, appropriate settings are:

Protocol page

Protocol: NMEA 0183

GPS Datum: WGS84

Use Height in Datum Transform:

GPS Initialization String:

GPS page

Port: COM8

Baud: 4800

Parity: None

RTS Control: enable

DTR Control: enable

Infra Red:

Data Bits: 8

Stop Bits: 1

Monitor CTS:

Monitor DSR:

Log:

Show GPS Activity in System Tray:

IMPORTANT: On the Capture page enable averaging. 10 points is a good number. This is necessary for certain VB script routines to be fired properly, but it is also good GPS practice.

Configure other GPS quality parameters and warnings as needed on the Quality, Capture, and Alerts pages. For instance, you can tell ArcPad to reject any GPS fixes with a PDOP (position dilution of precision) greater than 6 (4 is considered excellent and you may routinely see PDOP values better than 3. Never accept a PDOP greater than 8).

IMPORTANT: On the Paths page, set the Default Maps & Data Path to the project folder your data are in.

Save the map as `ArcPad.apm` within the default data folder. This map will now be opened by default when ArcPad is started.

Using GPS with ArcPad

Check that ArcPad is receiving valid NMEA strings by going to the GPS dropdown menu and choosing GPS Debug. If you see nothing, then something is configured incorrectly.

Always disable the GPS through ArcPad's GPS menu before you turn ArcPad off.

Likewise, disconnect the PDA from the GPS through the Bluetooth manager before turning the PDA off.

Failing to disconnect properly from the GPS will usually lock up the COM port which only a soft reboot will clear.

To start a new project

A mapping project has a common geographic area, a common geologic vocabulary, and a single map projection and datum. Many geologists will work on only one project. Others might have several, perhaps including a project mapping glacial deposits in western Washington in the Washington State Plane North feet-NAD83 coordinate system and a project mapping late Cenozoic rocks and deposits in northwest Oregon in the UTM10 meters-NAD27 coordinate system.

Directory structure

For each new project (new area, new projection, and (or) new theme), create a directory on your storage card by making a copy of Templates and renaming it to `<NewProj>`, where `<NewProj>` is a relatively short version of the project name. Within `<NewProj>`, create subdirectories for base layers and compilation geology as you see fit.. With two projects named BremE and Wen, the Storage Card directory tree would be :

```
\Storage Card\  
  BremE\  
    base\  
    old_geol\  
    WASPN83.prj  
    files for geolines, mylar, stations, structure  
    Units_1.0.dbf, StructTypes_1.0.dbf, etc.  
  Wen\  
    base\  
    old_geol\  
    UTM10NAD27.prj  
    files for geolines, mylar, stations, structure  
    Units_1.0.dbf, StructTypes_1.0.dbf, etc.  
  Templates\  

```

ArcPad.apm

ArcPad maintains a default data path (that is, a default directory). If a map-description file named ArcPad.apm is present in the default data path, that map will be opened when ArcPad is started.

Start ArcPad. Go to Tools>Options>Paths and change the default data path to your current map-project directory. Open a new map. Add base layers, Stations, Structure, Geolines, and Mylar to the map. Set the scales at which various layers plot, if you desire. Save the map--this will write an ArcPad.apm file to the map-project directory. ArcPad.apm defines the layers present in an map, the area shown on the display when the map is opened, and some symbolization.

You can re-save ArcPad.apm whenever you wish, and it may be useful to re-save before you exit ArcPad, though this is not necessary. It is best to overwrite the current version--don't Save As a new file.

Base materials

For convenience, keep all base materials in a subdirectory <NewProj>/Base. Possible base materials include:

- Standard USGS DRGs
- Shaded-relief images, calculated from standard USGS DEMs or high-resolution data
- Orthophotos
- Vector contours
- Digital assessor's parcel maps

Note that only one raster file can be shown at a time, as ArcPad does not support transparent rasters. If you want to display a raster composite, for example colored unit polygons over shaded relief, you must explicitly create this image in ArcGIS and export it to a suitable image-file format.

Raster images must all be in the same projection. Convert vector layers to the same projection as well; ArcPad won't reproject on the fly.

