Mobile GIS Data Collection/Update Application to Support Efficient Transportation Decision Making

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Abstract

The Florida Department of Transportation (FDOT) is implementing the Efficient Transportation Decision Making (ETDM) process to streamline the review of proposed transportation projects. This process utilizes GIS and Internet technology to present transportation project information and to facilitate input from review agencies and the public. A critical component of the ETDM process is the availability of complete and up-to-date data to support agency commentary and decision-making by FDOT. Mobile GIS is a cost effective tool for updating and maintaining these essential databases. This paper presents the development of an ArcPad application to support field data collection, site verification, and inventory/data update of sociocultural entity data (e.g., churches, cemeteries, schools, etc.) for ETDM. The paper addresses several issues including the application development process, imposing standards in data collection to facilitate integration with existing databases, and the use of GPS to update existing feature accuracy.

Introduction

The State of Florida has drastically changed the methodology that has been used for years for review and development of transportation planning projects. The Florida Department of Transportation (FDOT), working closely with the Federal Highway Administration and other federal, state, and local agencies, has developed a process called Efficient Transportation Decision Making (ETDM) that redefines how the State of Florida will accomplish transportation planning and project development within the context of federal and state statutes and regulations.

ETDM provides early and continuous involvement from review agencies and citizens in decision making, early identification of avoidance, minimization or mitigation requirements, linkages between land use, transportation and environmental protection or preservation efforts, and much more (FDOT, 2003). ETDM replaces the project review process previously used by FDOT with a new process which incorporates GIS and Internet technology to present transportation project information, provides data analysis and visualization tools, and facilitates input and synthesis of comments from review agencies and the public.

A critical component of the ETDM process is the availability of complete and up-to-date data to support review agency commentary and project planning and design decisions by FDOT. The GeoPlan Center at the University of Florida compiles and maintains the data layers used in the ETDM process as part of the Florida Geographic Data Library (FGDL). FGDL contains over 350 layers of GIS spatial data, satellite imagery, and aerial photographs for use by state agencies and the general public. Some of the data layers required for the ETDM process are not current and must be updated. FDOT has contracted with consultants to conduct this data collection effort. In order to facilitate cost effective field data collection and promote consistent standards for the collection of these critical data layers, the GeoPlan Center proposed the development of a

Mobile GIS application using ArcPad. ArcPad would allow seamless integration with existing data layers maintained for ETDM.

This paper presents the development of an ArcPad application to support field data collection, site verification, and data update of sociocultural entity (SCE) data used for the ETDM process. Sociocultural entities include churches, cemeteries, schools, community centers, and other community focal points that help define a neighborhood or community. The accurate location of these entities is essential in the ETDM process for evaluating the impacts of a proposed project on a community. The paper will also address several additional issues including the application development process, imposing standards in data collection to facilitate integration with existing databases, and the use of GPS to update existing feature accuracy.

Methodology

The application is composed of two parts, both of which are implemented in ArcPad. The first part is a custom application developed using ArcPad Studio intended to be used primarily to collect new sociocultural entity data. This custom application includes data entry forms linked with an existing shapefile and visual basic scripts which populate associated .dbf tables. The second part of the application uses ArcPad to verify the location of existing facilities in the field with GPS, and to "move" these facilities if necessary to increase locational accuracy.

Custom ArcPad SCE Application

The first step in developing the ArcPad application was creating a shapefile for the attributes of the sociocultural entities. The Central Environmental Management Office of FDOT had previously determined the entity attributes and associated data format specifications. The data specifications allowed for the collection of point or polygon features for the entities. However, since the emphasis of this project was on "Community Focal Points", it was decided that the application would collect point features only. Since all the entities were points, which would be uniquely identified during data collection, all the entities could be stored in a single shapefile for the application. Only one file had to be created as opposed to individual shapefiles for each entity type. The sociocultural entities are listed in Table 1.

