GIS in Landscape Architecture:
Introduction to the GIS-Workflow

using

ArcGIS
ArcMap 10

Version 10.2, English

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1 Basic Knowledge

1.1 ArcMap User Interface

1.1.1 Map display and Table of Contents

With ArcMap you can create maps consisting of different layers that contain the information you are interested in. Layers could be tables, vector layers like shapefiles or CAD-drawings, raster layers like images or raster files as well as WebServices (e.g. WMS, WFS).

The loaded layers are listed in the table of contents (TOC), by default on the left edge of your window. Here you can decide which layer should be visible, in which order the layers should be drawn and you can change the form of display.

The table of contents has several ways of listing layers: the list by drawing order, by source, by visibility and the list by selection. The display drawing order lists only the layers and their symbologies in order how they shall be drawn, the source display shows also the path where you can find the data. Moreover in this view added tables could be displayed. The display visibility orders the layers into the categories visible and not visible in the map display. List by selection divides layers into layers were features are selected and those with no feature selection.

The map display of ArcMap displays the layers in the order and colors defined in the table of contents.

Also for the map display two types of display are available: the data view shows only the geometry of your layers combined in a map. The layout view allows you to define a page and to arrange other elements beside your map such as pictures, legends, title etc. on the page. It is the more suitable view to prepare printings.

1.1.2 Toolbars

The surface of ArcGIS is freely adaptable so that every toolbar - except of the main menu - can be hidden or chosen only if it is needed. By default the Main Menu Toolbar visible. Also recommended
is to keep the Standard and the Tools toolbar visible. You can undock every toolbar and move it to a preferred place of your window.

**Main Menu Toolbar**

<table>
<thead>
<tr>
<th>File</th>
<th>Edit</th>
<th>View</th>
<th>Bookmarks</th>
<th>Insert</th>
<th>Selection</th>
<th>Geoprocessing</th>
<th>Customize</th>
<th>Windows</th>
<th>Help</th>
</tr>
</thead>
</table>

*File*: The menu collects tools and commands to organize and print your map document and to add data to it. Most of the commands are well-known of other programs.

*Edit*: The edit menu contains commands to copy/cut/paste elements of a map.

*View*: Contains a collection of tools to navigate in your map or to change the display of your ArcMap. If you change the appearance of ArcMap your next ArcGIS session will start with the changed surface no matter whether you work with a new or an existing document.

*Bookmarks*: Allows to create and manage bookmarks to mark an area of a dataframe.

*Insert*: Contains tools to insert new dataframes or elements to a layout.

*Selection*: The selection menu allows to define the selection options and to start selection by attribute and by location.

*Geoprocessing*: Gives fast access to the most common geoprocessing-tools out of the Arc Toolbox and to other useful dialog-windows.

*Customize*: Contains menu to add toolbars to prepare your data for analysis and to customize your application. The command Extension allows you to load additional function to your program.

*Window*: By default the window menu contains tools to improve the orientation in the map.

*Help*: The help menu leads to an online help as well as to an interactive help.

**Standard Toolbar**

Contains buttons with commands that are familiar from other products, e.g. to administer the project (New Project/Open a Project/Save/Print), to Cut/Copy/Paste items, to Undo/Redo a step or to get direct help for a command. Besides there are some special ArcGIS-buttons:

*Add Data*

Opens a dialog, where you can browse your network to add all the supported data types to the map display. Supported are for example shapefiles, coverages, different types of images, cad-files (dxf) as well as.

*Open/Close Editor Toolbar*

Opens a new toolbar to edit your data.

*Launch ArcCatalog*

Opens the ArcCatalog window inside ArcMap.

**Tools Toolbar**

Contains command buttons to navigate your map view, to select, identify and find features of your map and to make simple measurements inside your map.

*Zoom in/Zoom Out*

Zooms into/out of your map using a dragged rectangle.
**Zoom in/Zoom Out**
Zooms into/out of your map using system-given scales keeping the view center.

**Pan**
Changes the considered map view by dragging the map to the wanted direction.

**Full extent**
Zooms to the full extent of your map.

**Previous/Next extent**
Zooms to the previous/next extent.

**Select features**
Selects the elements of the predefined selectable layers.

**Select elements**
Select graphics in the map (e.g., text).

**Identify**
Tool to query the attributes of a chosen feature. The information will be shown in a popup window.

**Find**
Opens a window to type in a word, that will be searched in all attribute tables of the loaded layers.

**Measure**
Tool to measure distances by clicking the start- and the endpoint. The result is shown at the status bar at the bottom of ArcGIS.

**Hyperlink**
Opens another document such as image or text files or starts a macro that is linked with the features of a layer.
1.2 Exercise Explore ArcMap

Task

For the islands Gozo and Comino a map exists, that shows the agricultural use, the roads and the cities of both islands. Check the map to get familiar with the data.

Data

All the used data comes from the Malta Environmental and Planning Authority (MEPA) or the survey-office of Malta.

Used functions

- Navigating a map
- Make layers visible
- Use tools for orientation in your map

How to do this

1. Preparing the data

   Windows

   Right-click the Start button and point to Explorer to launch the Windows Explorer. Copy the folder Exercise with the origin data to your personal folder.

2. Navigating a map

   Windows

   Double-click the ArcMap icon on your desktop or click the Start button and point to Programs - ArcGIS - ArcMap to launch ArcMap.

   ArcMap dialog

   In the text box double-click Browse for more …, browse to <personalfolder>/exercise/projects and choose Expl_ArcMap.mxd. A map with the islands of Gozo and Comino will open.

   The layers are displayed in the order they appear in the table of contents (TOC). At present a part of your layer Roads is hidden by the layer Development zones. Bring the Roads in front of all other layers.

   Table of contents (TOC)

   Layer Roads

   Select the layer to highlight it. Drag it to the top of the TOC.

   While you are dragging a black bar shows you the present position of your layer in the TOC.

   Start to explore the map which contains the agricultural use, the roads and the cities of Gozo.

   Tools toolbar

   Tool Zoom In

   Drag a box around the westernmost end of the yellow major road that crosses Gozo from west to east to zoom there. In your Standard Toolbar point to the drop-down arrow next to the scale and set the scale to 1:10.000.

   Move the cursor to the blue polygon where the road ends. A MapTip shows you that you are in Dwejra.
Select the *Pan* tool and follow the road to the east. Every time you pass a settlement with your cursor a MapTip shows you the name of it. Finish to pan the map, when the MapTip shows that you have reached the capital *Rabat* (*Victoria*).

### 3. Use orientation tools

To get an impression where the capital is situated and which extent you just view you can use the Overview window of ArcMap.

**Main menu Windows,**

Command *Overview*

The overview window opens normally with the bottommost layer of the TOC as reference layer. In our case it is an orthophoto of Comino that is not suitable for an overview. To change the reference layer right-click on the title bar of the window and select properties.

**Overview properties**

Click the drop-down arrow and choose *Topographical Map 1:25.000* from the list. Press *OK*. The properties dialog disappears and a small window shows the topographical map with a red hatched rectangle marking the present extent.

**Gozo & Comino Overview window**

Move the mouse cursor over the rectangle. A four-headed arrow appears. Click inside the rectangle and drag it again to the west coast. The extent of your map changes appropriately.

Move your cursor to a corner of the rectangle till it change to a two-headed arrow. Click and drag to enlarge the rectangle. The extent of your map changes appropriately.

**Tools toolbar**

Tool *Previous extent*

Undo your pan and zoom until you reach the capital again.

**Close your overview window.**

**Tools toolbar**

Tool *Identify*

Because we are interested in the area of the capital we query its attributes. Click anywhere inside the blue area. The *Identify* window appears and shows depending on your choice either the attributes of the Topographical map or of the roads - the <Top-most layer> that is preselected by default. Change the identified layer from the drop-down menu to *Development zones*.

Click again inside the blue area. It blinks once green and the *Identify* window lists the attributes which it took from the table. The area in hectares should be 1'374'695 m. Close the *Identify* window.

### 4. Create spatial bookmarks

For a later quick access to the capital we want to create a spatial bookmark there. To begin we want to zoom automatically to the area of the capital. Therefore we select the capital.

**TOC**

List by selection, layers

Enable the possibility to be selected for the layers *Roads* and *Agricultural Use* by clicking the colored boxes beside the layer names. If you now use the *Select features* tool only features from the layer *Development zones* are selectable.
Click once inside the blue area of Rabat. Its outline will be highlighted in blue color.

Right-click on the layer name and **Zoom To Selected Features**. The view extent zooms automatically to the extent of the capital.

Select **Create**... The **Spatial Bookmark** window appears and asks for a name. Insert **Capital Rabat** and press **OK**.

The Selection of the capital will be removed.

Zoom to the full extent of the map.

Another spatial bookmark was already created for the island Comino. Use this bookmark to zoom to the small eastern island.

Select **Comino**. Your map extent is set to the island.

Use the measure tool, to give a statement to this island.

What’s the approximated extent of Comino?

North-South: _____ m; East-West: _____ m

In your table of content klick the box next to **3885o.jpg** to turn the layer on. A quadratic orthophoto will be drawn on the western end of the island.

**Zoom to the whole extent of your orthophoto by right-click on the layer name and point to** **Zoom To Layer**.

Turn off the **Agricultural Use**, **Topographical map** and **Gozo & Comino** by clicking their boxes to see the orthophoto without impairment.

Use the navigating tools from your Tools toolbar to explore the orthophoto.

Feel free to explore the other orthophoto.

**Zoom back to the full extent of the map.**

Exit the map. Click **Yes** if you are prompted to save.
1.3 ArcCatalog User Interface

By default the ArcCatalog User Interface consists of the following components. If you change the appearance of your Interface the next session will start with the changed surface.

1.3.1 Catalog display and catalog tree

Catalog tree

The catalog tree lists your data in a tree-like way similar the Windows Explorer, with plus signs and minus signs to expand or hide the content of a drive or folder. Different from your Windows Explorer the viewed data files are only the spatial data files of the dataset.

From the symbol next to the file name you can directly get the feature type of a vector data file:

- Polygon
- Line
- Point

While the main symbols are always the same, the color specifies the file type. The most common types are:

Grey: Geodatabase
Green: Shapefiles
Blue: CAD file
Yellow: Coverage

Other often used symbols are:

- Image or raster data. Irrespective from the file type the icon is always the same for raster data.
- TIN Surface model

Catalog display

The catalog display has three tabs to show information about your data: Contents, Preview, Description.
The Contents Panel allows to explore the content of a folder. You can choose different kinds of displaying the data: large icons, simple list, list with details or thumbnails. The different view modes can be chosen from the Standard toolbar.

Using the Preview Panel the geometry or the attribute table of a dataset can be viewed. (Enabling the ArcGIS 3D Analyst extension allows the 3D View tools to navigate around your data in 3D). The preview allows you to check your data quickly to decide which one is the best to add to ArcMap. Preview is only possible when a dataset with geographical content is chosen. While the Geography preview mode is active the Geography toolbar is enabled to navigate through the dataset.

The Description Panel shows information about the selected dataset that is stored in an xml-file named like the dataset. If still no metadata exist for the selected dataset the Metadata preview creates a new xml-file at the same path location. With the Description toolbar you can print, edit or import metadata.

1.3.2 Toolbars

As in ArcMap the surface of ArcCatalog is free adaptable. Every toolbar can be hidden or chosen only if it is needed. By default the Main Menu Toolbar is visible. Advisable is to keep the Standard and the Geography toolbar visible. You can undock every toolbar and move it to a preferred location of your window by click on the gray bar and drag it to the target location. A frame shows you the current form and position if you would drop the toolbar.

Main menu toolbar

File  Edit  View  Go  Geoprocessing  Customize  Windows  Help

File: Beside commands which can also be found in the Standard toolbar (such as Delete or Connect/Disconnect) the command New allows to create a new folder or dataset.

Edit: Contains commands which are to be found in the Standard toolbar (such as Copy/Paste or Search).

View: Controls the surface of ArcCatalog. Toolbars can be displayed or hidden as well as the Status Bar and the Catalog tree.

Go: Contains the Up One Level command of the Standard toolbar.

Geoprocessing: Gives fast access to the most common geoprocessing-tools out of the Arc Toolbox and to other useful dialog-windows.

Customize: Contains menu to add toolbars to prepare your data for analysis and to customize your application. The command Extension allows you to load additional functions to your program.

Windows: Contains additional dialog-windows.