MrSID compression is desirable, both to create image pyramids and to reduce overall file size. Experiment to find the appropriate degree of compression. We find 10-15x works well. The 50Mb limit for single files input to the MrSID converter in ArcGIS may require that some input files be chopped into smaller tiles.

Map projection

ArcPad needs to know the project map projection and the GPS cannot be enabled without one.

- 1) If you export the project from ArcGIS, a projection file (*.prj) should be created. Install this in the project directory.
- 2) You can put any prj.adf file (from within a coverage or grid – rename it to .prj) or .prj file (associated with a shapefile or from the ArcGIS\Coordinate Systems folder) into the project workspace. When you add a new layer that does not have an explicitly defined projection, you will be asked if you wish to use this projection.
- 3) You can assign a projection to each map layer with the Map Projection button (top right icon on the Layers dialog) in ArcPad.

ArcPad will not reproject data to a common projection for a map project. All layers must have the same projection.

All layers need not have a separately defined projection. Indeed, GDA takes advantage of this feature, and leaves the default geologic data layers with projections undefined, so that each new project may pick up its projection from an associated base layer or a freestanding projection file.

Your choice of projection will usually be forced by the projection of the raster layers (DRGs, shaded-relief images, DOQQs) used for a map base. In a given mapping project, such rasters should all be in the same projection.

Vocabularies

You will need to edit `Units_1.0.dbf` to establish an initial unit vocabulary for a new project. Open a copy of this file in Excel, OpenOffice Calc, Access, or similar, select and delete existing values, add new values, and re-arrange values. Note that "LITH" need not be specified. Save and move the modified copy of the file to the project workspace.

If symbolization is based on any vocabulary values you create or edit, you will need to change the symbology element within the shapefile's `.apl` file. You may do this manually from within a text editor if you wish, but it is much easier to use the method outlined below.

Symbolization

You can create symbology for a new project with ArcGIS or ArcView:

Included in the ArcPad install folder are two folders called `apTools3` and `apTools8`. In these folders are extensions with export tools for use in either ArcView 3.x or ArcGIS 8.x (and 9.x).

To install apTools8.dll for ArcGIS:

- Go to Start>Run and type: `regsvr32 "C:\Program Files\ArcPad\apTools8\apTools8.dll"` (or whatever the full pathname is to the file). Be sure you have administrator rights to your computer or the dll will not install properly.
- In ArcMap, go to Tools>Customize
- Click on the Commands tab and click on Add from file. Browse to `apTools8.dll` and select it.
- Four commands will appear in the right-hand window. Drag `Export Symbology` to any toolbar.

To install apTools3.avx for ArcView 3.x:

- Move all files in `apTools3` to `C:\ESRI\AV_GIS30\ARCVIEW\EXT32` (or the appropriate directory).
- In ArcView, go to File>Extensions and turn the extension on.

Add the shapefile for which you want to create symbology to an ArcMap or ArcView map
Create a feature for every possible attribute and symbolize it.

Points can be symbolized with any true type font character, lines can be symbolized with

different thicknesses and color only, and polygons can be symbolized with solid opaque colors only.

Click on the Export Symbology tool you just installed.

If you are setting the symbology for a point shapefile, open the .ap1 file for the shapefile that was just created and search for <TRUETYPEMARKERSYMBOL. Note the font being used for each occurrence of that XML element.

Drag and drop those fonts from your PC's fonts directory into the fonts directory on your PDA.

Rotating truetype symbols

To rotate point symbols according to an attribute value (eg Azimuth from the Structure shapefile):

Open the .ap1 file for the shapefile you are dealing with and search for VALUEMAPRENDERER.
Add these attributes to that XML element:

```
rotationfield="MYROTATIONFIELD" rotationtype="geographic"
```

Each time you start ArcPad

Each time you start ArcPad you will have to re-start communication between the PDA and GPS unit. With WinCE 3.0 and the Socket Bluetooth GPS,

Power on the GPS unit

Power on the PDA

Turn PDA Bluetooth radio ON (Tap blue and black icon in lower-right corner of PDA screen.)

Tap Bluetooth icon (now blue and white) and open Bluetooth Manager

Tap the entry for the GPS unit (EMTAC BTGPS 22..) to establish communication

Close Bluetooth Manager.