The data specifications from FDOT had classified attributes as recommended or optional. All the recommended attributes for each entity were included along with selected optional attributes. The recommended attributes were common to all the entities and included such items as name, address, city, and zipcode. The optional attributes selected for inclusion were for specific entities. The selection of optional attributes was based on whether or not the attribute value could be readily determined and collected in the field. For example, the "Type" of Cultural Center (museum, library, gallery, performing arts/theater, or monument) could readily be ascertained on site. The attributes for the community_focal_points shapefile are presented in Table 2. The community_focal_points shapefile was created using ArcCatalog.

The data specifications had further required that standalone .dbf tables be created for school education levels (educational grade ranges by category, e.g., elementary, middle, high, etc.), intermodal facility modes (transportation modes accommodated by an intermodal facility, e.g., bus, rail, taxi, etc.) and station amenities (a feature that contributes to comfort, convenience or enjoyment of an intermodal station, e.g., shelter, bench, or sidewalk. These .dbf tables were

created in ArcCatalog using attributes and formatting as prescribed by the data specifications. An example school education levels table is shown in Figure 1.

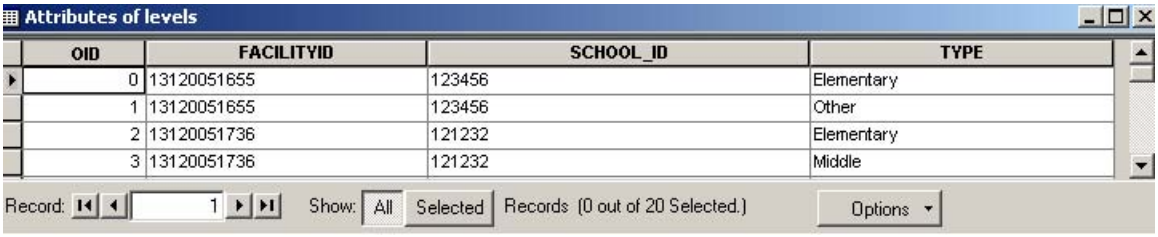


Figure 1: Example school education levels .dbf table

Table 1: Sociocultural Data Entities

ENTITY	DEFINITION
School	An entity that provides educational or technical instruction
Medical/Health Facility	An entity that provides health care
Fire Department	Public service entity that provides fire and emergency rescue
Religious Facility	Buildings or grounds used by religious organizations
Intermodal Facility	A facility that serves as a connection point between two or more transportation modes, typically transit and some other mode of transport
Station Locations	Geographic location of an intermodal station
Cultural Center	A facility with cultural offerings in such areas as the arts, humanities, science, and human knowledge, belief, and behavior
Law Enforcement Agency	A public agency charged with enforcing laws that protect the health, safety, and welfare of the members of a community
Park	Grounds used for recreation
Community Center	A facility for community organization meetings and/or regularly occurring activities, usually serving the needs of a neighborhood
Social Service Facility	A facility that provides public assistance services for persons in the community
Major Attractor	Large-scale public venues used for special events or entertainment-based parks
Government Building	Buildings occupied by governmental functions excluding those identified individually as community focal points such as schools and fire departments
Cemetery	Area reserved for burial
Miscellaneous	A facility, place, or object in a community which has special value to the people in that community and is not included in other tables

The next step in the development of the application used ArcPad Studio to create a layer definition file. The layer definition file provides the links from the data entry forms and associated visual basic scripts to a shapefile. ArcPad loads layer definitions automatically when the associated shapefile is loaded. ArcPad Studio was then used to create the Community Focal Points edit form, add individual pages to the form, and add the controls to each page for structured data entry.

Pages were created for Site Details, School, Medical/Health Facility, Fire Department, Religious Facility, Intermodal Facility, Station Location, Cultural Center, Park, and Major Attractor. It was not necessary to create pages for Law Enforcement Agency, Community Center, Social Service Facility, Government Building, Cemetery, or Miscellaneous as all required information for these entities was captured on the Site Details page.