Help: Contains well-known and extensive help tools and information about the currently used version.

Standard toolbar

Up One Level

Go up one level in the catalog tree.

Connect To Folder

Opens a dialog to browse your network for a drive or a folder you want to connect with. The connection appears in your catalog tree and enables to access its contents as well as its subfolders.
**Disconnect from folder**

Disconnect and delete the currently selected folder connection from your catalog tree.

**Copy/Paste/Delete Dataset**

All three commands handle all the files that are connected with the selected item. E.g. for shapefiles the action will be taken at least for the shp-, shx- and the dbf-file.

*Copy* copies the selected items into the clipboard. *Paste* adds the content of the clipboard at the current location. *Delete* removes the selected items. For the last action is no undo available so be careful to use this command.

**View modes**

View modes are only enabled if the Contents tab is chosen.

*Large icons* shows the content of the current location as icons.

*List* lists the content of the current location only by name.

*Details* lists the content of the current location with details. The viewable details can be set in the options.

*Thumbnails* shows the content of the current location as small thumbnail images. A thumbnail is only shown when it was created before. ArcMap document files are automatically shown as a thumbnail, other datasets such as shapefiles or coverage can get a thumbnail by using the Create Thumbnail tool in the Geography toolbar.

**Search tool**

Allows searching for a dataset using defined search criteria like name, content or date.

**Launch ArcMap**

Launches the ArcMap application.

**Launch Toolbox**

Launches the ArcToolbox application.

**What’s this?**

Click this tool and point to any command or tool you are interested in to get a short description about it.

**Geography toolbar**

**Zoom in/Zoom Out**

Zooms into/out of your map using a dragged rectangle.

**Pan**

Changes the considered map view by dragging the map to the wanted direction.

**Full extent**

Zooms to the full extent of the chosen dataset.

**Identify**

Tool to query the attributes of a chosen feature. The information will be shown in a popup window.

**Create thumbnail**

Is only active if Preview tab and Geography mode are chosen. Allows creating a thumbnail to view the content in the thumbnail view.
Location toolbar

The location toolbar shows the path of the currently selected item.
For quick access to an item with known location you can type in the path and press enter.

1.4 Exercise Explore ArcCatalog

Task
Examine the data of Exercise 1.3.

Used functions
- Connect to folder
- Preview information about data
- Use orientation tools

How to do this

1. Create connections
Windows
Click the Start button and point to Programs - ArcGIS - ArcCatalog to launch ArcCatalog.

By default only the local drives are shown in the catalog tree. Because we don’t want to browse every time all the subfolders of our drive we want to create a connection to our exercise folder.

Standard toolbar
Tool Connect To Folder
Click the button to open the Connect to Folder dialog.
Browse to your exercise folder. Use the plus signs to view the content of a drive or folder.
Select the subfolder Exercise in your personal folder and click OK. The connection <personalfolder>\exercise appears in the catalog tree.

2. Explore the Malta data
Catalog tree
Click the plus sign next to your exercise folder to see the content of it.

There should be five folders: images which stores raster data such as orthophotos or topographical maps, projects that contains map documents and map templates, shape with the vector data, tables with additional tables and import with original data in different data formats.

Catalog tree
Browse to the folder exercise/images/topmap and view its content. Make sure that the Contents Panel is selected in the catalog display.

Standard toolbar
Tool List
Choose the list view. A topographical map named malta_25.png should appear in the catalog display.

If you can’t see the file extension png change the settings to get it.

Main menu Customize, command Arc Catalog Options…
Open the ArcCatalog Options… dialog and choose the General tab. Uncheck the box next to <Hide file extensions> if necessary. Click OK to close the dialog.
Catalog tree

Browse to the folder `exercise/shape` to preview the vector data.

Standard toolbar

Tool Details

Choose the view with a list of detailed information about your data.

You can set the kind of details you want to view.

Main menu Customize, command Arc Catalog Options…

Again open the ArcCatalog Options … dialog and choose the Contents tab. Check the boxes next to <Name>, <Type>, and <Size>. Uncheck all the other boxes. Click OK to close the dialog.

Your detail view shows now the selected details.

Standard toolbar

Tool Thumbnails

Choose the thumbnail view. At the moment only symbols but no thumbnail should be visible.

Catalog tree

Select the shapefile `AGRI.shp`. Choose the Preview Panel of your catalog display. By default its geography is shown.

Geography toolbar

Tool Create Thumbnail

Click the tool to create a thumbnail.

Catalog tree

Go back to the folder `shape` and make the Content Panel active.

Standard toolbar

Tool Thumbnails

If you now choose the thumbnails view a small image of the shapefile `AGRI.shp` should be visible.

Repeat creating thumbnails for the other shapefiles in the folder.

Catalog tree

Select the shapefile `AGRI.shp` again. Choose the Preview Panel of your catalog display to view its geography.

Standard toolbar

Tool Zoom In

Drag a box anywhere at the island to zoom in.

Tools toolbar

Tool Identify

Click on any feature you are interested in. It blinks once green and an Identify Results windows pops up and shows the attributes of the feature. Scroll down to the field `SUMMARY_DE` to get the land use type.

Close the Identify Results window.

Standard toolbar, tool Full extent

Zoom back to the full extent of the map.

There are a number of preview options. You can view the geography of your datasets, the attribute tables, or the item descriptions.

Catalog display

From the drop-down menu next to <Preview> on the bottom of the catalog display choose Table.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalog display</td>
<td>Now the attribute table will be displayed. On the bottom the number of records (rows) is visible. How many records are contained in the table? _______</td>
</tr>
<tr>
<td>For later orientation</td>
<td>metadata should exist for every dataset. If you get data from an external association without metadata you can create your own metadata. When you create your own data however you should also create metadata.</td>
</tr>
<tr>
<td>Your Malta data contain no</td>
<td>metadata yet. Only for the topographical map metadata was created by the MLA staff.</td>
</tr>
<tr>
<td>metadata yet.</td>
<td></td>
</tr>
<tr>
<td>Catalog tree</td>
<td>Browse to the folder .../exercise/images/topmap and click malta_25.png. Choose the Preview tab to get an impression of the map. A dialog asks you whether ArcGIS should build pyramids or not. Choose Build pyramids.</td>
</tr>
<tr>
<td>Geography toolbar</td>
<td>When the image is ready build, create a thumbnail.</td>
</tr>
<tr>
<td>Tool Create Thumbnails</td>
<td></td>
</tr>
<tr>
<td>Catalog display</td>
<td>Choose the Description Panel. If the previous action was successful, you should see a small image of the map. Explore the metadata. To see the content of a green heading click on it.</td>
</tr>
<tr>
<td>Main menu File, command Exit</td>
<td>If you do not want to continue with the next exercise finish the program.</td>
</tr>
</tbody>
</table>
1.5 Layouts

ArcMap provides two ways to view a map: data view and layout view. Although you could print a map directly from the data view ArcGIS provides a layout view to work with the map layout elements such as titles, north arrows or scale bars.

If you want to display more than one data frame (e.g., a detailed and an overview map) you can display its spatial relations by showing extent rectangles.

For further use you can save map templates from already created maps to produce maps that conform to a standard. Moreover, they save time by letting you do the layout work for all of the maps in the series at once.

1.6 Exercise Creating maps

Task

For a short presentation of the island of Gozo you want to create the overview map you explored in the first exercise using your own colors and symbols.

Data

The vector data was created and made available by the Malta Environment and Planning Authority (MEPA). The topographical map was scanned from an analogue map 1:25,000 and georeferenced by the MLA staff. It is available as a png-file.

Used functions

- Symbolize the data
- MapTips, labeling
- Create a layer file from your symbolized data
- Create bookmarks
- Extent rectangles
- Use templates for layouts

How to do this

1. Create a new map

Start the program, create a new map document and add some data.

Windows

Double-click the ArcMap icon on your desktop or click the Start button and point to Programs - ArcGIS - ArcMap to launch ArcMap.

ArcMap dialog

Create a new empty document.

Standard toolbar

Browse to `<personalfolder>/exercise/shape`, select the feature datasets `agri.shp`, `dev_zone.shp` and `str.shp` by click on it and point to Add to add the dataset to your map. To choose more than one dataset at the same time press the CTRL key.

Confirm the warning that one or more layer misses spatial information. The layers will be displayed in the map.
At time the map has no scale. Set the properties of the display to change this.

Main menu View, Data Frame Properties…
Open the Data Frame Properties and click the General tab. Change the name of your data frame in Gozo & Comino and set the map units and the display units to meters. Click OK to apply your changes.

The layers are displayed in the order they appear in the table of contents (TOC). Bring it in the following order (from top) if necessary: str.shp, dev_zone.shp, agrি.shp.

TOC List By Drawing Order
To change the order of the layers click the layer you want to move and drag it to the target position.

Standard toolbar Tool Save
Save your map document as exercise1-6.mxd to your <personalfolder>/exercise/projects.

2. Symbolize your data
At present all the features in each layer are displayed in the same way: same (randomly chosen) color, same outline, same hatching and so on. We want to change the symbology based on the attribute table.

TOC Layer str.shp
Double-click the layer str.shp to open the Layer Properties dialog or open it by right-click on the layer and point to Properties…. Choose the Symbology tab.
In the <Show> box on the left side by default Single symbol is chosen for every feature. Change the method of symbolizing to Categories and Unique values. From the drop-down menu next to <Value Field> choose the field FEATCO, which contains different categories of streets. Click Add All Values.
In the former empty list five different categories each with another symbol appear. The Value column shows the coded categories of the streets on Gozo. The roads which code starts with a W3 are major roads, these with a W8 are secondary roads and those with W04 are gravel roads. Rename the road codes in the Label column using its meaning.

Layer Properties str.shp
Click once the W04 in the <Label> column and replace the text with Gravel roads.
Select now the roads with the value W35 and W36. To select more than one value use the CTRL key. Right-click and point to Group Values. Both values appear in one line. Rename the label to Major roads.
Repeat the step equivalent for the remaining values and rename it to Secondary roads.
Rename the Heading FEATCO in Type.

Now the road symbology should be displayed in a different way depending on their importance.
Double-click the symbol next to Gravel roads to open the Symbol Selector. Choose the dotted symbol for Road Unpaved from the symbol list. In the <Current Symbol> frame click the square next to <Color> to open the color palette. In the color palette click Gray 70%. Press OK when you are ready.

Repeat the steps for the other road types. Set for Secondary roads the symbol Road, Proposed and keep the settings. For Major roads choose the symbol Freeway. In the <Options> frame change the size to 2 and set Fire red for color.

Arrange your road types by their importance. Select your Gravel roads and bring it to the bottom using the black arrow down right of the box.

Turn off <all other values>.

If your dialog matches the following graphic click Apply to apply your changes.

Choose the General tab. Rename the layer in Roads. Click OK to close the dialog.

Repeat symbolizing the layers of your map. Apply every time Unique values to symbolize the data.

Again open the Layer Properties dialog with the Symbology tab. Use Unique values and SUMMARY_DE as <Value Field>. Right on top of your symbol window you can see the momentary <Color Ramp>. Right-click inside the given scheme and uncheck Graphic View. The graphical display changes to a text description of the color scheme. Choose Yellows from the drop-down menu.

Remove the outlines of the symbols. Right-click on any symbol and point to Properties for All Symbols… Click the box next to <Outline Color> to get the color palette. Choose No Color from the palette.

Remove the heading in the column <Label>. Apply your changes with the button Apply.

Choose the General tab. Rename the layer in Agricultural Use. Click OK to close the dialog.
Symbolize the layer dev_zone.shp yourself. Apply again unique values. Use the field FEATURE for value field. Change the symbol of Industrial Area to Blue Gray Dust, for Urban Area to Tuscan Red. Remove the heading and rename the layer to Settlements.

3. Label your map with MapTips and labels

Because the yellow colors of the agricultural used areas are often similar you want to support the identification with MapTips.

TOC Layer Agricultural Use

Double-click the layer name to open its properties. Choose the Display tab. Pick from the drop-down list next to <Display Expressions>: the field SUMMARY_DE. Check the box <Show Map Tips using display expressions>. Click OK.

If the command is not selectable close the dialog clicking OK.

Standard toolbar

Tool Editor Toolbar

Open the Editor toolbar if necessary.

Editor toolbar

Menu Editor

In the Editor menu select Start Editing to start an edit session. Double-click any Value Field of the layer Agricultural Use. Close the window Template Properties.

Stop the edit session using Stop Editing in the Editor menu.

