ESA CADASTRAL OPERATIONS COURSE MODULE B: DATA PROCESSING AND GIS COURSE NOTES AND EXERCISES

EGYPT FINANCIAL SERVICES PROJECT
TECHNICAL REPORT #83

OCTOBER 2006
This publication was produced for review by the United States Agency for International Development. It was prepared by Chemonics International Inc.

DATA PAGE

Activity Title and Number:	Egypt Financial Services (EFS) Project Contract No. 263-C-00-05-00003-00
Prepared for:	EFS CTO: Paul Bruning EFS DCTO: Ingi Lotfi Economic Growth Division Office of Financial and Information Technology USAID/Egypt
Task:	2: Registration
KRA:	2.3.6 and 2.3.8
Activities:	Prepare training material and field manual to support EFS technical instructions for cadastral operations in Mokattam.
Author:	Nigel Edmead Senior Systems Analyst/GIS Specialist International Land Systems, Inc
Date:	October 2006

<u>List of Key Words Contained in Report</u>:

Training, ESA, Cadastral Operations, GIS

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

TABLE OF CONTENTS

Acronyms		3
SECTION I	Course outline	5
SECTION II	An overview of the lectures	6
SECTION III	An overview of the exercises	7

ANNEX A	Module B – Lecture material and Student notes
ANNEX B	Module B – Course Exercises
ANNEX C	Course Evaluation Form
ANNEX D	Glossary of Terms

Acronyms

CAD	Computer Aided Design
CCITT	Comite Consultatif Internationale de Telegraphie et Telephonie
DWG	AutoCAD Drawing File
DXF	Data Exchange File
EDO	ESA District Office
EFS	Egypt Financial Services (Project)
EPO	ESA Provincial Office
ESA	Egyptian General Survey Authority
ESRI	Environmental Research Systems Institute
ETM	Egyptian Transverse Mercator
GCP	Ground Control Point
GDB	Geodatabase
GIS	Geographic Information System
GPS	Global Positioning System
MXD	ArcMap Map Document
MXT	ArcMap Map Template
MRO	Model Registry Office
NED95	New Egyptian Datum – 1995
PDF	Portable Document Format
REPD	Real Estate Publicity Department
RDBMS	Relational Database Management System
RMS	Root Mean Square Error
RO	Registry Office
TIFF	Tag Image File Format
TMS	Training Managers and Supervisors (Dutch-funded project)
USAID	United States Agency for International Development

Section I: Course outline

Introduction
The Egypt Financial Services Project, funded by USAID, is undertaking an extensive four-year technical assistance program to help develop a robust mortgage finance market in Egypt. Comprising four task areas, Task 2 'Registration' is working with the Ministry of Justice and Egyptian Survey Authority to improve property registration in selected urban areas to ensure that this emerging mortgage finance market can successfully be established. The ESA Cadastral Operations training course has been designed to support the surveying methodology devised by ESA/EFS to conduct an 'as built survey' in Mokattam. There are three course modules Module A: Geodetic Control, Module B: Data Processing and GIS (this course) and Module C: Surveying.

Training Location
ESA Training Center, ESA Headquarters, Cairo

Course format
The course comprises lectures and exercises. In addition to course exercises there will be ample opportunity to undertake practical work.

Course Duration
The course will run for 2 weeks for 4 – 5 hours a day, followed by a 1 week class project that will take place the ESA compound prior to commencement of field operations.

Trainees
Trainees from ESA and the private sector will attend this course. It is assumed that trainees are conversant with ESRI's ArcGIS software (this is a course pre-requisite).

Administrative Matters
The three course modules will run parallel. The Geodetic Control and Surveying modules will take place in the 2 classrooms at the ESA Training Center and the Data Processing and GIS module in the IT Lab at the ESA Training Center. Staff will be assigned to a single module for the duration of training according to their education, training and experience.

Benefits
Trainees will be able to competently and efficiently develop a cadastral index map for Mokattam.

Trainers
Trainers are all ESA staff members who have considerable experience in the development and delivery of training. All have participated in the Dutch TMS project.

Section II: An overview of the lectures

There are 6 topics covered in this course. Course lectures and student notes appear in Annex A. The lectures and student notes have been designed so as to serve as reference material once the course has ended and field operations have begun. The topics are organised as follows:

Introduction – covers an introduction to the GIS and Data processing methodology.

ArcGIS refresher – provides a quick recap of ArcGIS functionality describing core applications ArcMap and ArcCatalog used for GIS and Data processing.

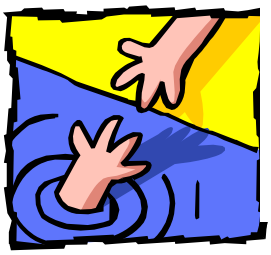
Data collection – in which we look gathering existing data and converting it into usable format, including the indexing of mutation forms.

Georeferencing data – in which we look how to transform local coordinates to coordinates of the ETM and make adjustments to the data so that it aligns correctly.

Processing cadastral data – in which we look at the creation of parcels and buildings by means of heads up digitizing and data conversion.

Preparing the Cadastral Index Map – in which we look at creating a cadastral index map using layouts adding standard cartographic elements such as north arrows and scale bars.

Each section is followed by course exercises and practical work.



Not sure of something?
We are here to help you get the most out of this course. If something is not clear please feel free to ask.

Section III: An overview of the exercises

Class exercises follow the lectures, see Annex B. There are a number of separate exercises which cover the data processing and GIS components of the methodology. The exercises have been designed to serve as a working manual for future reference once field operations have begun.

Indexing – in which you learn how to record attributes from scanned mutation forms.

Tracing – in which you will learn trace CAD polylines and create shapefile polygons (parcels).

Heads up digitizing – in which you learn how to capture parcels from satellite imagery.

Georeferencing – in which you learn how to georeference raster data.

Spatial Adjustment, edgematching and rubbersheeting – in which you will learn how to convert CAD data to an editable spatial format, transform the data, adjust vertices by means of rubbersheeting and match data along map sheet edges.

Hyperlinks and Associations– in which you learn how to link mutation forms to parcels using hyperlinks, joins and relates.

Merging – in which you learn how to combine different layers of data together.

Map production – in which you prepare a cadastral index map and apply standardized symbology.

Notations used in exercise notes

- ☐ Where a paragraph is indented with a square bullet as this one is then you are reading an instruction that should be followed.

Where a paragraph is not indented like this, then you are reading background information, generally indicating what it is you are about to do or have done. These are not instructions and should only be read.

Callouts
Where you see call out boxes such as this one then additional information is being provided to you to help you in your task.

NOTE: When you see a note like this then a tip or some advice is being given.

A course evaluation form appears in Annex C and a glossary of terms in Annex D.