Once GDA is installed and the first map is saved as \Storage Card\<<ProjName>\ArcPad.apm, ArcPad will restart with GDA up and running in the most recent project and map extent.

When we start GDA we routinely make GPS Active, enable GPS Tracklog, and--using the Layers form--make the GPS Tracklog invisible.

Data safety

Saving

Whenever you tap OK on the Station edit form, or tap ADD on the Structure, Photos, and Samples pages, data are written to memory. You need not tap the Save icon on the top toolbar.

The Save icon (or Save Map on the File menu) saves the current map extent, the list of map layers, and any special instructions you've defined with the Layers forms. Tapping the Save icon every now and then doesn't hurt--and mostly isn't necessary.

Data not written to files

We have had problems with data not being written to dbf files. We think these problems have occurred because of mixed versions (e.g., an old .apl file and a newer .dbf format) or corrupt XML in a layer definition (.apl) file.

If GDA is properly configured and you pay attention, failure to record data will be evident immediately. (A) Set up Station point symbolization to reflect MAPUNIT. Are the dots the right color? (B) Using the layer dialog, label each station point with MAPUNIT or the like. If you don't see MAPUNIT written beside a new station, data were not recorded. (C) Can you see structure symbols? If not, why? (D) Label each structure point with its INC.

If data are not written to dbf files, delete the feature and re-enter it. If data are still not saved, make paper notes.

If you find that data are not being written to dbf files, and particularly if you can establish the conditions that cause this to happen, please let us know.

Archiving

At intervals, copy all data files to an archive folder, copy this folder to a PC, and burn it to CD-ROM for safekeeping. Data files include

```
Geolines_1.0.dbf, Geolines_1.0.shp, Geolines_1.0.shx
Mylar_1.0.dbf, Mylar_1.0.shp, Mylar_1.0.shx
Stations_1.0.dbf, Stations_1.0.shp, Stations_1.0.shx
Structure_1.0.dbf, Structure_1.0.shp, Structure_1.0.shx
Tracklog.dbf, Tracklog.shp, Tracklog.shx
Photos_1.0.dbf
Samples_1.0.dbf
all note (.txt) and sketch files
any projection files
```

It may be useful to put a copy of Units_1.0.dbf in the archive folder, to better understand the MAPUNIT and LITH vocabularies that were suggested to the mapper. It will also be useful to put copies of all digital photographs into the archive folder. We suggest naming the archive folder with the geologists' initials and date of archiving, (a truncated version of a station ID), such as 06_0322ET. The directory structure of the PDA storage card may then look like this:

```
/Storage Card/
  <MyProject>/
    base/
    old_geol/
    06_0320ET/
    06_0322ET/
    Arcpad.apm
    Geolines_1.0.apl
    ...
    Units_1.0.dbf
  Templates/
```

Here are two strategies for archiving, each with its advantages and disadvantages: (1) You can **COPY** data files to the new archive folder. Grow a single, evolving set of data files for the project. Archive folders grow steadily larger and each archive folder supplants its predecessor. At any time, a single set of shapefiles encompasses all of the your data for the project. An advantage of this approach is that earlier observations are

readily accessible.

(2) Or you can **MOVE** all current data files to the new archive folder. Replace them with blank shapefiles from the Templates directory. Keep the current Units_1.0.dbf. Move/copy appropriate photo files and note files to the archive folder. Data are not duplicated in multiple archive folders. An advantage of this approach is that database files remain small for better performance. A disadvantage is that several sets of archived shapefiles must be concatenated to capture the entire project.

Turn GDA databases into a narrative

The Python script `gda2html.py` (located in the Utilities folder) will turn a GDA project folder, or an archive folder, into a narrative in HTML format that is easily read, edited, and printed. Most computers with ArcGIS have Python available as part of the ArcGIS installation. To use this script you will have to locate and install modules *dbf* and *image*; see instructions within file `gda2html.py`.

Incorporating GDA data into a desktop GIS

To move data into a desktop GIS, we have found it simplest to archive a project, then copy the entire archive directory to the computer that hosts the GIS. The archive directory on the PDA may then be deleted, or left for reference during further mapping. If the working directory on the PDA is on a storage card, you can temporarily mount the storage card on the GIS host for fast drag-and-drop transfer.