Standard toolbar

Tool Editor Toolbar

Close the Editor toolbar.

TOC Layer Agricultural Use

Again open the layer properties of Agricultural Use by double-click on the layer name. Choose the Display tab. Check <Show Map Tips using display expressions> should now be possible. Click OK.

Map display

Move your cursor over your map. The respective field type will be displayed as MapTip.

Moreover we want to display the cities names at all times.

TOC Layer Settlements

Double-click the layer name to open its properties. Choose the Labels tab.

Tick <Label Features in this layer>. For label <Method> make sure that Label all the features the same way is chosen. In the <Text String> frame choose NAME from the drop-down list next to <Label Field>.

Click the [Symbol...] tool in the <Text Symbol> frame. The Symbol Selector will be opened. Choose Country 2 as font type. In the <Current Symbol> frame set the color to Gray 70 %. Keep the other settings and click OK to close the Symbol Selector.

In the <Other Options> frame click the Placement Properties. In the opened Placement Properties dialog check <Remove duplicate labels>. Click OK to close the Placement Properties window.

Press OK to close the Layer Properties dialog. The names of the settlement appear in the chosen way.
TOC
Layer Settlements

Double-click the layer name to open the Layer Properties dialog. Choose the Label tab and click in the <Other Options:> frame. Make sure that Use the same scale as the feature layer is chosen. Click OK to close the dialog.

Standard toolbar
Map scale

Type a scale of 25000 in the text box. Press the Enter key to confirm the entered scale.

TOC
Dataframe

Right-click on the Dataframe and open Reference Scale Set Reference Scale.

Standard toolbar, tool Full extent

Zoom back to the full extent of the map. Your labels are displayed scaled now based on the defined Reference Scale of 25.000.

4. Create a bookmark

Tools toolbar
Tool Zoom in

Drag a rectangle around Comino to zoom there. Chose per Drag & Drop a scale of 25000 in the text box of the map scale.

Tools toolbar
Tool Pan

Use the pan tool to centralize Comino inside the display.

Menu View
Command Bookmarks Create

Type in the appearing Spatial Bookmark dialog next to <Bookmark Name:> Comino and press OK.

Standard toolbar, tool Full extent

Again zoom back to the full extent of the map.

Tool Save

Save your map.

5. Create layer files

We invested some work and time to change the appearance of our layers. To avoid the same work every time we use a layer in a new map document we want to store the settings of our layers.

TOC, Layer Roads

Right-click on the layer name and point to Save as Layer File.... The Save Layer dialog prompted for the path. Choose <personalfolder>/exercise/shape and save it using the suggested name.

Windows

Open ArcCatalog.

ArcCatalog!

Catalog tree

Browse to your <personalfolder>/exercise/shape.

Catalog display

Choose the Contents tab.

Standard toolbar, Tool Large Icons

Your new created layer file appears as a yellow square that stands on one corner.
Select the Icon for your file Roads.lyr and choose the Preview tab. The layer appears in the same way you created in your map document.

Click the tool to create a thumbnail.

Go back to the Contents tab. You should see a little thumbnail of your Roads layer file.

Go back to ArcMap and create layer files from the other data. Create thumbnails in ArcCatalog for it. If you can’t see your new files in ArcCatalog select the folder where it is saved and press F5 to refresh the content of the folder.

Overlay the topographical map
To complete our map we want to add the topographical map 1:25.000.

Arrange and resize your ArcCatalog window that you can see ArcMap in the background

Browse to your <personalfolder>/exercise/images/topmap.

Display the thumbnails of your data. Make sure that the Contents tab is chosen in the catalog display.

Choose the detailed display. Select the malta_25.png by click on it. If it is selected it is blue highlighted. Drag it to ArcMap.

Go back to ArcMap.

Drag malta_25.png to the top of your table of content if necessary.

Double-click the layer name to open the Layer Properties dialog. Choose the Display tab. Type 50 into the text box next to <Transparency>. Click Apply or OK to see the changes.

Create a new Data Frame
Create a new Data Frame. It will be inserted at the bottom of your table of contents as New Data Frame.

Double-click on the name of your new data frame to get the Data Frame Properties dialog. Choose the General tab if necessary. Rename the data frame next to <Name:> into Overview and set the map and display units to Meters.

The new data frame is still empty. For an overview we insert the topographical map 1:25.000.

Right-click the layer name and point to Copy to bring Malta_25.png into the clipboard.
TOC Data frame **Overview** Right-click the data frame name and point to Paste Layer to insert Malta_25.png from the clipboard.

TOC Data frame **Overview.** Layer Malta_25.png Double-click the layer name to open its properties. Choose the Display tab and set the transparency to 0%. Press **OK**.

TOC Data frame **Gozo & Com.** Right-click the data frame name and point to Activate to make the first data frame active.

Menu Bookmarks **Command Comino** Zoom to the extent of Comino using the bookmark.

8. **Create a layout using a template**

Map display bottom Tool **Layout View** Change your map display from the data view to the layout view. A page with both created maps appears. Moreover the Layout toolbar pops up.

Menu **File** Command **Page and Print Setup…** In the page and print setup dialog in the <Map Page Size> frame turn off the checkbox next to <Use Printer Paper Settings> if necessary. Choose from the <Standard Sizes:> drop-down list A2, and choose Landscape for <Orientation:>. Press **OK**.

Layout toolbar Tool **Change Layout** Choose the My Template tab from the Select Template dialog.

Select Template dialog Click the Open template button on the bottom of your dialog to browse to <personalfolder>/exercise/projects, select the Template_3_1.mxd and click Open.

The next window gives a preview to the order of the dataframes. Move the dataframe Overview to the top by selecting it and pushing the button <Move Up>. Click **Finish** to close the dialog and to apply the template.

The layout changes according to the template with arranged data frames.

Standard toolbar Scale Click once in the frame with the island Comino to get it marked by a dotted line. Pick from the drop-down list in the Standard toolbar the scale 1:10.000.

To see the location of Comino in our overview map we want to create an extent rectangle.
Map display

Click once into the right frame with the overview map to get this frame marked. Right-click inside the map and point to Properties. In the Data Frame Properties choose the Extent Indicators tab. In the textbox next to <Other data frames:> select Gozo & Comino and click the single arrow to the right. The data frame will appear in the box next to <Show extent indicators for these data frames>. Click the Frame button.

In the Extent Indicator Frame Properties dialog pick the borderline 4.0 Point from the drop-down list in the <Border> frame. Click the rectangle next to <Color:> to get the color palette and choose Ginger Pink. Press OK to close the Frame Properties and again to close the Data Frame Properties.

In your overview map should appear a rectangle that shows the extent of the map beside it.

Map display

Click the title of the layout to get it edged dotted. Right-click on it and select Properties. In the appearing Properties dialog choose the Text tab if necessary. Click inside the text box and replace the existing text with Island Comino. Click OK.

Enter your name and the present date in the boxes below the map frames.

Finally we want to add legend, scale bar and north arrow to our layout.

Layout toolbar

Zoom to the extent of your whole layout page.

Tool Zoom Whole Page

Menu Insert

Legend...

Legend Wizard

In the appearing Legend Wizard you can specify which item you want to display. By default all the items are selected. Remove Malta_25.png from the list next to <Legend Items> by selecting it and press the button with the single arrow to the left []. Click Next.

The next window treats the legend title. Delete Legend from the textbox. Click Next.

Confirm all the following settings clicking Next respectively Finish to close the dialog and create the legend.

At the moment there is no layer name written. Furthermore we decide because of the amount of patches in the legend to display it using two columns.
Tools toolbar
Tool Select Elements
Double-click the legend. In the Legend Properties dialog choose the Items tab. To change the style of all legend items select all the items in the box beneath <Legend Items:> using the Shift key. Afterwards click the Style... button to open the Legend Item Selector. Choose Horizontal Single Symbol Layer Name and Label from the list. Click OK.

Select from the list beneath <Legend Items:> the Agricultural Use and check the check box next to <Place in new column>. Click OK.

Tools toolbar
Tool Select Elements
Move the created legend to the empty space in the upper right corner of your layout.

Change the spacings between the columns and objects of your legend. Use for this purpose the Legend tab of the Legend Properties dialog.

Menu Insert
North Arrow...
Pick one of the north arrows from the appearing North Arrow Selector. Press OK. The arrow will be inserted in the middle of your page.

Tools toolbar
Tool Select Elements
Drag it to the frame down right of your layout.

Menu Insert
Scale Bar...
In the Scale Bar Selector select the Hollow Scale Bar 1 and click OK.

Tools toolbar
Tool Select Elements
Drag it to the empty space in the left down corner of the Comino data frame. To change its properties double-click the scale bar.

Hollow Scale Bar Properties
Choose the Scale and Units tab if necessary. In the <Scale> frame select Adjust width from the drop-down menu next to <When resizing...>. Set for <Division value>: 500 m. Type next to <Division Units>: 3 and next to <Label Position> select Meters beneath <Number of divisions>: 2. In the <Units> frame select Meters beneath <Label Units> and after labels beneath <Label Position> and replace Meters next to <Label:> with m. Press OK.

Enter a free eligible text in the middle field on the bottom of your layout. Choose the command Text from the main menu Insert.

Layout toolbar
Tool Zoom Whole Page
Zoom to the extent of your whole layout page if necessary. It should match roughly the following graphic.

Standard toolbar
Tool Save
Save your map document.
1.7 Exercise Create and modify data

Task
Someone has started to digitize the contour lines based upon the topographical map. Obviously the digitizer couldn't come to the end so the contour lines are still unfinished. You want to continue digitizing this layer.

Moreover there is a shapefile with the borders of all islands but with apparent mistakes and missing data. Your task is to correct the data.

Another task is to create a tourism guide for Gozo and Comino. Therefore you will start with a new shapefile that contains caves on both islands.

Data
Available is the georeferenced topographic map of Gozo in the scale 1:25.000 as png-format as well as a shapefile that contains beside others the caves and a dxf-file with the contour lines.

Used functions
- Digitize features in an existing shapefile
- Deal with the attribute table
- Change the display of your data
- Modify features
- Create shapefiles
- Create metadata

How to do this

1. Prepare your map

Windows
Double-click the ArcMap icon on your desktop or click the Start button and point to Programs - ArcGIS - ArcMap to launch ArcMap.

ArcMap dialog
blank map
Main menu View,
Data frame properties
Create a new empty document.

Tool Add Data
Browse to <personalfolder>/exercise/images/topmap/, select the image Malta_25.png and point to Add. Repeat the step for the layer Habitats_ellipse.shp from your folder <personalfolder>/exercise/shapes.

Furthermore add the linear elements from the dxf-file Elevation from <personalfolder>/exercise/import/. When you browse to the given path two files are offered. Double-click the one with the blue symbol to get its parts displayed. Now choose Polyline and point to Add.
Double-click the layer name of Habitats_ellipse.shp to open the Layer Properties dialog. Choose the Symbology tab. From the list in the box beneath Show: choose Categories and Unique values. In the box next to <Value Field> the field FEATURE should already be chosen. Point to Add Values and choose from the Add Values dialog only the caves. Click OK to close the Add Value dialog. Double-click the symbol next to CAVE to get the Symbol Selector dialog. In the Options frame choose a red fill color for it. Close all the dialogs by clicking OK.

Save your map document as exercise1-7.mxd to your <personalfolder>/exercise/projects.

2. Digitize features

You want to start your tasks digitizing the contour lines. Because ArcGIS is unable to modify dxf-files we have to transform the dxf-layer into another data format.

Right-click to your layer name and point to Data and Export Data… In the Export Data dialog click the folder symbol to specify the path <personalfolder>/exercise/shapes/ and name the new shapefile as contour. Keep all the other settings and press OK. Click Yes if you are prompted whether to add the new layer or not.

The dxf layer is no longer necessary. Right-click on the layer name and point to Remove to delete it from your table of content.

Every time you want to edit or modify features you have to start an edit session.

The fastest way to get the Editor Toolbar is the button in your Standard Toolbar.

Start the edit session in the Editor Toolbar. After have done so, you can set in the dialog box the targeted of your edit session.

Set contour for target if necessary.

Drag a rectangle in an area where obviously contour lines are missing.

To improve the accuracy of our digitizing use a scale that is bigger than this of the base map. In our case type 1:5.000 in the scale box of your standard toolbar.

Our new digitized lines should join existing ones where it is possible so it is better to set some snapping options.