ANNEX A:

Module B - Lecture material and student notes

ESA CADASTRAL OPERATIONS COURSE
MODULE B: DATA PROCESSING AND GIS
COURSE LECTURES AND STUDENT NOTES

[SPEAKERS NAMES] [DATE]

Objectives

- To learn how to process cadastral data
- To learn how to georeference and adjust data
- To learn how to prepare a cadastral index map

Objectives

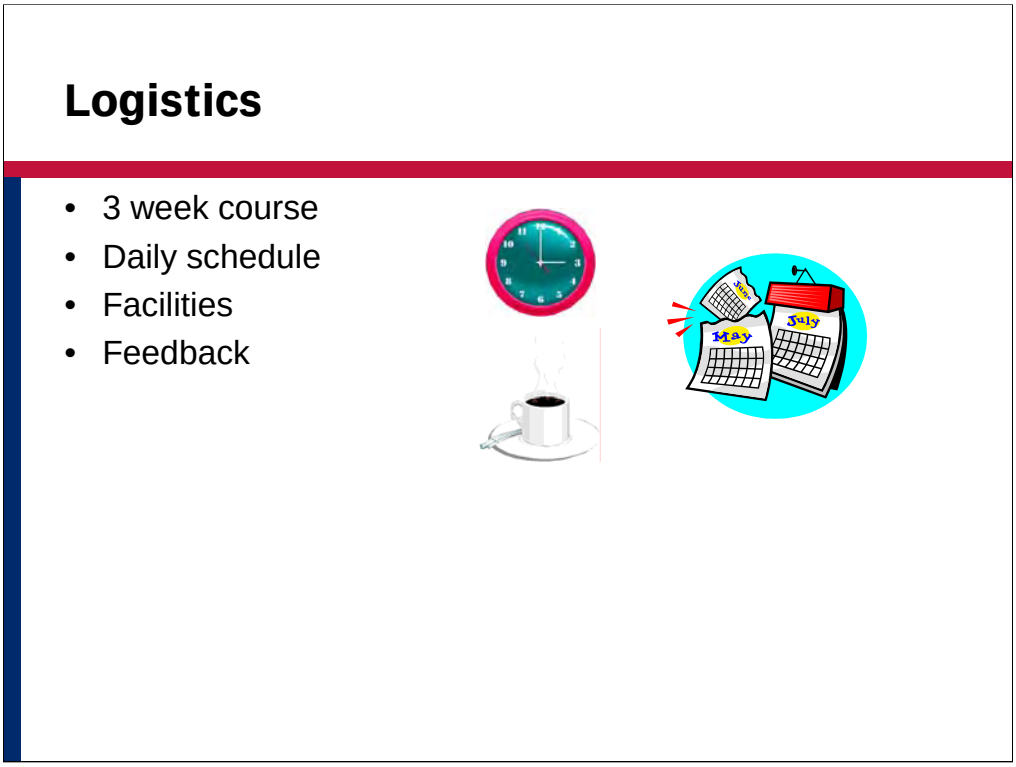
The objectives of this course are to introduce the methods and procedures required to process cadastral data including georeferencing and spatial adjustment, data capture and conversion and the preparation of the cadastral index map using GIS. The GIS software used for this course is ArcGIS.

Training Methods

- Presentations
- Exercises
- Class project

Training Methods

A variety of training methods will be used lectures (presentations), exercises and a class project. Your instructor will present a section, which will then be followed by a class exercise. A series of exercises using sample data are found at the back of this manual. These exercises are designed to convey the principles outlined in the lectures. You can revisit these exercises at anytime. During the course you have plenty of opportunity to use ArcGIS for data processing operations. The class notes are designed to serve as a manual for field work when you begin field operations. If you have any questions during the course please ask your instructor.



Logistics

This is a 3 week course. 2 weeks of the course are classroom based, to be followed by a 1 week class project which will take place in the ESA compound.

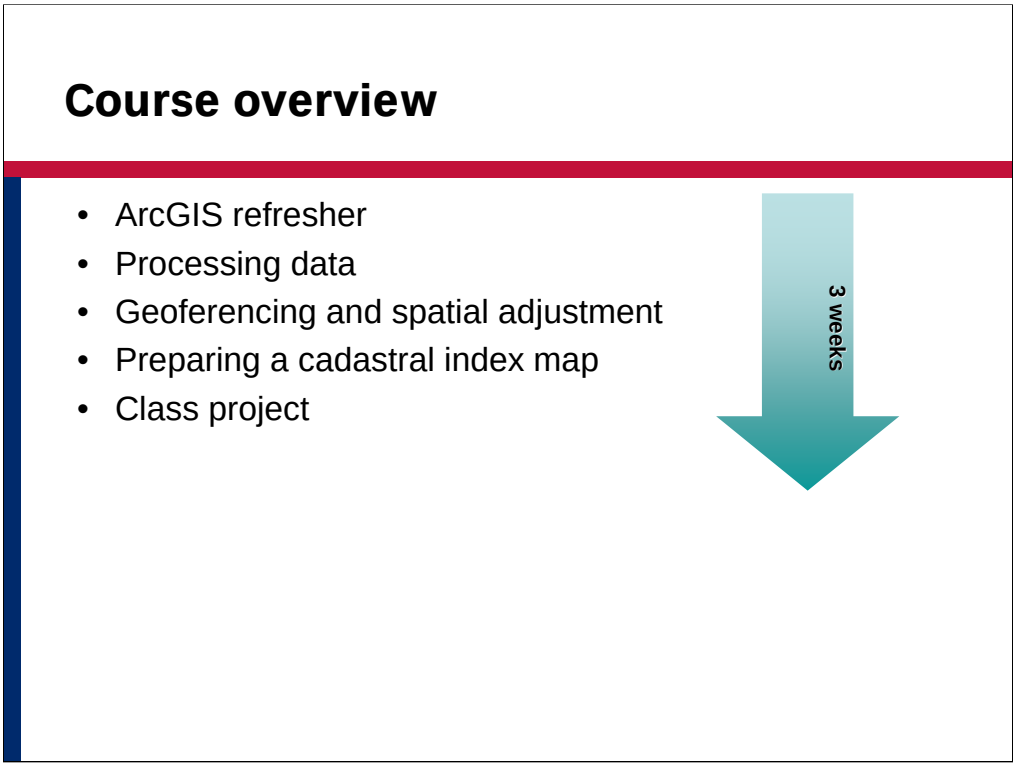
The trainer will explain the logistics of the course, the daily schedule, the layout of the training facility and advise you of the location of toilets and fire exits. On completion of the course please complete a course evaluation form so that we can improve the course in future. You will find the course evaluation at the back of this manual, along with a glossary of terms which you can use for reference purposes.

Section overview

- Course overview
- GIS refresher
- Data processing methodology

Section overview

This section outlines the topics covered, provides a recap of GIS principles and GIS functionality, a description of ArcGIS and an overview of the proposed GIS and data processing methodology.



Course overview

This course covers the use of ArcGIS to process existing cadastral data and new acquired field data to generate a cadastral index map and cartographic product. During the course we will cover data collection and data processing, georeferencing and transformation of existing data and the preparation of the cadastral index map.

What is a GIS?

- “A computerized information system for the management of spatial data”
- An integration of five basic components:
  - People
  - Data
  - Hardware
  - Software
  - Procedures

What is a GIS?