Table 2: Community_Focal_Points Shapefile Attributes

ATTRIBUTE	DESCRIPTION
FID	Internal feature number.
SHAPE	Feature geometry.
FACILITYID	Unique entity identifier created from entity type, month, day, year, and time
NAME	Facility designation
ADDRESS	A description of a facility's physical location providing direction for delivery and provision of emergency services
CITY	City of facility's physical location
ZIPCODE	US postal delivery designation of facility's physical location
STATE	State of facility's physical location (Florida is default)
TABLE	Type of sociocultural entity
OP_CLASS	Classification of the operating entity
TYPE	Category of facility
OPERATING	The responsible organization for management and operation of a facility
COMMENT	Additional descriptive information about the entity
SCHOOL_ID	Unique identifier number of the School

The Site Details page is shown in Figure 2. The controls on this page provide a drop down menu for selecting the entity from a list of possible choices (see Table 1) and input for Name, Address, City, State, and Zipcode. The unique Facility ID field is generated and populated by visual basic script code called when the Community Focal Point Entity pull down loses the focus.

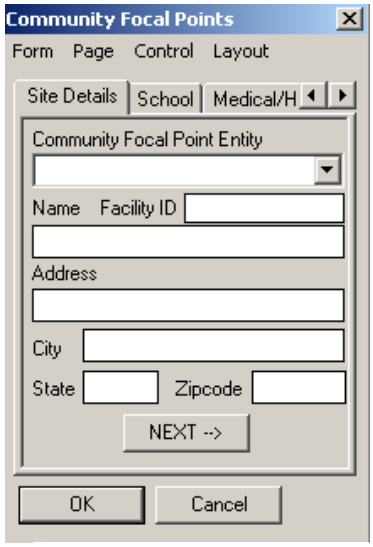


Figure 2: Community Focal Points Editform, Site Details Page

When the Next button on this page is clicked, additional visual basic script code is called which implements error checking (e.g., has an entity been chosen?) and determines which entity has been chosen, automatically loading the appropriate page of the form. For example, if School was the selected entity, when the Next button was clicked the School page would be displayed. If

one of the entities that do not require a page is selected from the entity drop down, the form will close when the Next button is clicked.

The School page is presented in Figure 3. This page allows input of the School ID number, check box selection of Education Level, input of comments as required, and selection of operating entity Type (public or private). The Next button calls visual basic code (see Appendix B), which opens the school education levels .dbf file and writes a new record for each education level checked. Each record contains the Facility ID number, School ID, and Education Level Type (see Figure 1 above). The form then closes.

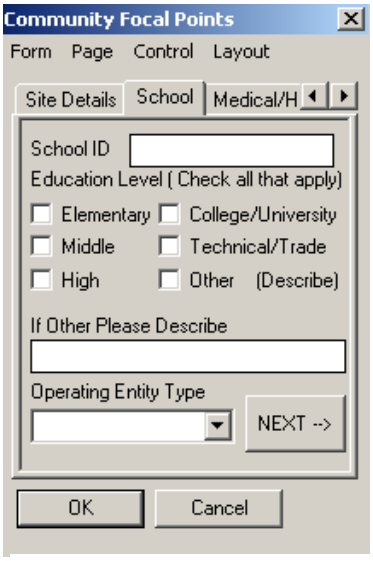


Figure 3: Community Focal Points Editform, School Page

The Medical/Health Facility page allows selection of Facility Type (emergency room, specialty medicine, etc.) and Operating Entity Type (public or private) from drop down menus. This page is shown in Appendix A.

The Fire Department page allows selection of the Operating Entity Type (city, county, special district, etc.) from a drop down menu and input of comments as required. This page is shown in Appendix A.

The Religious Facility page allows selection of the Religious Facility Type (sanctuary, shrine, etc.) from a drop down menu and input of comments as required. This page is shown in Appendix A.