Open the Snapping Toolbar and select End Snapping.
Double-click on the layer contour inside of the dialog box Create Feature opened on the right side of the map display. Confirm by clicking OK.

Start to digitize contour lines on the base of your topographical map by clicking once. Click at every change of direction to set a new vertex. If you come near an endpoint of an existing line the cursor will snap to the endpoint. To finish a line either double-click or right-click and point to Finish Sketch.

After you have finished one line click the Attributes button of your Editor toolbar. A window appears that gives you the opportunity to insert attributes for the digitized (and still selected) feature. Type in the appropriate z-value next to elevation and close the window.

Continue digitizing for at least three complete contour lines. The more contour lines you digitize the more accurate gets your terrain model later.

Finish your digitizing and click Yes when prompted for saving.

Double-click the layer name to open its Layer Properties. Choose the <Symbology> tab if necessary. In the box beneath <Show:> change the choice from Features to Quantities. Graduated Colors should be the default setting. In the <Fields> frame select the Elevation field from the drop-down list next to <Value:>

Right-click in the box next to <Color Ramp:> und uncheck <Graphic View>. The display of the color scheme changes from colors to text. Choose Surface from the drop-down menu.

In the <Classification> frame click Classify... to get the Classification window. If necessary choose Natural Breaks as <Method:> for classification and 18 <Classes:>. Click OK to close the Classification window. In the Layer Properties check <Show class ranges using feature values>.

Right-click in the box that shows the current symbology and point to Format Labels... to open the Number Format window. In the <Rounding> frame change the number of decimal places to 0 and click OK to close the window.

Make sure that your Properties match the following graphic then click OK to close the Layer Properties.
3. Modify existing data

**Standard toolbar**

**Tool Add Data**

Load the shapefile *islands* from your `<personalfolder>/exercise/shape/...` to your data frame.

**TOC**

Drag the layer *Islands* to the top of your TOC if necessary.

**TOC**

Layer *Islands*

Right-click on the layer name and point to **Zoom To Layer** to view the whole extent of the layer.

The *Islands* layer should cover all the islands of your map. As you can see there are some mistakes in the layer, you have to correct. Because we will often use the island Comino we want to create a spatial bookmark.

**Tools toolbar**

**Tool Zoom in**

Drag a rectangle around Comino to zoom there.

**Standard toolbar**

**Scale**

Type 25000 in the scale textbox and press Return.

**Tools toolbar**

**Tool Pan**

Choose the Pan tool to center the island.

**Menu Bookmarks**

**Command Create...**

When you are prompted for the bookmark name type *Comino* in the appropriate place.

**TOC**

Layer *Islands*

Check off the layer islands to see the right border of Comino. Turn it on again. There is one part in the north of Comino that looks very strange. Right-click on the layer name and point to properties. Click the Display tab. Type a transparency of 60% in the appropriate textbox. Click OK.

To correct the border we have again to start an edit session.

**Editor toolbar**

**Menu Editor**

**Command Start Editing**

Start the edit session in the Editor Toolbar. Set *Islands* as target and modify Create Features by clicking Organize Templates.
Organize Feature Templates
Menu New Templates

Choose in the Organize Feature Templates dialog box the layer Islands and click in the menu New Templates. Set the check box beside the layer Islands and click <Finish>. Close the Organize Feature Templates dialog box by clicking <Close>. The features from the layer Island are now added to the Create Feature window on the right side of the Map display. Select Islands by clicking.

Tools toolbar
Tool Zoom in

Zoom nearer the part you want to correct. The new extend of the border should match the 0 contour line.

Editor toolbar
Menu Editor
Command Snapping…

Snapping Toolbar

Editor toolbar
Tool Edit

Click once inside the polygon you want to modify, then right-click and point to Edit Vertices. Its vertices are displayed. For our aim we do not need all the vertices. Right-click on one of the vertices and point to Delete Vertex. If there is only one left move the cursor over it and drag it to the edge of the contour line. Because of the set snapping option it should snap to the vertex of the contour line.

Click anywhere outside to see your changes applied.

Tools toolbar
Tool Go back to the previous extent

The previous extent should be the one of whole Comino. If not zoom to the full extent and drag again a rectangle around Comino.

As you can see the small island Kemmunett (or Cominotto) isn’t still contained in the layer Islands. You want to add this feature to the shapefile. Moreover you want to name the islands in the attribute table.

The outline of the small island Cominotto corresponds to the contour line for 0. Therefore we want to trace this line.

Tools toolbar
Tool Zoom in

Drag a rectangle around Cominotto.

Tools toolbar
Tool Select feature

To trace a feature you need to select it. Click once the contour line for the elevation 0. It should become highlighted in blue.

Map Display
Create Feature dialog box

Click the Construction Tool Polygon inside the Create Feature dialog box to activate the hidden tools in the Editor toolbar. Choose the Trace tool. Click at any point on the highlighted contour line and follow the outline around the island. If you have reached the start point finish the feature with a double-click.

Menu Selection,
Command Clear Selected features

Remove the selection of the island.

Finally correct the island Gozo that momentary consist of two parts (one that covers almost the whole island and one circular part). Both parts should become unionized.
For a better view of the problem turn off all the layers except of the Islands layer.

Tools toolbar
Tool Select feature

Editor toolbar
Menu Editor
Command Merge.

The layer is now almost ready. For further information you want to add an attribute field with the island name and the area of the island.

Editor Toolbar
Menu Editor
Command Stop Editing

TOC
Layer Islands

Attribute table of Islands
Menu Table Options
Command Add Field…

To add an attribute field you have to finish the edit session. Click Yes when asked for saving.

Right-click on the layer name and point to Open Attribute Table.

Open the Add Field dialog. Type in the text box next to <Name>: English Na and choose from the menu next to <Type>: Text. Give the field a length of 20.

Repeat the step and add another text field called Maltese Na also with a field length of 20.

A third field shall be the field Area, field type Double with unchanged other settings.

Start calculating the Area of the islands using an SQL statement.

Attribute table Field Area

Right-click the Area field name and click Calculate Geometry…. A message reminds you, that outside an edit session undo your calculating is not possible. Click Yes to continue.

In the appearing Calculate Geometry dialog choose out of the drop-down list by <Property> Area if necessary.

Click OK. ArcGIS takes the area from the geographic features and uses the units you have set in the data frame properties, which means you get square meters!

Because square meters are to accurate to display the area you want to add a new field that contains the area in hectares.

Attribute table Islands
Menu Table Options
Command Add Field…

Add another field called Area_ha, field type Float, type for <Precision> (field width) 8, and for <Scale> (digits right of the comma) 2.
Attribute table

Field Area_ha

Right-click the Area_ha field, point to Field Calculator… and confirm the warning.

To calculate hectares you can use the field Area divided by 10000.

To get the right expression double-click Area in the Fields list. It appears in the text box beneath Area_ha= in angular brackets. From the buttons right of the text box take the button by one click. Type finally 10000 in the text box so that your expression matches the following:

\[\text{[Area]} /10000\]

Click OK and examine the results. Afterwards close the attribute table.

What is now still missing are the names of the islands. To enter them you have to start the edit mode again.

Editor Toolbar

Menu Editor

Command Start Editing

Tools toolbar

Tool Select feature

Start selecting the polygon of Gozo by click inside the polygon.

Editor toolbar

Tool Attributes

Open the Attribute insert window and type Gozo next to both English_Na and Maltese_Na.

Tools toolbar

Tool Select feature

Select the island of Comino.

Editor toolbar

Tool Attributes

Enter Comino next to English_Na and Kemmuna next to Maltese_Na.

Repeat the step for Cominotto (Kemmunett). Southeast of Cominotto there are two small islands with no names at it. Select them one after another and enter Unknown for their names.

Still there are some little islands left. They are obviously too small to find them easily so you can use the attribute table to search for them.

TOC

Layer Islands

Right-click on the layer name and point to Open Attribute Table. Examine the records which have still no entry. Click on the gray box left of one record with no entry to get it highlighted. Minimize the attribute table so that you can see the table of content.

Right-click on the layer Islands and point to Selection and Zoom To Selected Features. Your map display switches to the extent of the selected feature.

Tools toolbar

Tool Fixed Zoom Out

Zoom out until you can see whether there is a label on the topographical map.

Editor toolbar

Tool Attributes

If there is an English and a Maltese label enter the names next to English_Na and Maltese_Na. For those labels missing enter Unknown.
Restore the table and repeat the steps for every record with missing entries. Close the table after finish all records.

TOC
Layer Islands
Symbol Selector
Double-click the rectangle symbol beneath the layer name to get instantly the Symbol Selector dialog for it.

Choose the Hollow symbol from the symbol list. In the right frame click the button Edit Symbol to open the Symbol Property Editor. Choose the Outline button to change its appearance. In the Symbol Selector choose the symbol category Dashed from the list and change in the <Current Symbol> frame its <Width> to 2 and Mars Red for <Color>. Click OK to close the Symbol Selector, again to close the Symbol Property Editor and a third time to close the remaining window.

TOC
Layer Islands
Save your display settings by right-click on the layer name and point to Save As Layer File… Take the suggested name Islands.lyr and save it to <personalfolder>/exercise/shape….

Because the Layer Islands has a transparency the 0 contour line shines through it. We want to fade out the contour lines with the value 0.

TOC
Layer Contour
Double-click the line next to 0 to get the Symbol Selector.

In the <Current Symbol> frame choose No Color from the drop-down list next to <Color:>. Close the dialog clicking OK.

4. Create a new shapefile

To create a new layer you have to change to ArcCatalog.

Windows Point to Programs - ArcGIS - Arc Catalog to launch Arc Catalog.
ArcCatalog!

ArcCatalog tree
Browse to your personal project folder <personalfolder>/exercise/shape. Right-click the shape folder, point to New and Shapefile…. A Create New Shapefile dialog pops up.

Shapefiles can store only one type of geometry: either polygons or lines or points. Because our shapefile should store the tourist attractions of the island of Gozo and Comino we prefer to set the feature type to point.

Create New Shapefile dialog
In the dialog type Attractions in the textbox next to <Name:>. The drop-down list next to <Feature Type:> should show Point by default. Click OK to finish. An empty shapefile named Attractions is created in your shape folder.

Catalog display
Tab Preview
If you preview the geography of your new shapefile it is completely empty. However, in the preview of the attribute table should be at least three fields: FID, Shape and ID (but no record).

Catalog tree
Right-click on your layer Attractions.shp and point to Properties. In the Shapefile Properties click the <Fields> tab if necessary.

In the column <Field Name> add a new field entering Type in the next empty cell. In the column <Data Type> select Text as data type. In the <Field Properties> frame in the lower portion change the field length to 24. Click OK to get the dialog closed and the new field added.

ArcCatalog window
Reduce the size of your application window and arrange it to see ArcMap beside it.

Drag your layer Attractions.shp to your map document in ArcMap and change to ArcMap.

ArcMap!

5. Create point features

TOC
Layer Attractions
Drag your layer to the top of your table of content if necessary.

You still should be in an edit session. If not start the edit session again.

Map Display
Create Feature dialog box
Click the Organize Templates button to open the Organize Feature Templates. Choose the layer Attractions and open the Create New Templates Wizard by clicking <New Templates> in the menu.

Check the box next to the layer Attractions if necessary and continue with <Finish>. Close the Organize Feature Templates by clicking <Close>.

Select the layer Attractions in the Create Feature dialog box at the right side of your map display.

The information about caves you take from the layer Habitats_ellipse. Although we already changed the color of the caves to red they are not really good recognizable. Therefore we want to zoom to the habitats which are caves.
Menu Selection  Open the Select By Attributes dialog. From the drop-down list next to <Layer:> choose Habitats_ellipse.

Command Select by Attributes…

In the textbox in the lower portion of the dialog you make an SQL expression to query your data. You can either type in the expression or you take the parts of the expression from lists. The last one allows creating SQL statements without care about the syntax. To create an expression, double-click the field you want to use, click an operator, then double-click the value.

Select by Attributes dialog  Create the expression "FEATURE" = 'CAVE' by double-click the field "FEATURE" from the box beneath <Fields:>, simple click the Equal to button and double-click 'CAVE' from <Unique Values:>. Choose the Verify button to check your expression and – if it was successful – Apply your selection and close the dialog.

TOC
Layer Habitats_ellipse  Right-click on the layer Habitats_ellipse and point to Selection and Zoom To Selected Features. Your map display switches to the extent of the selected features which are highlighted in blue.