Definitions of a geographic information system can vary considerably. The definition provided here combines both the components and functions of a GIS. The components needed to perform GIS tasks include those listed below:

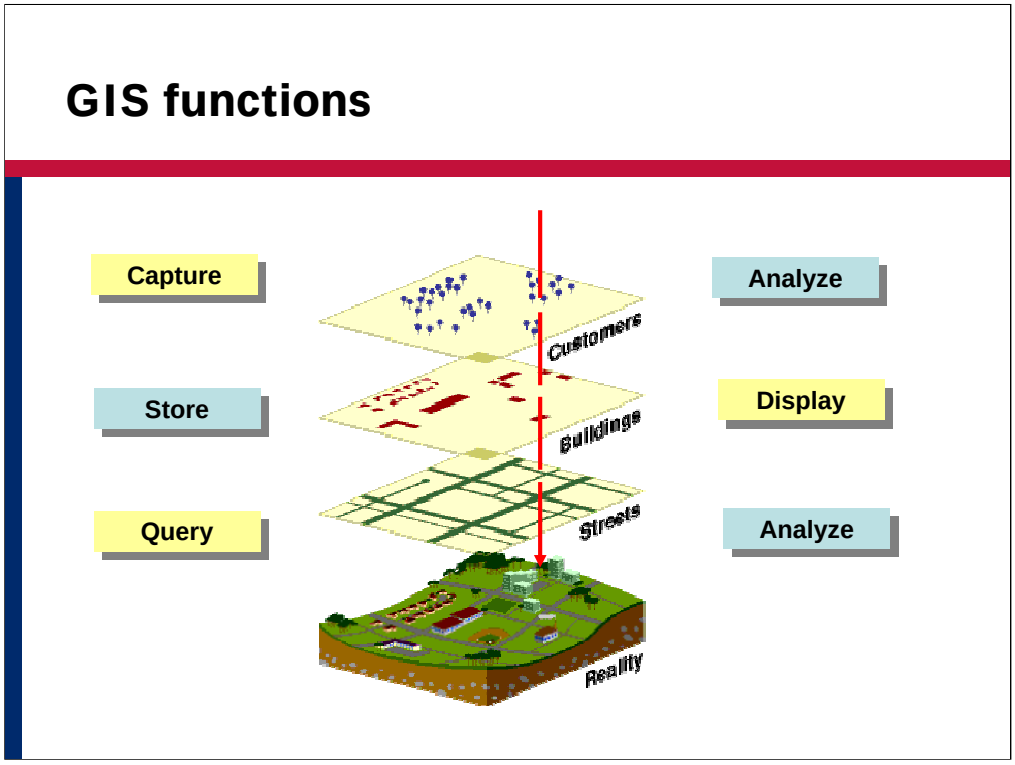
People: This is the most important component in a GIS. People must develop the procedures and define the tasks of the GIS. The best software and computers in the world cannot compensate for incompetence.

Data: The availability and accuracy of data can affect the results of any query or analysis.

Hardware: Hardware capabilities affect processing speed, ease of use and the type of output available.

Software: This includes not only the actual GIS software, but also various database, drawing, statistical, imaging or other software.

Procedures: Analysis requires well defined, consistent methods to produce correct and reproducible results.



GIS functions

Any geographic information system should be capable of the following fundamental operations in order to be useful for finding solutions to real-world problems.

Capturing data: A GIS must provide methods for inputting geographic (coordinate) and tabular (attribute) data. The more input methods available, the more versatile the GIS.

Storing data: There are two basic data models for geographic data storage vector and raster.

Querying data: A GIS must provide utilities for finding specific features based on their locations or attribute values.

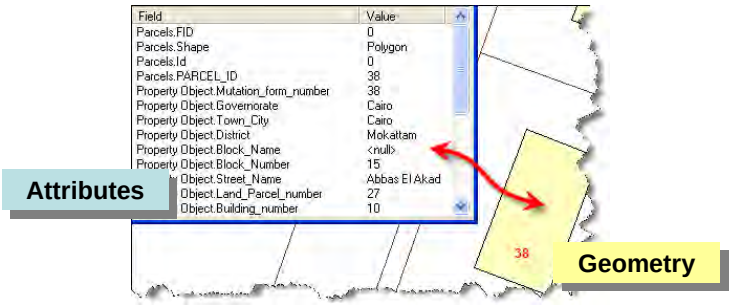
Analyzing data: A GIS must have the ability to answer questions regarding the interaction of spatial relationships between multiple datasets.

Displaying data: There must be tools for visualizing the geographic features using a variety of symbology.

Output: Results of display should be able to be output in a variety of formats such as maps, reports, and graphs.

Components of geographic data

- GIS data has two basic components

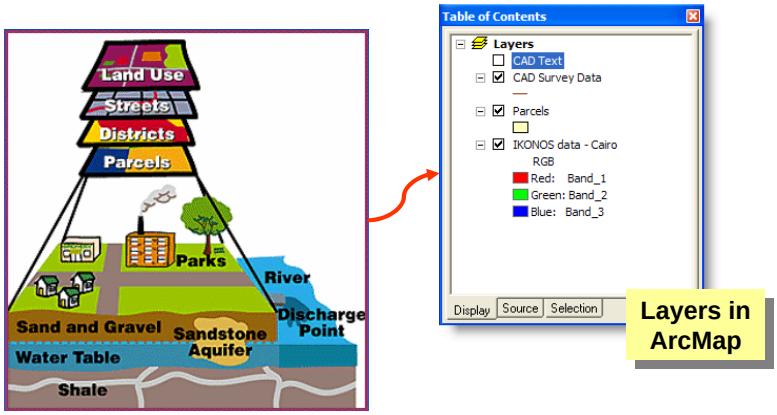


Components of geographic data

The two basic components of GIS data are Geometry and Attributes. Geometry is the physical representation of a real world object. Real world objects are abstracted into point, line or polygon (area) features. Attributes are descriptive information about a feature. In the geodatabase (a new spatial format for ArcGIS) another component of GIS data is behavior. For example domains can be used to enforce permissible attribute values ensuring something is not incorrectly described.