The Intermodal Facilities page is shown in Figure 4. This page allows input of the Name of the facility, drop down selection of facility Type (city, county, authority, etc.), input of comments as required, and check box selection of the modes served by the intermodal facility. The Next button calls visual basic script code (see Appendix B), which opens the intermodal facility modes .dbf file (see Figure 5) and writes a new record for each mode served which is checked. Each record contains the Facility ID number and Mode. The form then closes.

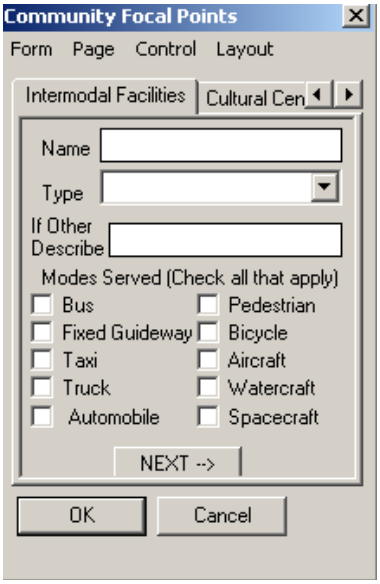


Figure 4: Community Focal Points Editform, Intermodal Facilities Page

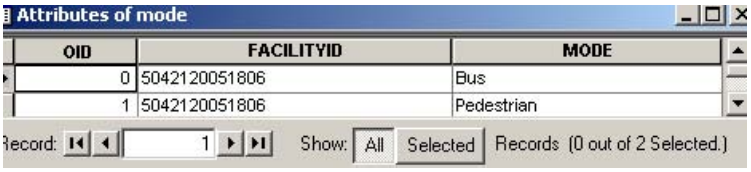


Figure 5: Example intermodal facility modes .dbf table

The Cultural Center page allows selection of the Cultural Center Type (museum, library, gallery, etc.) from a drop down menu and input of comments as required. This page is shown in Appendix A.

The Park page provides a drop down menu for selection of the Operating Entity Type (local/neighborhood, community, etc.) of park from a drop down menu. This page is shown in Appendix A.

The Major Attractor page allows selection of the Major Attractor Type (convention, agricultural, fair, etc.) from a drop down menu and input of comments as required. This page is shown in Appendix A.

The Station Locations page is shown in Figure 6. This page allows input of the Name of the station, input of the Station ID number, check box selection of the amenities available at the station, input of comments as required, and a drop down selection of Operating Entity Type (city, county, regional, etc.). The Next button calls visual basic script code (see Appendix B) that opens the station amenities .dbf file and writes a new record for each mode served which is checked. Each record contains the Facility ID number, Station ID number and Amenity. The form then closes.

The SCE application is automatically activated when the Community_Focal_Points shapefile is loaded in ArcPad. Additional data layers can be displayed for reference when using the application. When the user creates a new feature by tapping a location on the screen or activates the GPS Point button in ArcPad, the application displays the Site Detail page for attribute entry.

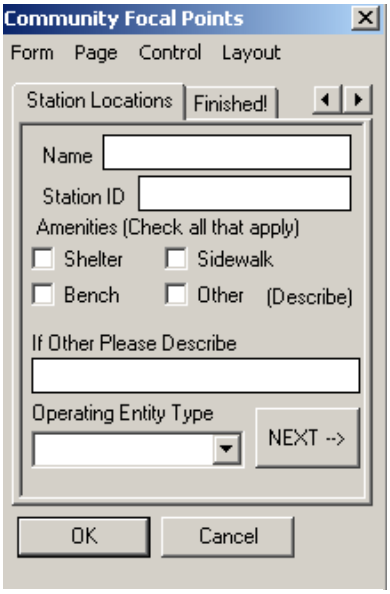


Figure 6: Community Focal Points Editform, Station Locations Page

Editing Geocoded SCE Data Using ArcPad

The second part of the SCE application involved developing and documenting procedures for using ArcPad with GPS to update or verify the spatial location of sociocultural entities. The spatial accuracy of SCE features is important in the GIS analysis portion of the ETDM process. Using the built-in capabilities of ArcPad, a user in the field can display the location of an existing SCE feature and with GPS move the feature, if necessary, to increase spatial accuracy.