TOC
Turn off all layers except of Attractions, Islands and Habitats_ellipse to have a better view onto the selected features.

Editor toolbar
Tool Sketch Properties

Use the Sketch tool and click once inside one of the selected ellipses. A point appears that is displayed in the blue color that shows selected features.

After setting the first point the selection of your caves disappears. But in the apparent view extent you can make out the red dots that are caves. For a better accuracy of your points use the magnifier window.

Menu Window
Command Magnifier…  Click in the heading bar of your magnification window to drag it to another position. Use the appearing crosshair to navigate the window over the red dots.

Editor toolbar
Tool Sketch tool  Continue digitize the caves. It has to be five points at the end.

Close the magnification window.

The layer is called attractions so we can assume that caves are only the beginning of its content. For a later differentiation we enter the type of the already existing points. Because every point belongs to the same type we want to calculate it at once.

TOC
Layer Attractions  Right-click on the shapefile and point to Open Attribute Table.

Attributes of Attractions  Right-click the heading of the field Type and click Field Calculator…. In the appearing Field Calculator type “Cave” in the text box beneath <Type=>.

Click OK to enter the text. Look at the result and close the attribute table.

Editor Toolbar
Menu Editor
Command Stop Editing  Finish the edit session and click Yes if you are prompted to save.
Click the Editor Toolbar button in your Standard Toolbar to remove the Editor toolbar from the display.

Double-click the symbol beneath the layer name to get the Symbol Selector.

Point to Style References and check Caves in the list. Some useful symbols to display caves are added to the list in the left window. Choose the symbol Blast Rubble from the list. To find it easier click inside the list and press the key with the initial letter of the symbol (B) until the selection jumps to the right symbol.

In the options frame change the symbol size to 20. Click OK to apply your changes.

Zoom to the full extent of your map.

The symbols remain their size no matter which scale is chosen. Because the size is optimized to a scale of 1:50,000. You will change the settings.

Double-click the layer to get its Layer Properties dialog opened. Choose the Display tab if necessary.

Make sure that Scale Symbols when a reference scale is set is checked. Click OK to close the dialog.

The layer Habitats_ellipse is no longer necessary. Right-click the layer name and point to Remove.

Type 50000 in the scale textbox and press Enter.

Zoom to the extent of Comino. All layers are now scaled to the reference scale because this is the default setting for all layers.

For contour lines and the islands outlines it makes no sense to scale the display. Remove the scaling for them.

Zoom back to the full extent of your map.

Save the changes of your map document.

Close the program.

6. Add metadata

Always after you have created a new layer you should create metadata to give other users information about the data. Metadata you can create in ArcCatalog.
Windows Start menu

If ArcCatalog is already closed point to the Windows Start button – Programs – ArcGIS - ArcCatalog to open ArcCatalog.

**ArcCatalog!**

**ArcCatalog tree**

Browse to your personal project folder <personalfolder>/exercise/shape. Click the plus sign next to shape to view its content. Select the shapefile Attractions.shp.

For the catalog display choose the Preview tab. The five digitized point should appear.

**Geography toolbar**

**Tool Zoom in**

Drag a rectangle around the right three points to zoom there.

**Geography toolbar**

**Tool Create Thumbnails**

Click the tool to create a thumbnail of the current view extent. Change the view mode of the catalog display to Contents by clicking the appropriate tab to see the created thumbnail.

**Catalog display**

Change to the Metadata view mode by changing to Description. Except of the thumbnail the metadata file contains no data. We want to enter the most important metadata.

**Main menu Customize**

**Toolbars**

Make sure that the <Metadata> toolbar is checked. In case it isn’t check it. If necessary dock the toolbar in the upper portion of your program window.

ArcGIS uses a simple description of metadata as standard which is called *Item Description*. You can also change the style of the metadata profil if necessary. A choice of metadata profils is given in the *Arc Catalog Options*. Therefore open in the Main Menu Toolbar the menü Customize and chose the command Arc Catalog Options. Select the tab Metadata and chose in the <Metadata Style> frame out of the drop-down list the metadata profil that is needed, e.g. INSPIRE Metadata Directive.

**Catalog display**

**Tool Edit metadata**

Click the button to open the *Item Description* of ‘Attractions’. In the <Title> window type *Tourist Attractions*. In the textbox next to <Summary (Purpose)>: type *Lists the popular tourist spots of Gozo and Comino*. Click inside the textbox next to <Description (Abstract)>: to place a descriptive text. Type beneath <Credits> Malte Environmental Planning Authority (MEPA) and MLA staff and limit the use of this data beneath <Use Limitation> to education purposes.

Click **Save** to apply the changes and close the Editing ‘Attractions’ dialog.
The metadata was now written into an XML-file. To see the file change to your Windows Explorer. Beside ArcCatalog it is readable with your internet browser. Editing is also possible with any text editor.
2 Advanced I

2.1 Tables

Every feature class no matter if it contains points, polylines or polygons is connected with an attribute table. The content of the attribute table depends on the needs of the creator. On principle every entry is imaginable: text, numbers and even hyperlinks to pictures or web pages.

Structure of tables

Inside ArcGIS table rows are called records and columns are called fields. A field is defined by its name, its field type and its width. All features of a dataset - means all records - share the same fields or attributes.

No matter which data format you use the attribute table has to contain a field that stores the geographical information. In ArcGIS this is the field Shape. It will be created automatically as well as the field FID with a numbering for the program intern organization of the features. In your attribute table the field Shape appears with an entry that specifies whether your dataset stores points, lines or polygons.

Normally every record belongs to one geographical feature of the dataset in your map. They are dynamically linked each other. If you select a feature in your map the corresponding record in your table will be highlighted, if you make a selection in your attribute table the linked features in your map will be highlighted.

Like in a database there could be relationships between tables. Depending on the goal tables can be linked or joined using a key field.
2.2 Exercise Analyze data

Task

The strength of GIS consists not only in display but in analyzing and querying your data. For an agricultural report you want to query your existing data, create a statistic about the different kinds of using the fields and their share of the whole area.

Moreover there was an inquiry whether viticultural fields are situated near a main road and which kind of fields lay inside a 50 meters buffer of the main roads.

Data

The needed data are the streets layer and the agricultural use - both come from the MEPA - and the topographic map of Gozo in the scale 1:25.000 as png-file.

Used functions

- Identifying and symbolizing data
- Prepare tables appearance
- Calculate field values
- Create statistics
- Select features by attribute
- Select features by location

How to do this

1. **Prepare your data frame**

   Start the program if necessary, create a new map document and add some data.

   **Windows**
   
   Double-click the ArcMap icon on your desktop or click the Start button and point to <Programs>, <ArcGIS> and <ArcMap> to launch ArcMap.

   Choose blank map from the ArcMap dialog.

   **TOC**
   
   Set the properties of your data frame by right-click on the data frame name (Layers) and point to Properties.... In the Data Frame Properties choose the General tab, rename your data frame to Analysis and choose Meters for map and display units. When you have done so click OK to close the Data Frame Properties dialog.

   **Standard toolbar**

   Tool Add Data
   
   From <personalfolder>/exercise/shape/... add the layer files Roads.lyr, Islands.lyr and Agricultural Use.lyr you created in former exercises and the shapefile dev_zone.shp to your map. For a better orientation add the topographical map malta_25.png from <personalfolder>/exercise/images/topmap... to the map.
To use the topographical map as an orientation layer the representation should be changed to transparent. Right-click at the layer name, point to properties, choose the Display tab and enter 50% next to <Transparency>.

Choose the General tab and rename your layer next to <Layer Name:> to TopMap.

Click OK to close the Layer Properties and apply your changes.

Bring your layers into the following order (from top): Islands, TopMap, Roads, DEV_ZONE, Agricultural Use.

Remove the no longer needed transparency for your layer Islands. Furthermore change the name of your layer DEV_ZONE to Settlements.

Save your map document as Exercise2-2.mxd in your <personalfolder>/exercise/projects/....

2. **Identify and symbolize data**

The simplest way to get information about a feature is to identify it with a suitable tool as you have done in former exercises.

Click on any feature that belongs to your layer Settlements. Probably the wrong feature blinks short then the **Identify** window pops up and shows the result from the top-most layer. Because you are interested not in that layer you change the layer next to <Identify from:> to Settlements. Keep the window opened and repeat clicking the feature. Again the selected feature blinks once green and the **Identify** window shows the attributes of the feature. E. g. next to the field FEATURE you can find out whether it is an urban or industrial area.

Close the **Identify** window.

A simple but often not distinct way to get information about a feature is how you symbolized it. Your layers Roads and Agricultural Use are already useful symbolized. For Settlements you do it yourself.

Right-click on your layer Settlements, point to Properties... and choose the **Symbology** tab if necessary.

In the left box beneath <Show:> change from Features/Single Symbol to Categories/Unique Values. Choose from the drop-down list next to <Value Field> FEATURE and add all values using the appropriate button on the bottom of the **Layer Properties** window. Accept the randomly chosen colors by clicking OK.

To get information about more than one feature of the attribute table you can combine them for symbolizing. For example you are interested in the names of the settlements and their belonging to urban or industrial areas.
Open the Layer Properties and the Symbology tab of Settlements again.

In the left box beneath <Show:> change to Categories/Unique Values, many fields. The count of selectable fields beneath <Value Field> increases to three. Choose from the first drop-down list FEATURE from the second one NAME and point to Add All Values. Values and labels consist now of the content of both attribute fields.

Choose the top-most scheme from the drop-down list beneath <Color Ramp>. Click OK.

Now you may be able to assign feature to their name and type although the more values exist the more difficult it gets to distinguish the colors. Therefore there should be other ways to display more information. One is the possibility to label features.

Change the appearance of the layer back to Categories/Unique Values with <Value Field> FEATURE. Refresh the symbols by clicking Add All Values.

Change the color for urban areas to Dark Umber for industrial areas to Cocoa Brown. Click Apply.

Choose the Labels tab. Check <Label Features in this layer>. Make sure that in the <Text String> frame next to <Label Field: > Name is set.

Click the Symbol… button in the <Text symbol> frame to open the Symbol Selector. In the <Current Symbol> frame change the font settings to Arial, bold, font size 8 and black color.

Click the Edit Symbol… button. The Editor window will be opened. In the <Properties:> frame change to <Advanced Text> tab. Check <Text Background> and again click Properties… Choose Line Callout from the menu next to <Type: > and uncheck Leader and Accent bar.

Make sure that your dialog matches the following graphic and click OK until all dialog windows are closed.
Some of the settlements consist of more than one part (especially Ghasri). To avoid multiple labels change the settings of the label again.

TOC Layer Settlements

Reopen the Layer Properties and choose the Labels tab if necessary. In the <Other Options> frame click [Placement Options...]. In the Placement Properties choose the Placement tab.

In the <Duplicate Labels> frame on the bottom of the window check <Remove duplicate labels>.

Click OK to close the Placement Properties and again OK to close the Layer Properties.

Another way to provide the user with information about features is to give map tips. Map tips pop-up when you move the mouse cursor over a feature. For your layer Agricultural Use map tips are already set which show the entry of the attribute field SUMMARY DE, but actually you are more interested in tips about the islands names.

TOC Layer Agricultural Use

Open the Layer Properties by double-click the layer name and choose the Display tab if necessary. Uncheck <Show Map Tips using the display expression>.

Click OK to close the Layer Properties.

TOC Layer Islands

Switch to the Display tab. Check <Show Map Tips using the display expression> and choose out of the drop-down list next to <Field> Maltese Na. Click OK to apply your changes. Examine your settings by moving the cursor over the islands.

3. Change tables appearance

Tables may contain a lot of columns that are not very useful for you when you are looking for special entries. You can hide recently not needed columns as well as change the order of the size of columns. The changes have no influence on your table on the disc but only inside your map document.

TOC Layer Agricultural Use

Right-click on the layer name and point to Open Attribute Table.
Attribute table of Agricultural Use

Scroll to the right to get an overview to all fields. One impression you may get is that many of the fields are momentary empty and only the field SUMMARY_DE contains helpful information. Scroll to this field. Right-click into the field heading and point to Freeze/Unfreeze column. The column switches to the left edge of the table and remains there, no matter if you scroll to the left or to the right.

By clicking on its right black bar and dragging you can reduce the column width. Do it for all the headings to a necessary degree especially for these of the fields FEATURE and SOURCE.

To hide columns you have to go to the layer properties.