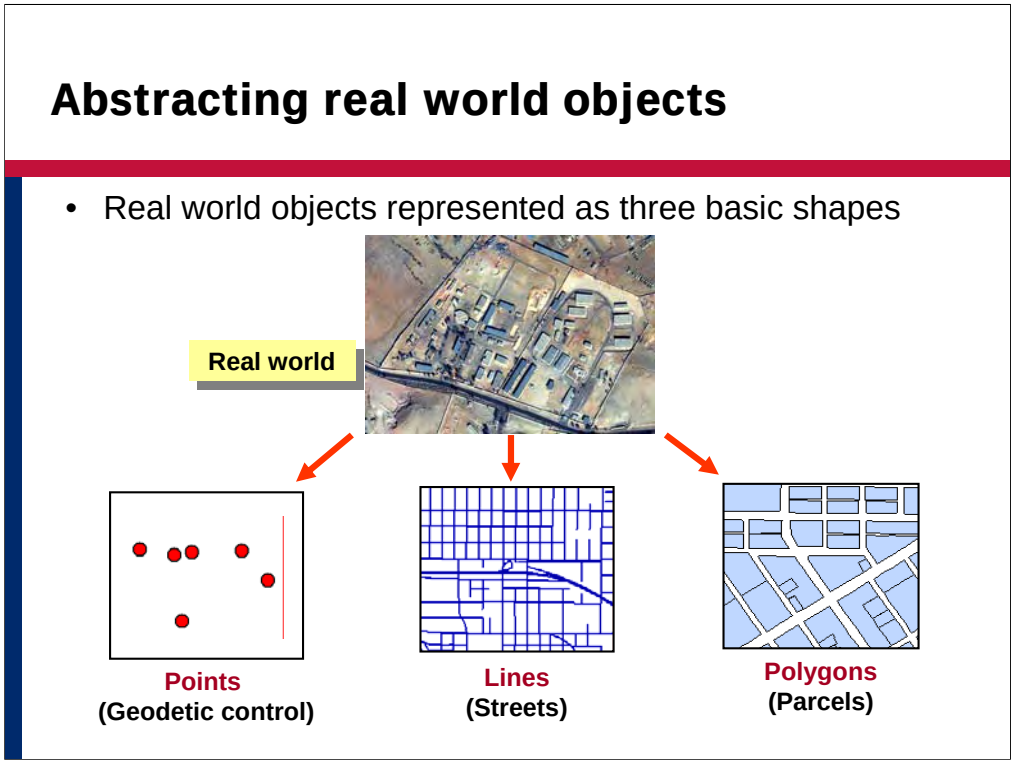
Organizing spatial data

- A GIS works with layers of spatial data



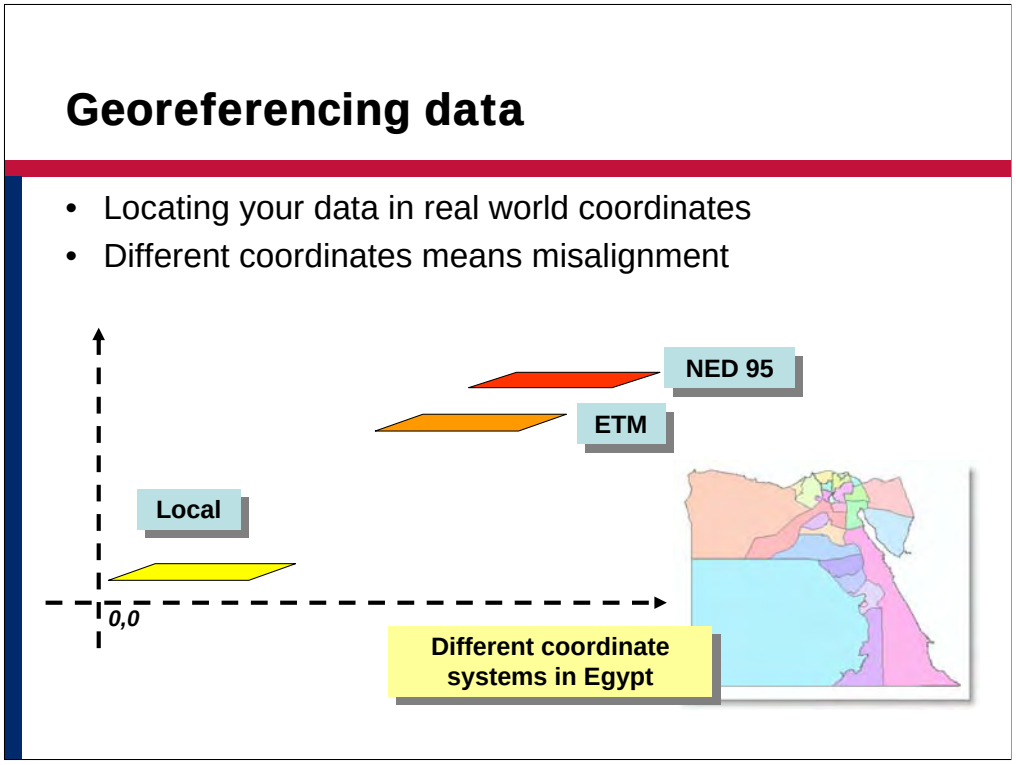
Organizing spatial data

A GIS organizes and stores information about the world as a collection of thematic layers that can be linked by geography. Each layer contains features having similar attributes, like streets and cities, that are located within the same geographic extent. This simple but extremely powerful and versatile concept has proven invaluable for solving many real world problems from tracking delivery vehicles to modelling global atmospheric circulation.



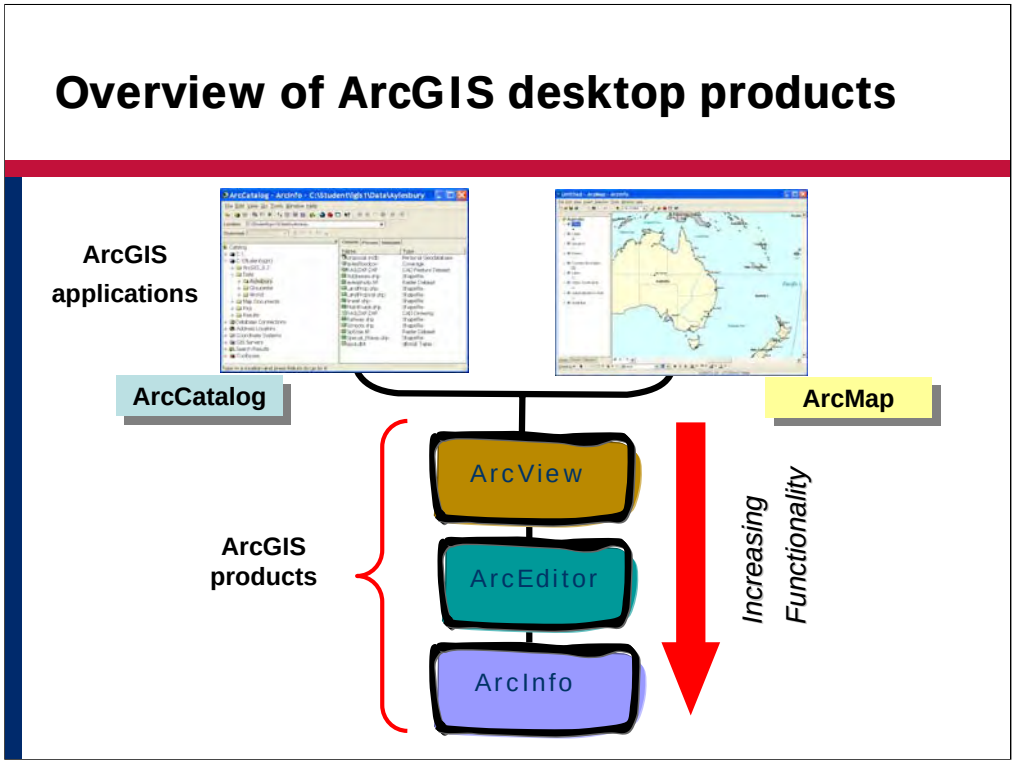
Abstracting real world objects

It is impossible to capture everything from reality inside a computer. Instead, GIS users must somehow abstract real world phenomena, or entities, into a geometric representation of those entities. There are three basic geometric shapes used for geographic features: points, lines, and areas. These shapes are often called geometric objects, geometric features, or feature types.