In an effort to facilitate field data collection and update, GeoPlan Center staff compiled addresses for existing SCE entities from a variety of Internet and federal, state, and local agency sources. These address locations were then geocoded using ArcGIS to create point shapefiles. Additional data layers for these entities were also created, where available, from parcel data from 61 individual counties obtained through the State of Florida, Department of Revenue 2003 tax data. Data were not available for six counties out of a total of 67 for the state. These data layers were intended to facilitate field data collection by providing users with a quick start on verifying location and attributes for SCE features. The derived SCE base layers are shown in Table 3.

In many cases the parcel derived SCE layers proved to be more accurate than the geocoded layers due to the inherent accuracy problems related to geocoding. Geocoding works well in urban settings where uniform lot sizes allow the geocoding algorithm to accurately place address locations along a street centerline. In places where lot sizes may not be as uniform, such as rural

Table 3: Geocoded and Parcel Derived SCE Data Layers

SCE DATA LAYER	GEOCODED DERIVED LAYER	PARCEL DERIVED LAYER
Cemeteries	X	X
Civic Centers	X	X
Community Centers	X	X
Cultural Centers	X	X
Fire Stations	X	
Government Buildings	X	
Health Care Facilities	X	X
Intermodal Facilities		X
Law Enforcement Facilities	X	
Right of Way		X
Park Facilities	X	X
Religious Centers	X	X
Public and Private Schools	X	X
Social Service Centers	X	X

or suburban areas, geocoding accuracy tends to be much less accurate. In addition, when the geocoding for the SCE layers was implemented, no assumptions were made on potential offset of the feature point from the road centerline. Since the users would physically be at the site during field data collection/verification process, it would be easy to validate locational accuracy with GPS and move the point feature if necessary.

Figure 7 illustrates the accuracy issue described above and the process of using GPS to move the point feature to the correct location. In this example both the point and the parcel polygon represent the same church. The geocoded point is off by about 105 feet. The procedure to move the feature using GPS would be as follows. With the GPS active, the point feature to be moved is selected using the selection tool. Tapping the Vertex Edit button will display a blue square around the selected feature indicating that Vertex Moving has been enabled. Tapping and holding within the blue square will display the Move To menu. Tapping Move to GPS will result in the selected point feature being moved to the current GPS position.

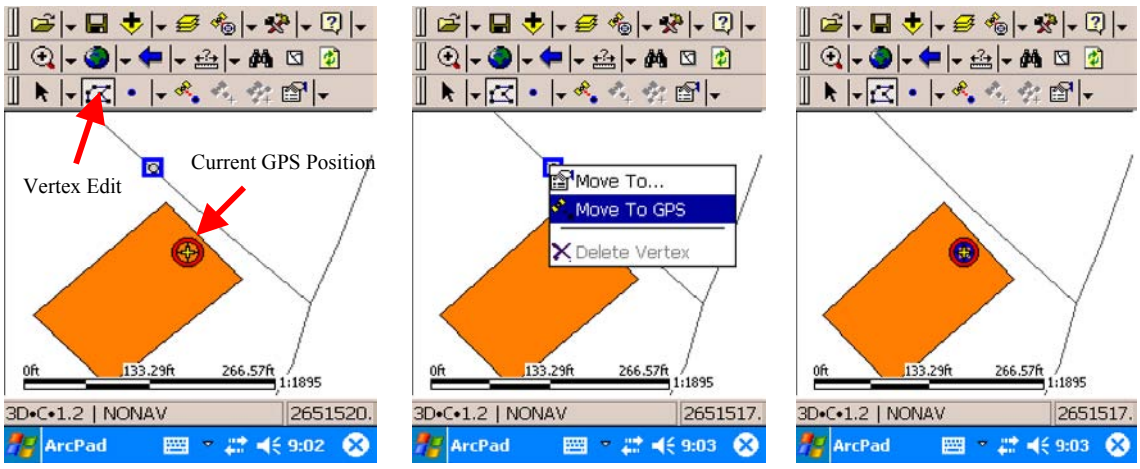


Figure 7: Moving an SCE Point Feature Using GPS

The procedures for displaying and editing spatial location as well as attributes of the SCE features were developed and documented in a users' manual. The manual also documented the use of the Custom ArcPad SCE Application. The users' manual was provided on a CD-ROM