Attribute table of Agricultural Use

Drag your table to the side so that you can see the TOC.

TOC

Layer Agricultural Use

Double-click on the layer name to open its properties. Choose the <Fields> tab. A box lists you the whole table fields and their properties. In the frame <Choose which fields will be visible> click on the field AGRI_ID. It will be marked with a blue background. Beside the name uncheck the box for this field. In your map document the field AGRI_ID is no longer visible when you open the table or identify a feature. Repeat the last step for the fields GENERAL_CO, DETAILED_C, REF_NO, REF_TYPE, CATEGORY, TYPE, REPORT_REF, SOURCE, PLOTTED_BY, FILE_SAVE to hide them all.

Because SUMMARY_DE is not really descriptive about the field content we give an alias for it. Select the field SUMMARY_DE and replace the text next to <Alias:> (beside the list) with CULTIVATION.

Click OK to close the properties.

Because there are only some fields left the freezing of the renamed field CULTIVATION is no longer needed. Right-click on the field heading and point to Freeze/Unfreeze Column. The black bar on the right edge of the column vanishes but the field remains on the most-left position.

Click in the heading and drag the column right of the field FEATURE. A red bar shows the position while you drag it.

Close the table.

Check the result of your last actions.

Tools toolbar

Tool Identify

Click on any field on the islands. In the pop-up window Identify change the identified layer next to <Identify from:> to Agricultural Use. Click again any feature. The result should show only the remaining and partly renamed fields. Close the window.
4. **Calculate values**

A strength of GIS consists in its ability of a quick supply of values like area of polygons or length of polylines. In a previous exercise you already calculated the area of the layer *Islands*. Furthermore we need for our analysis the length of the roads and the areas of our agricultural fields.

TOC

Layer Roads

Right-click on the layer name and point to **Open Attribute Table**.

Attribute table of Roads

Point to [Table Options](#) and click **Add Field**... In the **Add Field** dialog name the field *Length_km*, choose the `<Type:>` **Double** and click **OK**. The new attribute field is added at the end of the table. You may have to scroll to the right to see it. As its name suggests we should calculate the values in kilometers.

Make sure that no record is selected in your table because otherwise the calculation would only be made for the selected records. You find information about it on the bottom of the table. If there is one or more record selected point to **Table Options** and click **Clear Selection**.

Right-click the heading for the new created field *Length_km* and point to **Calculate Geometry**... Confirm the warning to get the **Calculate Geometry** opened. Click **OK**.

Right-click again the heading of the field *Length_km* and point to **Field Calculator**... and insert following expression in the text box beneath `<Length_km>=` [Length_km]/1000. Click **OK**.

The **Field Calculator** converts now the length from Meters into Kilometers.

Right-click the field heading and point to **Sort Ascending**. Scroll up and down and view the largest and smallest road parts.

As you could see there are three parts with 0 for length. Probably these parts result from faulty digitizing and – because of their not existing length - are no longer necessary. To delete these from the table you have to be in an edit session.

Attribute table of Roads

Move your table that you can see the menus and toolbars.

Standard toolbar

Tool **Editor toolbar**

Editor Toolbar, Menu **Editor**, Command **Start Editing**

Open the Editor Toolbar if necessary.

Start the edit session for the layer *Roads* and go back to the attribute table of your layer *Roads*. 
Attribute table of Roads

Select the three records you wish to delete by clicking on the gray box left of the record. To select more than one record either press the CTRL-key or keep the mouse clicked and drag it over the three boxes. Press the DEL-key to delete the records.

Editor Toolbar, Menu Editor, Command Stop Editing

Finish your edit session and click Yes to save your changes.

Standard toolbar

Close the Editor Toolbar.

Tool Editor toolbar

Go back to your table. Right-click on the heading of your field Length_km and point to Statistics. A statistic window opens and shows beside others the shortest and longest digitized part, the average length and the sum.

Create a new field called Area in the attribute table of your layer Agricultural Use. Calculate the area for it and convert it into square km.

5. Join tables

The attribute table of your layer Roads contains a field called FEATCO with coded values about the road types. In another table the description for the codes are stored. A join makes available the description in your attribute table of the layer Roads.

Browse your <personalfolder>/exercise/table for the table Roadcodes.dbf, select it and click Add.

The table is added to your table of content. To see it in the TOC its mode switches automatically to List by Source tab on the top of it.

Right-click on the table name and point to open. View the content of the table. Afterwards close the table.

Right-click on the table name, point to Joins and Relates and click Join…. The Join Data dialog will be opened.

Make sure that Join attributes from a table is chosen from the first drop-down menu.

In the first step choose the field FEATCO from the drop-down list. In the second box choose Roadcodes from the list. Enter the field you want to use for joining in step 3. It should be the field Code. When your dialog matches the following graphic click OK.
Right-click on the table name and point to Open Attribute Table. Your table consists now of the columns of the layer Roads and the joined columns of the table Roadcodes. Scroll to the right to see the joined columns. Afterwards close the table.

Because the table Roadcodes is no longer needed you can remove it from the TOC. Right-click on the table name and point to Remove.

Defined relationships between tables exist only in the map document they were defined for. For every new document you have to define it again.

The joined columns can be used in the same way like the original fields.

Double-click the layer name to open its properties. Choose the Display tab. From the drop-down list next to <Field> the field Descript and check <Show Map Tips using the display expression>. Click OK.

Turn off the layer Islands and move the cursor over your map. Every time the cursor meets a road the text from the joined field Descript appears.

Save your map document.

6. Query data

Suppose you work in a project that concerns the groundwater management. Therefore first of all the amount of irrigated and semi-irrigated fields is required. You want to make a statement about the number, whole and average area.
You could now select them interactively by clicking all them in the table. Because there are a lot of fields which are irrigated or semi-irrigated it is more comfortable to use a query.

TOC
Layer Agricultural Use
Select By Attributes dialog
Make sure that Create a new selection is chosen from the menu next to <Method:>. Double-click “SUMMARY_DE” from the list beneath <Fields:>. It appears in the textbox in the lower part of the dialog. From the middle of the dialog click the Equal operator (=). In the box right of the operators nothing is stated. Click the Get Unique Values button to see all the values. Afterwards double-click ‘IRRIGATED’ to get it from the list to textbox below. The expression in the textbox should now be “SUMMARY_DE” = ‘IRRIGATED’. Click Verify to check whether your expression is all right. Depending on the result of the verifying either correct your expression or continue by clicking Apply.

TOC
Layer Agricultural Use
The table switches to the foreground. On the bottom of it you can read that 594 of the 4889 records are selected. Switch back to the Select By Attributes dialog.

Currently only the irrigated fields are selected. In fact you want to select all the records which are either irrigated or semi-irrigated. To insert more than on criteria you have to combine your single conditions with the operators <AND> or <OR>.

Select By Attributes dialog
Continue the expression in your dialog by clicking the appropriate elements of the box. The expression has to look like the following statement:

“SUMMARY_DE” = ‘IRRIGATED’ OR “SUMMARY_DE” = ‘SEMI-IRRIGATED’.

Again Verify your expression and in case of a successful expression Apply it. Close the Select By Attributes dialog.
Scroll down to see the selected records. To view only the selected records click Show Selected Records on the bottom of the table.

Scroll to the right to see the column AREA on the right edge of the table. Right-click on the heading and point to Statistics.... The Selection Statistics of AGRI window states besides others the count of the fields, the sum of the area and the mean area.

After you have examined the statistic you can close it.

For your analysis you are only interested in the irrigated fields which are bigger than 10,000 square meters.

Again point to Table Options in the menü of the table and click Select By Attributes....

Change the selection <Method:> to Select from current selection. Clear any expression if necessary.

Create a new expression “Area_km” > 10, Verify and Apply it. Because of the changed selection method only records from the existing selection will be queried.

7. **Summaries**

A more durable way of statistic is to create a summary. Because you were asked to create a statistic about the agricultural use you want to create a new table with these information.

On the bottom of the table choose all records by clicking the Show all Records button. Afterwards point to Table Options and click Clear Selection. The status bar on the bottom of the table should now state that no record is selected.

Scroll horizontal to get the SUMMARY_DE (Cultivation) field. Right-click on the heading and point to Summarize....

In the Summarize dialog make sure that SUMMARY_DE is set for field in the first step.

For summary statistics select from the offered list the summed area, the first feature and the first contact_pe. To do so click the plus next to Area_km and check <Sum>. For FEATURE and CONTACT_PE check <First>.

In the third step navigate to your folder tables and name the table Sum_agri.dbf. Make sure that the dialog matches the following graphic then click OK. Click Yes when prompted to add the table to your map.
TOC
Close the table.

Layer Agricultural Use

TOC
Right-click on the table name and point to Open.

Table Sum_agri
In the table reduce the column width until you can read all the columns without scrolling. Right-click on Sum_Area and point to Sort Ascending.

As you can see flower fields are the fields with the fewest area whilst abandoned fields are very common. You want to calculate their quota of the whole.

TOC
Point to Table Options and click Add Field…. In the Add Field dialog name the new field Quota_perc and choose Float for field <Type>. Set 4 for <Precision> and 2 for <Scale>. Click OK to add the new field to the table.

To calculate the percentage we need the whole area of the agricultural used land.

TOC
Right-click on the heading Sum_Area and point to Statistics…. Make a note of the stated Sum.

Table Sum_agri
Right-click on the heading of Quota_perc and click Field Calculator….

In the Field Calculator create the formula to calculate the area percentage. Double-click the field Sum_Area from the box beneath <Fields>, click the divide button from the right (\(\frac{)}\)) and type in the value you have noted. Finish the formula with a multiplication with 100 so that it looks similar to the following:

\[
\frac{\text{Sum_Area}}{12345678.9012} \times 100
\]

Click OK to calculate the values. To verify the results create a statistic

! To verify the results create a statistic of the field Quota_perc. The sum of all percentages should be – of course – 100 %. 


8. Creating graphs

Open Create Graph Wizard.

In step 1 select Vertical Bar for <Graph Type> and make sure that Sum_agri is chosen at <Layer/Table>. Choose out of the drop-down list next to <Value Field> Quota_perc and next to <X label field> SUMMARY_DE. For <Color> chose Palette and Classic and click <Next>.

In step 2 type into the window next to <Title> in the <General graph properties> frame Agricultural Use and check the box <Graph in 3D view>. Make sure that the box for the <Graph legend> frame is checked. Beneath the <Axis properties> click the tab Left and type Percentage for <Title>. For the tab Bottom make sure that the box for <Visible> is unchecked and click <Finish>.

A graph window pops up that shows the just created diagram. Afterwards you can still change some properties of it by right-click on the title bar of the window and and the command Properties....

The diagram should look like the following graphic.

<table>
<thead>
<tr>
<th>Agricultural Use</th>
<th>Graph Agricultural Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close the Graph by clicking the cross sign in the upper right corner. The graph is stored in your map document and can be reopened over the main menu View with the command Graphs.</td>
</tr>
</tbody>
</table>

TOC

Change the TOC view from List By Source to List By Drawing Order using the appropriate tab on the top of the TOC.

9. Spatial queries

The goal for the agricultural report you have to create was to examine whether viticultural fields are situated near any main road. To analyze this you have to combine attribute and location queries. First you have to select the main roads. These are the features of the layer roads which have the entry W35 or W36 in the column FEATCO.

<table>
<thead>
<tr>
<th>Tools toolbar</th>
<th>Zoom to the full extent of your map (only necessary if you have changed the extent of your map view before).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool Full extent</td>
<td></td>
</tr>
</tbody>
</table>
Open the **Select By Attributes** dialog. Choose **Roads** for <Layer:>. Make sure that **Create a new selection** is chosen next to <Method:>

All columns of the original attribut table from **Roads** have now the prefix **STR.**, columns of the joined table **roadcodes** got the prefix **roadcodes**. That happened automatic and shouldn’t bother you.

Create the expression "**STR.FEATCO** LIKE 'W35'" by double-click the appropriate elements from the boxes.

Because of the two types of main roads replace the numeral 5 with a wildcard. When your expression matches the following "**STR.FEATCO** LIKE 'W3_'" all records will select whose FEATCO starts with W3 no matter which character follows.

Verify your expression and in case of a success Apply it. Afterwards Close the **Select By Attributes** dialog. You should now see the main roads blue highlighted in your map.

Open the **Select By Location** dialog to define the spatial query.

Make sure that **select features from** is chosen next to <Selection method:>. Check the layer **Agricultural Use** from the next list. As <Source layer> select **Roads**, make sure that the box <use selected features> is checked.