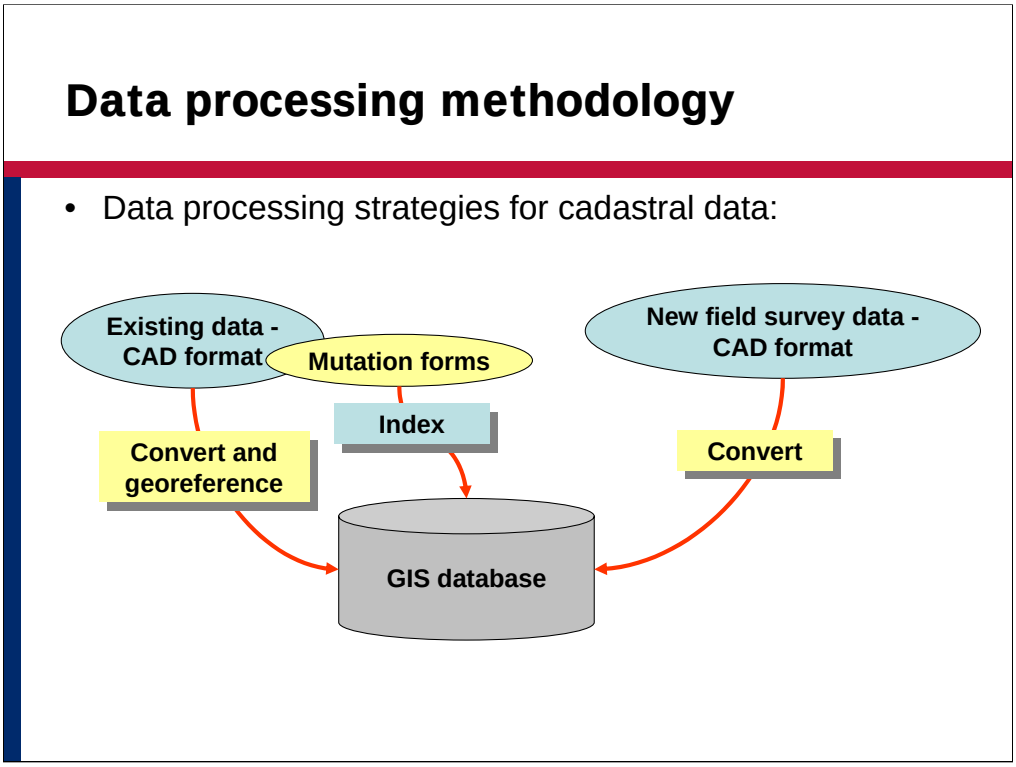
Georeferencing data

One important issue you must confront when adding data to your database is how to ensure that all of the features in the individual datasets are properly aligned to locations on the earth's surface. In Egypt you may encounter local coordinates, coordinates in the Egyptian Mercator System (ETM) and even coordinates in the New Egyptian Datum 1995 (NED 95). The problem is that none of these layers, in the differing coordinate systems, will align correctly and transformations will need to be applied to correct this misalignment. Transformations are covered in more detail in Section 4: Georeferencing and Adjustment. It is important that you understand the coordinate system of data provided to you to ensure you apply the correct transformation, although in reality you may have little idea about a dataset's coordinates and projection system unless it is described by metadata.



Overview of applications

During this course you will make use of ArcGIS. ArcGIS is a desktop GIS from ESRI. There are 3 ArcGIS products: ArcView. ArcEditor and ArcInfo that increase in functionality and price. You will be using ArcView in this course. Each of the 3 products share the common applications ArcMap and ArcCatalog. These are designed to work together to perform all GIS tasks. For example, you can search for and find a map document in ArcCatalog, then open it in ArcMap by double-clicking it in ArcCatalog. You can then edit and enhance your data through the tools available in the ArcMap editing environment.

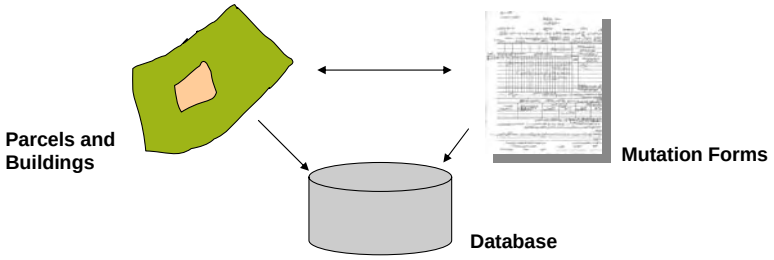


Data processing methodology

The GIS and data processing methodology proposes that both existing and new CAD data be converted to the ESRI shapefile format and mutation forms indexed. When necessary *existing* data will be transformed to ensure its coordinate system is correct. All data processed will be held in a GIS database that is amenable to analysis, map production, modification and update.

Processing existing data

- Process existing data
  - Index mutation forms
  - Convert CAD data to shapefile format
  - Attribute properties
  - Link mutation form details

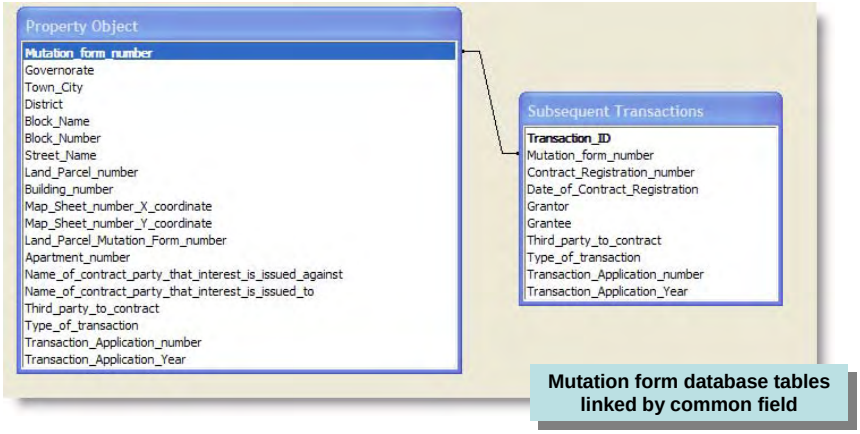


Processing existing data

Where parcel and building information is already available in CAD format (e.g. from ESA for the Mokattam area) this will be converted to shapefile format using ArcGIS. Where mutation forms exist they will be indexed using MS Access. It will then be possible to link the mutation form and parcel/building/apartment together.

Mutation form database

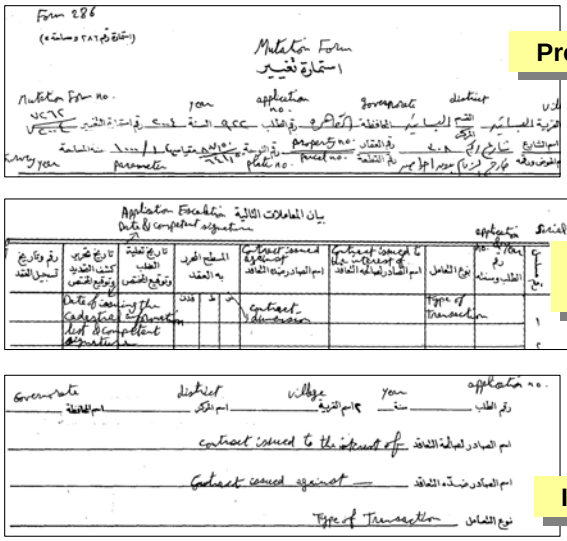
- Property Object and Initial Transaction table
- Subsequent Transactions table