containing SCE data layers distributed to consultants accomplishing the data collection. Several consultants are currently beta testing the application. Preliminary feedback has been positive.

Conclusions

Mobile GIS is an effective tool for field data collection, update and verification. The Custom ArcPad SCE Application described in this paper allows accurate collection of data critical for a key analysis component of the ETDM process. The custom forms in the application ensure that attributes collected for the SCE entities are in a standard format to promote compatibility with existing data layers. The use of ArcPad will allow seamless integration with data layers currently being maintained for ETDM. Procedures for editing existing SCE data layers in the field were developed and documented to facilitate data collection.

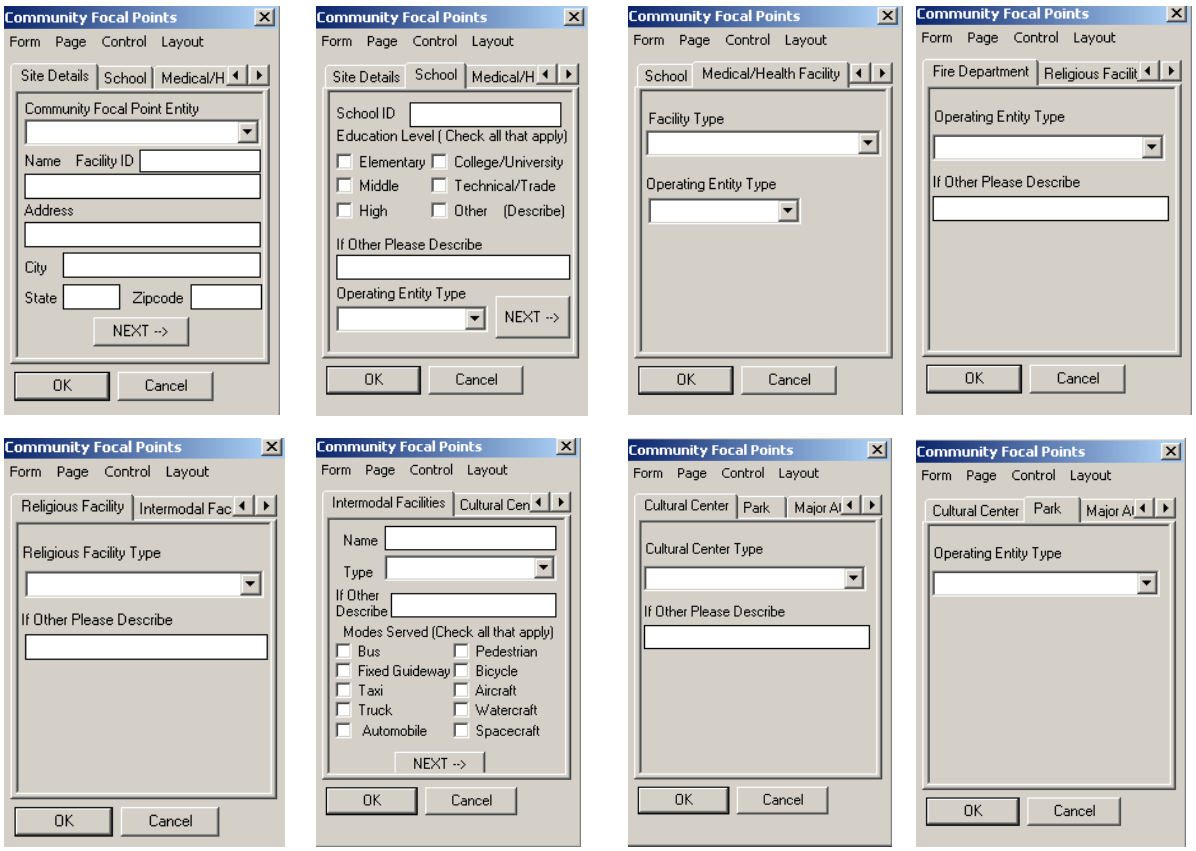
The GeoPlan Center is in the process of developing additional ArcPad applications for update of other existing datasets critical to the ETDM process. These data layers include wetlands demarcation, archaeological site occurrence, and endangered species occurrences.