How GDA data are incorporated into a compilation project in the desktop GIS will depend strongly on the data structure of the desktop project. We suggest these guidelines:

-  p all GDA data in a "FieldData" directory within the compilation project workspace
- Create a script for transferring data from archive subdirectories within the FieldData directory to the appropriate data layers in the compilation project. Think about how to avoid incorporating data from a single archive more than once!
- We find it useful to incorporate almost all of the GDA Stations and Structure layers into the corresponding layers in the GIS compilation project. Geolines and mylar are used primarily as backdrops for digitizing linework in the compilation project.
- Symbolize the stations layer in the GIS with dots the colored to match MapUnit. Plot (on screen or paper) these dots on top of unit-colored polygons from the units-contacts-faults compilation layer. This allows visual confirmation that the compiled geology matches field observations. One can also intersect the stations layer with units-contacts-faults polygons and search the resulting point coverage for mismatches.

Customization

We wrote GDA in the course of our employment with the U.S. Geological Survey. It is not subject to US copyright. You have an unrestricted right to modify and redistribute GDA code. However, we request that, as a matter of courtesy:

1. If you redistribute GDA code, please include the file `Copying.htm` (in the folder `Applets/GDAHelp/`),

- with appropriate modifications.
2. If you modify and redistribute GDA code, please retain notice of our authorship and identify your contributions.
 3. If you modify and redistribute GDA code, please rename all files (e.g., change the version number) and make corresponding changes to internal file references. This will minimize errors associated with mixing files from different versions of GDA. See `Utilities/set_version.py` for help.
 4. If you redistribute GDA code, with or without modifications, please allow others to freely modify and redistribute it also.

Customize with a DBF editor

During use--perhaps on a daily basis--you may find that `Units_1.0.dbf` should be edited for clarity and performance. We particularly find it useful to edit values in the `LITH` field, reduce the number of rows that correspond to differing values of `LITH`, and re-order rows. `StructTypes_1.0.dbf`, `SampType.dbf`, and `Geologists_1.0.dbf` can be similarly edited.

Customize with ArcView or ArcGIS`

For new projects, and as projects evolve, symbolization will have to be created and modified. This can be done on a PC with ArcView or ArcGIS, and new symbology exported to layer definition (`.apl`) files that are then copied to the PDA. See [Symbolization](#), above.

Customize by editing XML and VBS files with a text editor

All of GDA's behavior can be modified by editing the appropriate XML and VBS files. Use a text editor that works gracefully with plain ASCII, not Microsoft Word! Modifying VBS files requires knowledge of VBS and a clear understanding of the internals of GDA. We don't recommend this for most GDA users.

Modifying XML files to change picklists, to change vocabularies from open to closed, and to modify some symbolization is relatively straightforward. Use existing XML as a guide to format. Copy, paste, and modify. Experiment! Be sure to keep an unmodified copy. To test for corrupt XML, open the modified file with a browser such as Firefox (Microsoft's Internet Explorer 6 doesn't display XML). If the file will not display, it probably won't work.

Note that if you modify symbolization by directly editing the layer definition (`.apl`) file, the EXACT statements within `VALUEMAPRENDERER` must be in strict ASCII order, followed by a single OTHER statement. If the EXACT statements are not properly ordered, the symbolization will not work as you expect.

Customize using ArcPad Application Builder

If you wish to significantly modify forms, change or add attributes, or add new tables, we suggest working with ArcPad Application Builder. This is expensive. We found that the \$1,500 cost of Application Builder is cheaper than the time required to learn VBScript and the innards of ArcPad. Expect to spend a lot of time reading ESRI's User Forums.

References Cited

Haugerud, R.A., and Thoms, E.E., 2004, Geologic Data Assistant (GDA): an ArcPad extension for geologic mapping , *in* Soller, D.R., editor, Digital Mapping Techniques '04: U.S. Geological Survey Open-File Report 04-1451, <http://pubs.usgs.gov/of/2004/1451/haugerud/index.html>.