Mutation form database

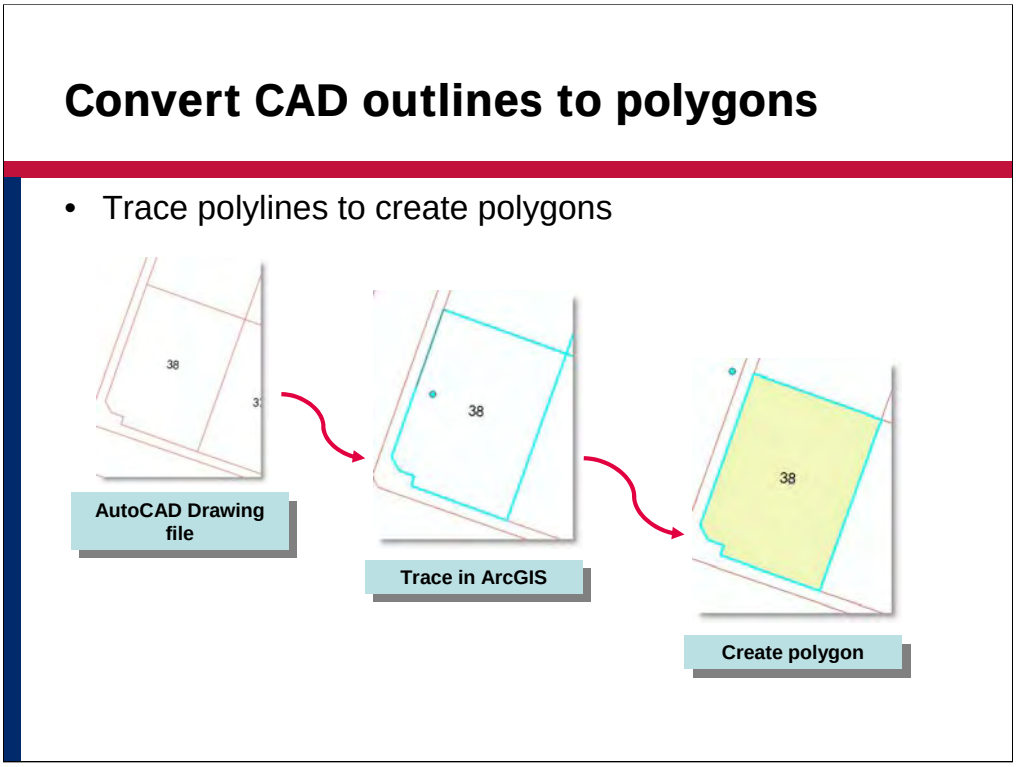
A mutation form database will be created to hold details from mutation forms – there are two required tables one for the property object and its initial transaction and one for subsequent transactions. Using a common field (e.g. mutation form number) these tables can be linked together as shown in the graphic above. This is described as a one to many relationship type, one property object – many transactions.

Index mutation forms



Index mutation forms

Mutation forms will be scanned and key details be indexed. Mutation forms comprise 4 pages and they are slightly smaller than A3 size. The slide above shows some of key attributes that will be indexed. All pages of a mutation form (including the sketch) will be scanned using a flatbed scanner and saved as a TIFF image file.

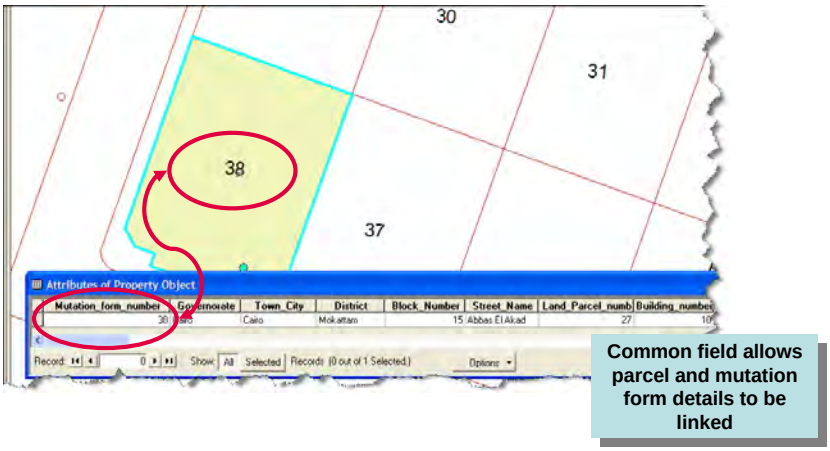


Convert CAD outlines to polygons

Where CAD data exists for an area, typically the CAD data represents parcels and buildings as a series of connected lines. Whilst this is correct in the strict sense that parcel boundaries have dimensions (i.e. length and direction) the lines themselves do not constitute an area i.e. there is no way to click inside a parcel and determine its area or determine its identifier. Where CAD polylines exist they will be converted to polygons using different editing tools in ArcGIS, for example the Trace tool as shown above. Where CAD polygons exist (i.e. closed polylines) they will be converted directly to an ESRI spatial format.

Linking mutation form details

- Common field mutation form number
  - Links property details and transactions to a property



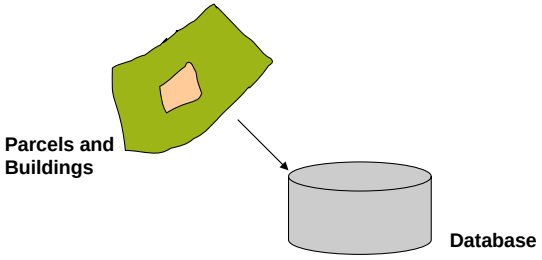
Common field allows parcel and mutation form details to be linked

Linking mutation form details

Once parcels have been created and mutation form details indexed they can be linked together using the common field mutation form number which is an attribute both of the property feature class and the property object and subsequent transactions table in the mutation forms database.

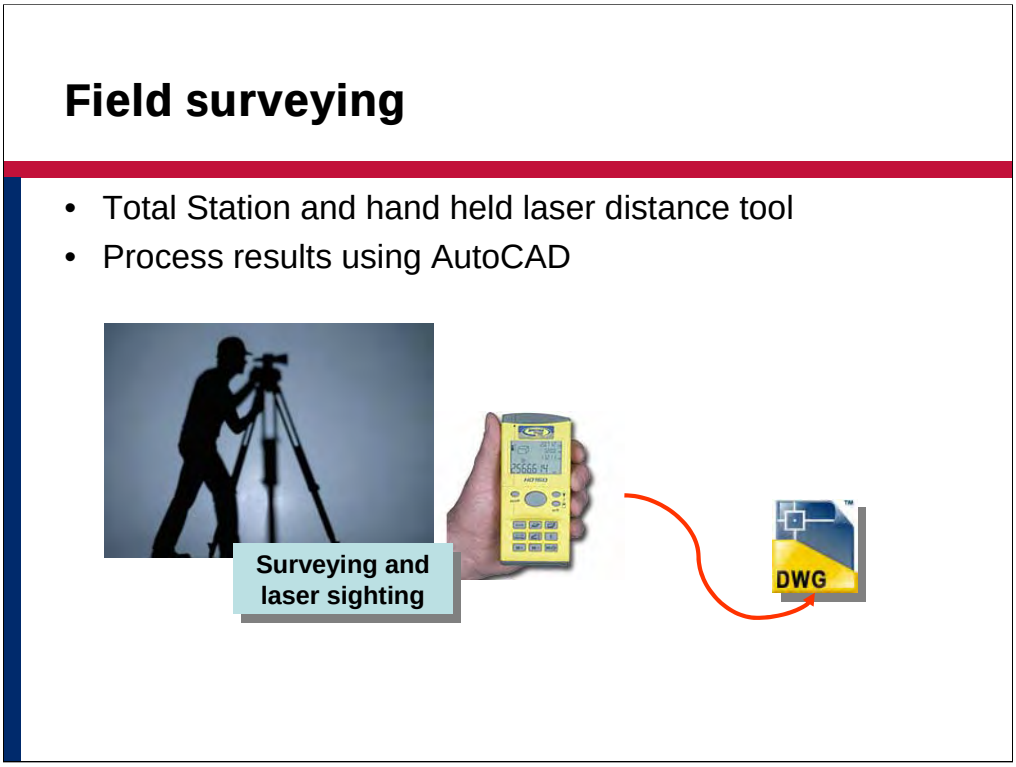
Processing new data

- Field survey data
  - Process field data using AutoCAD
  - Convert CAD data to shapefile format
  - Attribute properties