Acknowledgments

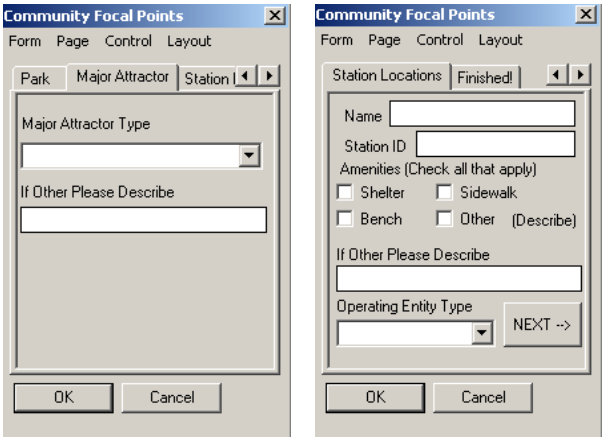
Kate Norris, Senior GIS Specialist at the GeoPlan Center compiled the SCE parcel derived and geocoded derived databases.

Appendices

Appendix A: Community Focal Points Edit Form, Entity Pages



Appendix A: Community Focal Points Edit Form, Entity Pages (Continued)

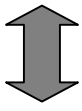


Appendix B: Selected Sections of Visual Basic Script

Selected sections of the visual basic code used for the SCE application are provided to demonstrate how some of the customization was implemented. Gaps in the code are indicated by: ⇕