From the <Spatial selection method> box choose **Targed layer(s) features are within a distance of the Source layer feature**.

Check <Apply a search distance> if necessary and enter a buffer of **20 Meters** in the last two textboxes.

When your dialog matches the following graphic click **Apply** to run your spatial query and afterwards **Close** to close the dialog.
To turn off the layer Roads to see the selected features of the Agricultural Use.

At the moment all fields within a distance of 20 meters are selected. From the selected set we have to filter the viticultural fields.

Main Menu Selection
Select by Attributes...

Again open the Select By Attributes dialog. Set Agricultural Use for <Layer:>. Pick Select from current selection for the selection <Method:>. Create the expression "SUMMARY_USE" = 'VITICULTURE'. (Click the Get Unique Values button if you can not see all values in the box beside the operators.

Verify and Apply your expression. Afterwards Close the dialog.

To save the selection right-click on the layer name, point to Selection and click Create Layer From Selected Features.

On top of the TOC a layer called Agricultural Use selection is added while the selection of the layer Agricultural Use was cleared. Turn off all layers except the new selection layer to get a better impression of it. Afterwards turn on all layers again.

Right-click the layer name and click Open Attribute Table.

The table should contain 46 records at all. Right-click on the field heading Area and click Statistics.... Examine the summed area of all the viticulture that is near a main road.

Save your map document.
Find out the length of the gravel roads which run through settlements. Start by making a spatial query of all roads that are completely within the layer Settlement. After that reduce the selection of your roads to those which are gravel roads (roads with the code W04 in the field FEATCO). For this use an attribute query. Finally make a statistic of the field Length to see the summed length of all the selected features. If the sum states 2,153434 km your queries were all right.
2.3 Exercise Georeferencing

Task

If you want to create a vector layer you often use on-screen digitizing based on an existing raster image. Scanned raster data contain no digital readable information where the data is situated. You can provide your data with this information by georeferencing.

For your map of Gozo and Comino you want to add data about geology. The analog base map was scanned, is now available without any spatial reference and ready for georeferencing.

The geological information has to be vectorized to use it in an appropriate form. In ArcGIS/ArcView vector data can be stored either as shapefile or as feature class inside a geodatabase. The geodatabase offers some advantages such as the storage of lines, points, polygons in one file, the possibility of defining topologically associated feature classes (spatial dependence), the storage of annotations and the possible definition of rules (e.g. domains) for attribute values. Therefore we want to use the geodatabase to create a new feature class geology and digitize the geological formations on your screen. Moreover we want to add other existing data to the geodatabase.

Data

Available is the scanned but not georeferenced geological map of Gozo and Comino as jpg-file and the topographic map of Gozo in the scale 1:25,000 as png-file already with spatial reference. Moreover there are all the data you had used or created before.

Used functions

- Georeferencing
- Create a geodatabase
- Work with domains
- Import data to your geodatabase
- Modify features

How to do this

1. Georeference an image

Start the program, create a new map document and add some data.

Windows

Double-click the ArcMap icon on your desktop or click the Start button and point to Programs - ArcGIS - ArcMap to launch ArcMap.

ArcMap dialog

Create a new empty document. Blank Map

Set the properties of your new empty data frame.
Right-click on the name of your data frame and point to Properties. In the following Data Frame Properties window choose the General tab if necessary. Rename your data frame in the textbox next to <Name:> to Geodatabase and pick as usual Meters from the lists for the map and display units.

Change to the Frame tab in the <Background> frame select Grey 10% from the drop-down list. If so done click OK.

Browse your <personalfolder>/exercise/import for the raster dataset geology.tif, select it and point to Add. If you are prompted for check <Build pyramids>. Click Yes. After building the pyramids the raster dataset will be drawn in the map.

Check the lower left corner for its coordinates by moving the cursor there. The coordinates will be shown at the status bar at the bottom of ArcGIS.

At the moment the pair of coordinates should be nearly 0.00, 0.00, that means the image has no spatial reference. Therefore we need to georeference our map. To georeference the image at least one layer with spatial reference is required (a target layer). In our case this is the already georeferenced topographical map.

Add the topographical map malta_25.png from the folder <personalfolder>/exercise/images/topmap/.

Zoom to the full extent of your map. At the upper edge you can see now the topographical map while the geology image lies somewhere on the bottom (but too tiny to see it clear).

Save your map document as Exercise2-4.mxd in your <personalfolder>/exercise/projects/.

To georeference we need to identify points which are to find in both layers. For the process of georeferencing we have to align the position of the points to the desired position. We can do this using the georeferencing toolbar.

Point to the command georeferencing to open the required toolbar. From the Georeferencing toolbar click the layer drop-down arrow and click the raster layer you want to georeference - in our case geology.tif.

At the moment the raster image we want to georeference and the target layer lay on different positions of the map. For georeferencing it would be easier to handle if they are in the same display view.

Right-click the target layer malta_25.png and click Zoom to Layer.

This action shows the layer you defined for georeferencing at the same position like your target layer.
Double-click the layer name to open its properties. Click the Display tab. Type a transparency of 30% in the appropriate textbox. Click OK.

To get more accurate results you can use a magnifier to zoom in the area of interest.

Menu Window Command Magnifier… A Magnification window appears. In the title you see the factor of magnification. To change it right-click inside the title and point to Properties…. Inside the <Zoom> frame enter 300 next to <Modify main view by>, press the Return key and click OK. The new factor appears in the title.

To use a magnified view drag the Magnification window to the area you are interested in. A cross-wires shows the present location.

The basic procedure for georeferencing is to set links between raster and target layer. A link means to set prominent points or points of known x,y coordinates in both raster and target layer. Such prominent points could be a cape or the crossing of two roads or - more accurate - a coordinate raster. To have at least one link near each corner of the raster and a few throughout the interior produces the best results.

Georeferencing Toolbar Tool Control points Set a link using a mouse-click on a prominent point of your raster geology.tif and the second click at its location at the target layer. Well suited for such links are the coordinate crossings on both layers. A better sight on the points you will get if you turn off all layers except of this one you will just work with.

After you have set a pair of linked points the map moves a little.

Tools toolbar Navigation tools After setting a pair of points zoom to the fuel extent to look for the next suited location. Because the maps match better after every set pair of points you can use a bigger scale for further points. Try to set points at a scale of about 1:15.000. Additional you can enlarge the magnification zoom to a zoom factor of 500 or even 800.

Georeferencing Toolbar Tool Control points Repeat to set links until you have a more or less regular point cloud on your map. At least you need three pairs of points, but better results we will reach with ten or more links.

Georeferencing Toolbar Tool View Link Table Open the Link Table. It shows the accuracy of your set links. The residual error shows the error for each link, the RMS the entire average error. For this you need at least four points.

Tools toolbar Tool Zoom In A rough orientation for the RMS error gives the raster resolution of your target layer and the layer you are just georeferencing on its target position. To get their resolutions zoom in as far you can recognize the raster cells. This should be a scale around 1:250.

Tools toolbar Tool Measure Measure the extent of a single cell in both your layer geology.tif and the layer malta_25.png.
Reopen the **Link Table** if necessary. Compare the `<Total RMS Error>` with the raster resolution. It should not be bigger than the higher cell width of both of your measured layers but even better half of it.

To improve the `<Total RMS Error>` you can delete links with a high residual error from your table. To do so select the link by clicking on it. It will be highlighted in yellow in your map. Afterwards point to the Delete button (x) on the upper right hand corner of your window to delete the link.

Add and delete links until your are satisfied with the `<Total RMS Error>`. Click **OK** to close the **Link Table**.

The command **Rectify…** calculates a new georeferenced raster image. In the appearing **Save As** dialog click the folder button next to the textbox beneath `<Output raster:`>. Browse to your `<personalfolder>\exercise\images\…` and `<Name>` the new raster `geo_rec` and choose as `<Format>` `TIFF`. Make sure that Nearest Neighbor is chosen for `<Resample Type>` and keep the suggested `<Cell Size>`.

Click **Save**. The new file will created.

Add your created raster image `geo_rec.tif` to ArcMap.

The layer `geology.tif` is no longer needed. Right-click on the layer name and point to **Remove**.

Check the success of the former process by comparing the accuracy of both layers. Set a transparency if necessary.

Save your map document.
3 Advanced II

3.1 Exercise Geoprocessing with ModelBuilder

Task

Geoprocessing is the processing of geographic information, one of the basic functions of a geographic information system (GIS). It provides a way to create new information by applying an operation on existing data. Any alteration or information extraction you perform on your data involves a geoprocessing task. It can be a task such as converting geographic data to a different format, or it can involve multiple tasks performed in sequence, such as those that clip, select, then intersect datasets.

Within ArcGIS you can perform geoprocessing tasks in a number of ways. In the following example we would like to create a model that runs the sequence of geoprocessing tools. Creating a model provides a way to run a sequence of geoprocessing tools by enabling you to string your tools together in a visual diagram. A model can be run again and again and you can alter parameter values to experiment with different outcomes.

Your task in this exercise is to locate potential areas for a touristical project on Gozo Island. You'll create an new model incorporating the following three criteria:

1. The landuse for our potential areas should be abandoned areas.
2. We need flat areas, so the slope should be less than 15%.
3. The maximum distance to urban areas should be less than 500m, so that everybody could walk there by feet.

Data

The vector data was created and made available by the Malta Environment and Planning Authority (MEPA). The slope was calculated and reclassified by the MLA staff.

Used functions

- Working with the ArcToolbox Environment
- Creating a new Toolbox
- Creating a new model
- Running and debugging the model
- Saving and document the model

How to do this

1. Opening the ArcMap and ArcToolbox window and setting workspaces

   Start the program, create a new map document and add some data.

   Windows
   
   ![](ArcMap_11.png)

   Double-click the ArcMap icon on your desktop or click the Start button and point to Programs - ArcGIS - ArcMap to launch ArcMap.

   ArcMap dialog

   Create a new empty document.

   Blank Map

   Set the properties of your new empty data frame.
Right-click on the name of your data frame and point to **Properties**. In the following **Data Frame Properties** window choose the **General** tab if necessary. Rename your data frame in the textbox next to **<Name:>** to **Analysis** and pick as usual **Meters** from the lists for the map and display units.

If so done click **OK**.

Browse your `<personalfolder>/exercise/shape` for the vector dataset agri.shp, slope.shp and dev_zone.shp, select it and point to **Add**.

Zoom to the full extent of your map.

Save your map document as **Analysis.mxd** in your `<personalfolder>/exercise/projects/`.

When working in ArcMap, you access toolboxes through the **ArcToolbox window**. By saving the map document you save any changes made to the ArcToolbox window. This allows you to have different versions of the ArcToolbox window with each map document you create, depending on which tools you want to use for each project.

Click the Show/Hide ArcToolbox window. If the ArcToolbox window does not display inside the ArcMap table of contents window, click and drag the bar at the top of the ArcToolbox window and place it over the top of the table of contents window, then drop the panel.

The Arc ToolBox is now placed in the TOC window, you can change between Arc Toolbox and TOC by selecting them via tab on the bottom of the TOC window.

Right-click the ArcToolbox window and click environments. Click the **Workspace** dropdown arrow. Click the Browse button and check the location. Please use for the `<Current Workspace>` `<personalfolder>/exercise/shape` and for `<Scratch Workspace>` `<personalfolder>/exercise`. Click **OK**

Right-click the ArcToolbox window and create a New Toolbox with the command **Add Toolbox**. In the **Add Toolbox** window click the **New Toolbox** Tool and name the Toolbox **My_Analysis_Tools**.

Save your map document. The Geoprocessing settings include environment settings, the state of the ArcToolbox window and variables you have created at the command line. These settings are saved in the ArcMap document.
2. Creating a new model

ArcToolbox window
My_Analysis_Tools

You will now create a model by building processes and connecting them together to find areas with the best potential for our project. Right-click your My_Analysis_Tools toolbox, point to New and click Model. An empty ModelBuilder window will open.

Now we start to create our model by using different tools and combine them to analyse the data by the given criteria.

2.1 Selecting abandoned areas and repair geometry

For the new project only abandoned areas should be selected for the detailed planning. So we have to select these areas from our landuse layer agri.shp. Because we don’t know exactly if the data is really correct, we try to repair the topology.