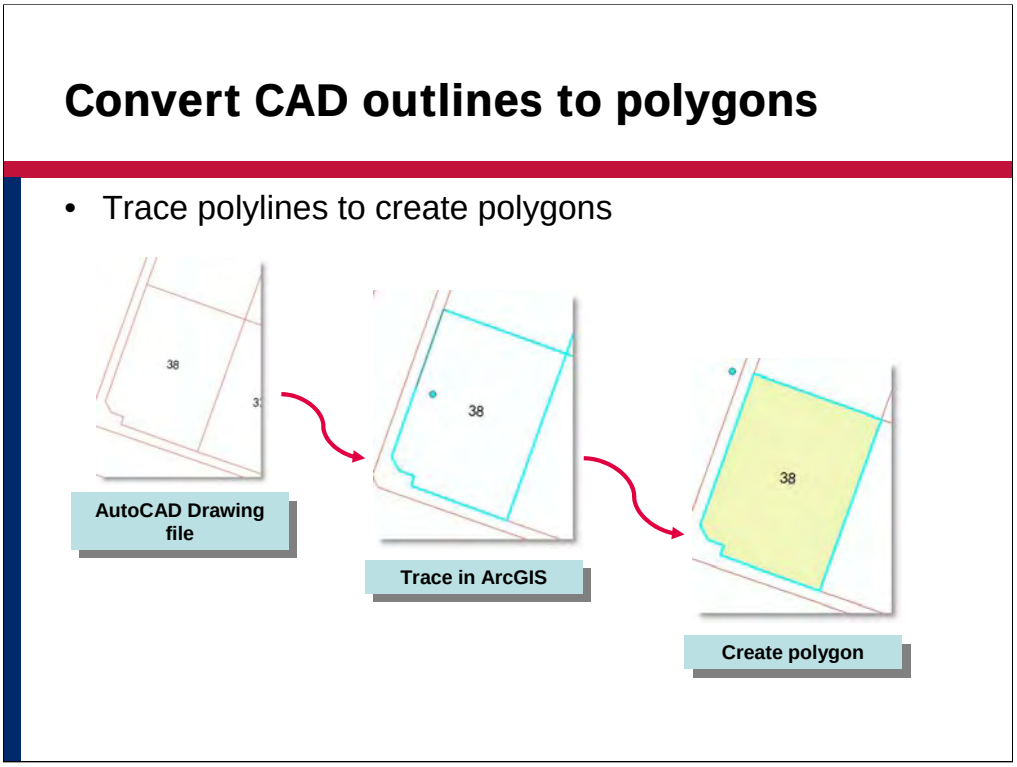
Processing new data

New data will be acquired during the field surveying phase. Since this is new data, there will be no mutation form associated with the parcel/building and the feature will only be assigned a property identifier. New data will be referenced directly to the ETM coordinate system and will not need to be transformed. Once new data has been processed it will be combined with existing data to create a complete cadastral picture for an area of interest.



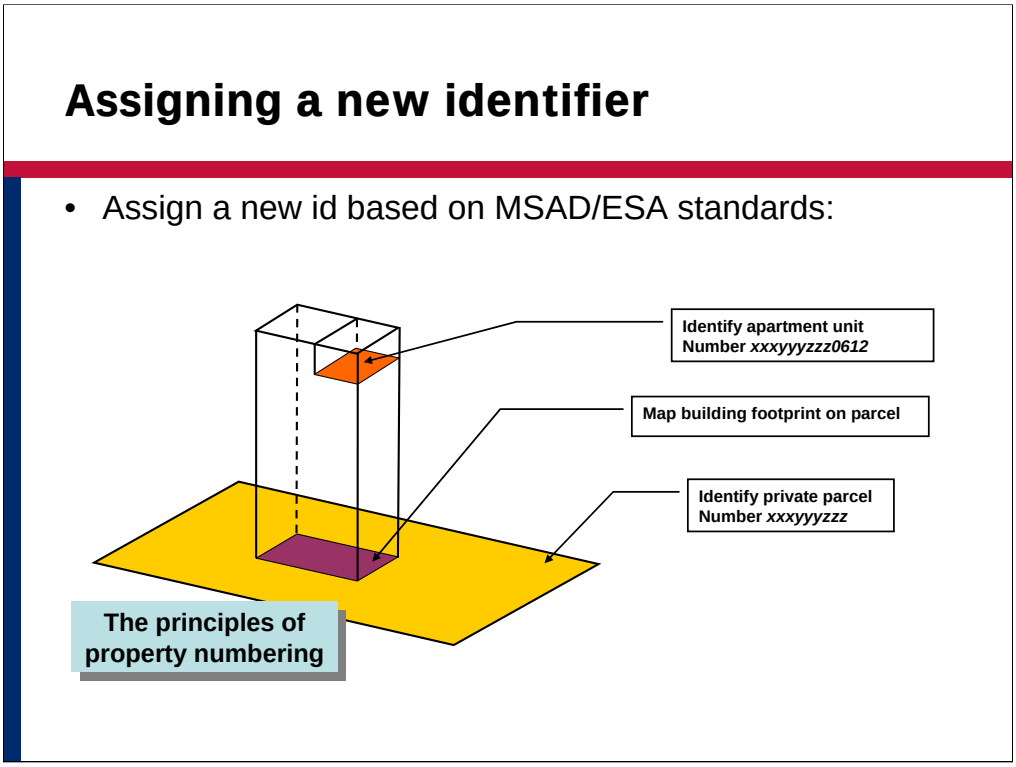
Field surveying

Survey crews will gather parcel outlines and building footprints using Total Station and Hand Laser distance tools. All data (as per current ESA practices) will be processed using AutoCAD. There are separate course modules covering Geodectic Control and Field Surveying.