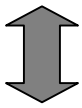
```
'-----------------------------------------------------------------
'SCE: Community Focal Points Application: Subroutines
'GeoPlan Center
'University of Florida
'Contact: Stanley Latimer 352 392-9406, latimer@geoplan.ufl.edu
'-----------------------------------------------------------------
'Global variables
Dim theID
Dim MyString
'Globally store the EditForm and its Controls
Dim objEditForm, objEFPageOneControls
'-----------------------------------------------------------------
Private Sub DisableID ' Called by onload event (form is loading) of editform
  Set objEditForm = Application.Map.Layers("Community_Focal_Points").Forms.Item("EditForm")
  Set objEFPageOneControls = objEditForm.Pages("Page1").Controls
  'Disable the Facility ID edit box
  objEFPageOneControls("txtFacilityID").Enabled = False
End Sub
'-----------------------------------------------------------------
Private Sub WriteTheID ' Called by onkillfocus event of cboTable control
    'Get the Community Focal Point layer's recordset (to pass into the CreatetheID function)
    Dim objFocalPtsRS
    Set objFocalPtsRS = Layer.Records
    'Update the Facility ID
    objEFPageOneControls("txtFacilityID").Value = CreatetheID (objFocalPtsRS, "FACILITYID")
  End Sub
'-----------------------------------------------------------------
Function CreatetheID (objRS, strFieldName) '
Dim objThePage
Dim objTheComboBox
Dim FixDay
```

```
Dim FixMonth
Dim FixYear
Dim FixTime
Dim FixID
 Set objThePage = Application.Map.Layers("Community_Focal_Points").Forms.Item("EditForm")
Set objTheComboBox = objThePage.Pages("Page1").Controls("cboTable")

'Create the unique id to be used in shapefile and DBFs
FixID = (objTheComboBox.ListIndex + 1)
If FixID > 0 And FixID < 10 Then
        FixID = "0" & FixID
End If
FixDay = DAY(DATE)
If FixDay > 0 And FixDay < 10 Then
                FixDay = "0" & FixDay
End If
FixMonth = MONTH(DATE)
If FixMonth > 0 And FixMonth < 10 Then
        FixMonth = "0" & FixMonth
End If
FixYear = YEAR(DATE)
FixTime = FormatDateTime(Time,vbShortTime)
FixTime = Replace(FixTime,":","")
theID = (FixID & FixMonth & FixDay & FixYear & FixTime)
CreatetheID = theID
End Function
'---------------------------------------------------------------------
Private Sub JumpToPage 'called from Site Details, NEXT button event
Dim objThePage
Dim objTheComboBox

Set objThePage = Application.Map.Layers("Community_Focal_Points").Forms.Item("EditForm")
Set objTheComboBox = objThePage.Pages("Page1").Controls("cboTable")
'If no choice made, notify
If objTheComboBox.ListIndex = -1 Then
msgbox "Please Choose Entity!"
Exit Sub
End If
'Determine Page to jump to based on entity chosen
If objTheComboBox.ListIndex = 0 Then
objThePage.Pages("PAGE2").Activate
End If
If objTheComboBox.ListIndex = 1 Then
objThePage.Pages("PAGE3").Activate
End If
.Pages("PAGE5").Activate
End If
```



```
If objTheComboBox.ListIndex = 14 Then
objThePage.Pages("PAGE11").Activate
End If
End Sub
'---------------------------------------------------------------
Private Sub WriteToSchoolDBF  'called from the School, NEXT button event

Dim objThePage
```

```
Set objThePage = Application.Map.Layers("Community_Focal_Points").Forms.Item("EditForm")
Dim myRS
Set myRS = Application.CreateAppObject("recordset")

'myRS.Open ("e:\ipaq_ready\levels.dbf"),2
'myRS.Open ("C:\etdm\levels.dbf"),2 'mode of 2 allows for read/write capability
myRS.Open ("D:\pc_ipaq_test\levels.dbf"),2
'myRS.Open ("My Documents\etdm\levels.dbf"),2 'mode of 2 allows for read/write capability; iPAQ file access
If Not myRS.recordcount=0 Then
 myRS.MoveLast 'moves to last record
End If

 'check if the check box has been clicked or not
If objThePage.Pages("Page2").Controls("chkType1").Value = True Then
 myRS.AddNew 'adds a new record

myRS.Fields("FACILITYID").Value = theID

myRS.Fields("SCHOOL_ID").Value = objThePage.Pages("Page2").Controls("txtSID").Text

myRS.Fields("TYPE").Value = objThePage.Pages("Page2").Controls("chkType1").Text

myRS.Update 'saves information to the recordset

End If
```



```
If objThePage.Pages("Page2").Controls("chkType6").Value = True Then

myRS.AddNew 'adds a new record

myRS.Fields("FACILITYID").Value = theID

myRS.Fields("SCHOOL_ID").Value = objThePage.Pages("Page2").Controls("txtSID").Text

myRS.Fields("TYPE").Value = objThePage.Pages("Page2").Controls("chkType6").Text

myRS.Update 'saves information to the recordset

End If
myRS.Close

End Sub
'--------------------------------------------------------------------------
```

End Notes

Software

The software used for this project included ArcGIS 9.0 (ArcCatalog and ArcMap), ArcPad Studio 6.0, and ArcPad 6.0.3.

Hardware

The application was tested on a Hewlett Packard iPAQ hx2410 running Pocket PC 2003 Premium. The GPS used for the project was a TeleType GPS Bluetooth Receiver.

References

Florida Department of Transportation (2003). " Florida's ETDM Process: Efficient Transportation Decision Making While Protecting the Environment", Retrieved May 15, 2005 from (http://etdmpub.fla-etat.org/website/PublicInfo/help/ETDM.pdf).

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