ArcToolbox window
Data Management Tools toolbox

Expand the Features toolset inside the Data Management Tools toolbox. Click and drag the Repair Geometry tool into the display window. An element that references the Repair Geometry tool is created in the display window.

Select tool element Repair Geometry

Right-click the Repair Geometry tool element and click Open. Click the <Input Features> dropdown arrow and click the layer Agri. Click OK.

Modelbuilder toolbar Tool Auto Layout

Click the Auto Layout tool.

Modelbuilder toolbar Tool Full Extent

Click the Full Extent tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Now the process is colored in, meaning it is ready to run.

Select data element AGRI

Right-click the AGRI data element and click Add To Display. With the Add To Display property checked, the derived data referenced by this element will be added to the display each time the model is run.

Select tool element Repair Geometry

Right-click the Repair Geometry tool element and click Run to run the process. The process is documented in the message section of the Command Line window. When the process has finished close the window. Now the geometry of the layer has been repaired so that we can select the abandoned areas.
Expand the Extract toolset inside the Analysis Tools toolbox. Click and drag the Select tool into the display window. An element that references the Select tool is created in the display window.

Right-click the Select tool element and click Open. Click the <Input Features> dropdown arrow and click the layer Agri. Notice that you have now variables (blue ones) at the top of the list of inputs as well as all the layers in the table of contents to choose from.

When you drag data into the ModelBuilder window or when you set the data referenced by input or derived data elements within a tool's dialog box, the elements created in the ModelBuilder window are variables that can be shared between processes. Leave the default location and type select_output for the <Output Feature Class>. Type "[SUMMARY_DE] = 'ABANDONED'" for the value of the <Expression (optional)> parameter or click the Browse button next to the Expression parameter and use the Query Builder to build the expression. Click OK.
Click the **Auto Layout** tool.

Click the **Full Extent** tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Now the process is colored in, meaning it is ready to run.

Right-click the **Agri_Select.shp** data element and click **Rename**. Type **Abandoned Area** and Click **OK**. Right-click the Abandoned Area data element and click **Add To Display**. With the Add To Display property checked, the derived data referenced by this element will be added to the display each time the model is run.

Right-click the Select tool element and click **Run** to run the process. The process is documented in the message section of the Command Line window. When the process has finished close the window. Minimize the ModelBuilder window.

Examine the layer **Abandoned Area** in your ArcMap display. Only the abandoned areas from the repaired layer **agri.shp** have been selected.

Save your map document.

### 2.2 Selecting Suitable Areas with a slope less than 15% and repair geometry

Because it is too expensive to build in very steep areas we need to know where the slope is less than 15%. So we have to select all these areas from our layer **slope.shp**. Before we can start, we have to repair the geometry to make our analysis.

Expand the **Features** toolset inside the **Data Management Tools** toolbox. Click and drag the **Repair Geometry** tool into the display window.

Right-click the **Repair Geometry** tool element and click **Open**. Click the **<Input Features>** dropdown arrow and click the layer **slope**. Click **OK**.

Click the **Auto Layout** tool.

Click the **Full Extent** tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Right-click the slope data element and click **Add To Display**. With the Add To Display property checked, the derived data referenced by this element will be added to the display each time the model is run.
Select tool element  
*Repair Geometry*

Right-click the Repair Geometry tool element and click *Run* to run the process. The process is documented in the message section of the Command Line window. When the process has finished close the window.

Now the Geometry of your data has been repaired so that we can go on with our analysis.

Standard toolbar

Tool Save

Save your map document.

ArcToolbox window

Expand the *Extract* toolset inside the *Analysis Tools* toolbox.

Analysis Tools toolbox

Click and drag the *Select* tool into the display window. An element that references the Select tool is created in the display window.

Select tool element

*Select*

Right-click the *Select* tool element and click *Open*. Click the `<Input Features>` dropdown arrow and click the variable `slope`.

Leave the default location and type `Slope_output` for `<Output Feature Class>`. Type “`Slope` <= `10-15`” for the value of the `<Expression (optional)>` parameter or click the Browse button next to the Expression parameter and use the *Query Builder* to build the expression. Click *OK*.

Modelbuilder toolbar

Tool *Auto Layout*

Click the *Auto Layout* tool.

Modelbuilder toolbar

Tool *Full Extent*

Click the *Full Extent* tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Now the process is colored in, meaning it is ready to run.

Select data element

*Select_output.shp*

Right-click the *Select_output.shp* data element and click *Rename*. Type *Suitable Area* and Click *OK*. Right-click the *Suitable Area* data element and click *Add To Display*.

Select tool element

*Select*

Right-click the *Select* tool element and click *Run* to run the process. The process is documented in the message section of the Command Line window. When the process has finished close the window. Minimize the ModelBuilder window.
2.3 Locating Suitable Abandoned Areas

You’ll now want to find the areas that are abandoned and that have a slope less than 15%. Therefore you intersect the two calculated layers Abandoned Area and Suitable Area.

Expand the Overlay toolset inside the Analysis Tools toolbox. Click and drag the Intersect tool into the display window.

Right-click the Intersect tool element and click Open. Click the <Input Features> dropdown arrow and click the variable Abandoned Area. Click the <Input Features> dropdown arrow again and click the layer variable Suitable Area.

You’ll use the default and will not assign any ranks to the input feature classes. The default takes an average if the distance between feature classes is less than the cluster tolerance. You would assign ranks if you knew that some of your feature classes were more integrally sound then others. Features in the feature classes with lower ranks will snap to features in the feature classes with higher ranks. The highest rank is 1, and lower ranks go up in the value.

Leave the default location for the <Output Feature Class> and type Intersect_output for the name. Leave the default to All by <JoinAttributes (optional)>. Leave the default value for the value of the <XYTolerance (optional)> parameter and select the units as Meters. Leave the default for the <Output Type (optional)> so the geometry of the output feature class will be the same as the input. Click OK.
Modelbuilder toolbar Tool Auto Layout Click the Auto Layout tool.

Modelbuilder toolbar Tool FullExtent Click the Full Extent tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Select data element Right-click the Intersect_output.shp data element and click Rename. Type Intersect Output and Click OK. Right-click the Intersect Output data element and click Add To Display.

Select tool element Right-click the Intersect tool element and click Run to run the process. When the process has finished close the window. Minimize the Model Builder window.

TOC Examine the layer Intersect Output in your ArcMap display.

Layer Intersect Output Change the color to red. Now you can see all the areas that are abandoned and have a slope less than 15%.

Standard toolbar Tool Save Save your map document.

2.4 Calculate zones round urban areas and exclude the Suitable Abandoned areas inside

You’ll now calculate the zones round urban areas in a defined distance, because people living there should be able to go there by feet. First you have to buffer the urban areas using a distance field in the attribute table, then clip the resultant buffer zones from the Suitable abandoned areas.

ArcToolbox window Expand the Proximity toolset inside the Analysis Tools toolbox. Clik and drag the Buffer tool into the display window.

Select tool element Right-click the Buffer tool element and click Open. Click the <Input Features dropdown> arrow and click the layer DEV_ZONE.

Type for <Distance [value of field]> beneath Linear unit : 500 and click the drop-down arrow beside to choose Meters. The values in this fields will be used for the width of the buffer. Click the <Dissolve Type (optional)> dropdown arrow and click LIST to list the Dissolve Fields. Click OK.
Click the Auto Layout tool.

Click the Full Extent tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Right-click the Buffer_output.shp data element and click Rename. Type Buffer Urban Areas and Click OK. Right-click the Intersect Output data element and click Add To Display.

Right-click the Buffer tool element and click Run to run the process. When the process has finished close the window.

Examine the layer Buffer Urban Areas in your ArcMap display. Change the color to transparent. The areas within a distance of 500m can be seen.

Save your map document.

Expand the Extract toolset inside the Analysis Tools toolbox. Click and drag the Clip tool into the display window.

Right-click the Clip tool element and click Open. Click the <Input Features> dropdown arrow and click the layer Suitable Area.

Click the <Clip Features> dropdown arrow and click the layer Buffer Urban Areas.

Leave the default location for the Output Feature class and change the name in Clip. Click OK.

Click the Auto Layout tool.

Click the Full Extent tool to apply the current diagramm properties to the elements and to place the elements within the display window.

Right-click the Clip.shp data element and click Rename. Type Potential Areas and Click OK. Right-click the Potential Areas data element and click Add To Display.

Right-click the Clip tool element and click Run to run the process. When the process has finished close the window.
TOC
Click all results except Potential Areas in the table of contents, right-click and click Remove. Change the color of the layer Potential Areas in red. It shows all areas based on the criteria set.

Standard toolbar
Save your map document.

3 Saving and renaming the model
Any new model you create has a default name (Model). You can change the name of the model in the Model Properties.

Model menu Model
Model Properties
Click the General tab. Specify a new name for your model, Dev-Analysis, and a label, Find Potential Areas for a Tourism Project. You would use the name if you were running the model at the command line or inside a script. The label is the display name for the model.

Add a description for the model, describing the model’s contents. This description will appear in the Help panel of the model’s dialog box.

Check Store relativ path names so that all paths for sources of information referenced by the tool are saved relative to the location of the toolbox. If the toolbox and its data are moved, paths to data sources will be altered accordingly.

Click OK.

Model menu Model
Save
After saving your model the name changes in the ArcToolbox window. Close your model.

4 Setting model parameters
You’ll likely want to set certain parameters as model parameters, so the user of your model can specify values for these parameters when running your model from the dialog box. You can do this in the ModelBuilder window or in the model’s properties dialog box. By setting model parameters you can control which parameter values the user of the model can specify and which are hard coded inside the model. For instance, you might want users to be able to specify the input dataset they want to use.
You must set the variables in a model as model parameters that you want to display in your model’s dialog box.

Right-click the AGRI2 data element and click Model Parameter. A P will appear next to the element indicating it is set as a model parameter.

Right-click AGRI2 and click Rename. Type Input Agri and click OK. This is the name that will be displayed for the input data parameter in the models dialog box.

Right-click the Slope2 data element and click Model Parameter. A P will appear next to the element indicating it is set as a model parameter.

Right-click Slope2 and click Rename. Type Input Slope and click OK.

Right-click the Dev_Zone data element and click Model Parameter. A P will appear next to the element indicating it is set as a model parameter.

Right-click Dev_Zone and click Rename. Type Input dev_zone and click OK.

Right-click the Potential Areas data element and click Model Parameter. A P will appear next to the element indicating it is set as a model parameter.

Right-click Potential Areas and click Rename. Type Output Potential and click OK.

After saving the model close the model.

Now you can use your model as part of a new model.

Running the model

Double-click the Find Potential Areas for a Tourism Project model to open its dialog box. Click OK to run the model. Click Close.

Generating a report and documenting a process

You can view or save a report for your model. The report documents everything contained in the model, including the time and date it was generated, the variables used and the processes created.
ArcToolbox window | Right-click the Find Potential Areas for a Tourism Project model and click *Edit*…
---|---
My_Analysis_Tools | Model menu Model Report
| Now you can choose if you want to view a report in a window or Save report to a file.
| Choose View report in a window and click **OK**. In the temporary window scroll to the Processes section and expand the contents of one of the Intersect tool. Have a look at the Parameters that were used in the model. After you have finished click **OK**.

Processes in your model can be documented too. The documentation you add might describe what the process does. You can add paragraphs, bullet items, hyperlinks, illustrations, subsections or intended text.

| Select tool element | Right-click the Find Potential Areas for a Tourism Project model and point to Item Description. Click Edit to change the description. Type the text in the right side of the dialog box. Click the Thumbnail button. Choose the agri.jpg image from the folder \images. Click **OK**.
---|---
Repair Geometry | Model menu Model Save
| Save and close your Model.

| ArcToolbox window | Right-click the Find Potential Areas for a Tourism Project model and click Help. Click the Model section to expand its contents and navigate to the documented process. Close the window.
---|---
My_Analysis_Tools | 7 Setting up and printing a model

To document your model you are able to print it out.

| ArcToolbox window | Right-click the Find Potential Areas for a Tourism Project model and click Edit…
---|---
My_Analysis_Tools | Model menu Model
Print Setup | Change the default options to more appropriate settings to your model. Click **OK**
Bild printsetup
Model menu Model | Choose the Acrobat Distiller as Printer and click **OK**. Type in the name tourism_model.pdf and click **Save**.
Print | Now your model is documented as a *.pdf-file and can be send to anybody you want.
Model menu Model | Save and close your model.
Save | Standard toolbar | Tool Save
| Save your map document and close it.