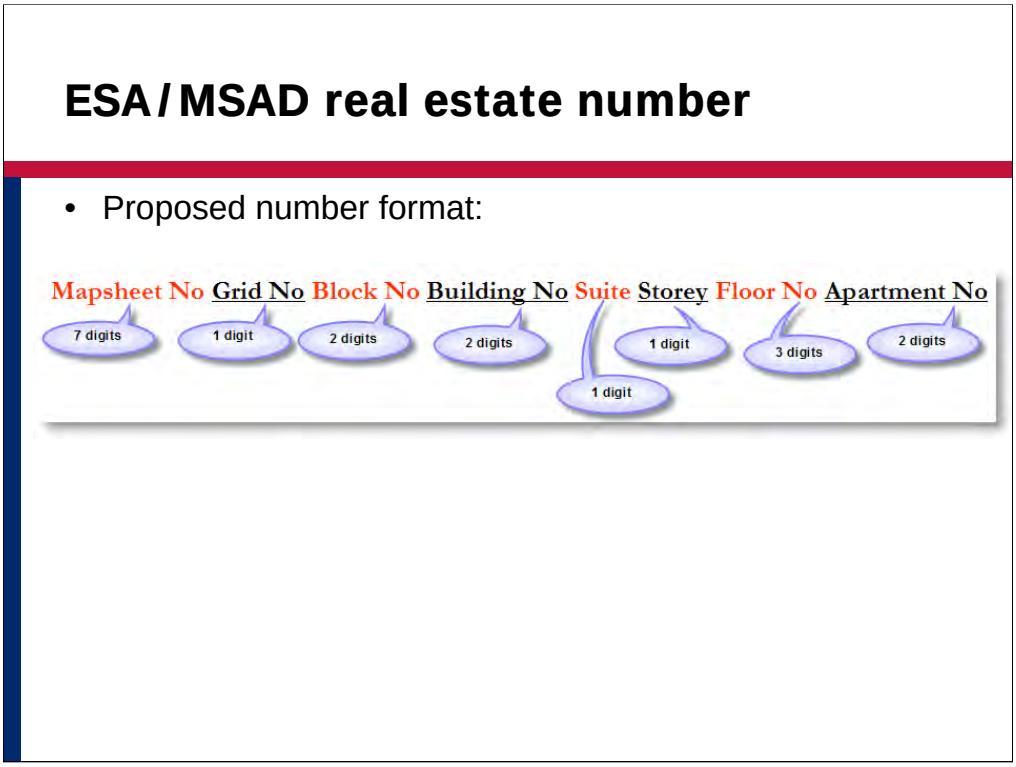
Convert CAD outlines to polygons

As with existing CAD data polylines will be converted to polygons using different editing tools in ArcGIS, for example the Trace tool as shown above. If CAD polygons are generated by the field survey teams this data will be converted directly to the ESRI shapefile format.



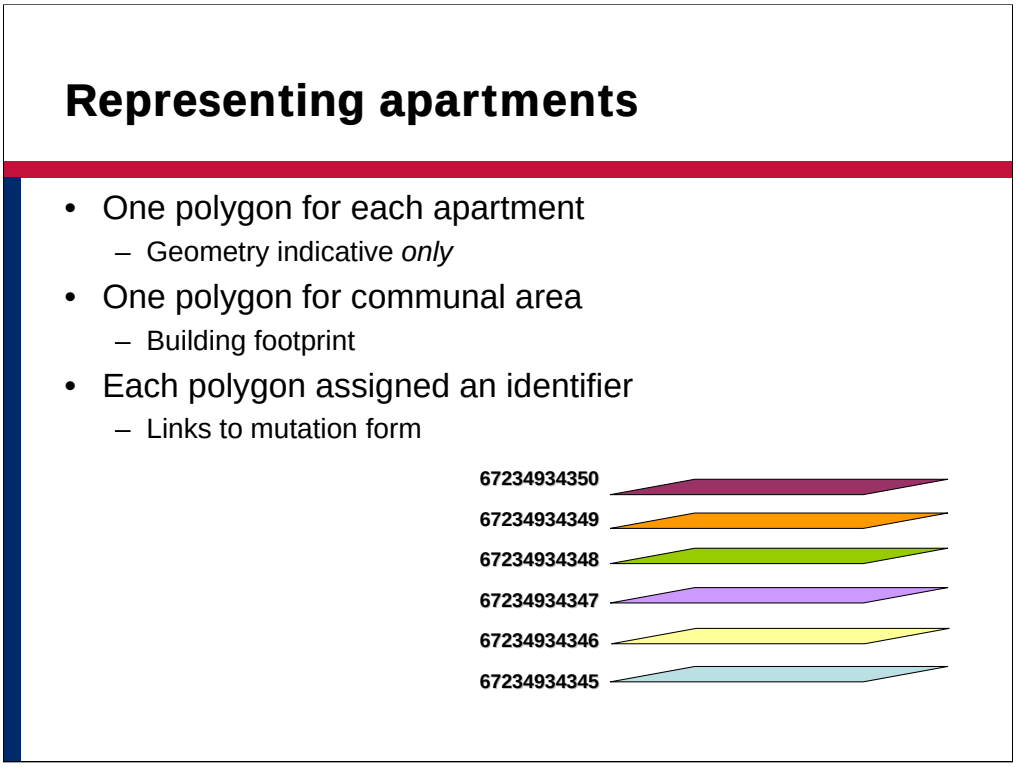
Assigning a new identifier

New properties will be assigned a unique parcel identifier using the coding system devised by MSAD/ESA (or another alternative numbering system, for example as devised the ESA Provincial Office). The principles of a property coding system is shown above, typically these systems include numeric identifiers for administrative areas as well as the property itself, they may even be alphanumeric. For example in the UK each property is identified by a Unique Property Reference Number (UPRN). Each UPRN is a maximum of twelve digits and is unique within the UK.



ESA/MSAD real estate number

The ESA/MSAD real estate numbering (REN) system foresees Egypt broken down into map sheets of 1.5 by 1 km which in turn are broken down into 6 grids. The numbering system then is broken down by block, building, suite, storey, floor and apartment number. The identifier comprises a total of 19 digits, note that this a proposed numbering and is subject to change.



Representing apartments

Each apartment (and communal area) should be represented by one polygon, the geometry is only indicative i.e. that this an area of ownership, it is not meant to show the exact boundaries or dimensions of the apartment. For example if there were a 15 apartments there would be 16 polygons – one for the communal area which has its own mutation form and one polygon for each apartment. Each polygon is then assigned an identifier so that it can be linked to its mutation form. Field teams will collect information about apartments when surveying building footprints. They will complete a Building Report which includes number of apartments as well as those occupied and unoccupied.

Create cadastral index map

- Final product is a cadastral index map
  - Digital and analogue
- Analogue product follows ESA cartographic standards

Hardcopy Cadastral Index map

Create cadastral index map

The hardcopy output of the GIS and Data processing component will be the Cadastral Index map. ESA has standards regarding the content and symbology of these maps and these standards will be followed when printing or plotting large scale maps for the Mokattam area. The cadastral index map will be vetted by ESA to ensure it meets their quality control standards.

Section 2:
ArcGIS refresher

Section 2 overview

- What is ArcGIS?
- ArcMap
- ArcCatalog
- ArcToolBox

Section overview

This section provides a brief overview of ArcGIS, the applications that comprise it and how they are used.

Objective

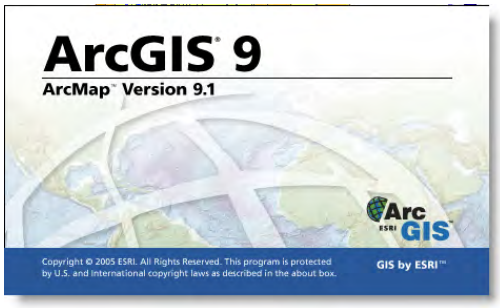
- To provide an overview of ArcGIS and how it can be used to process cadastral data

Objective

In order to be able to successfully undertake data processing operations using GIS, a brief overview of the GIS solution is provided. As mentioned this is not an ArcGIS per say but this section serves as a refresher for those already familiar with ArcGIS.

What is ArcGIS?

- Desktop GIS
  - Provides tools for the management of spatial data
- Easy to use GUI based application
  - Fully documented with on-line help
- Two core applications:
  - ArcMap
  - ArcCatalog

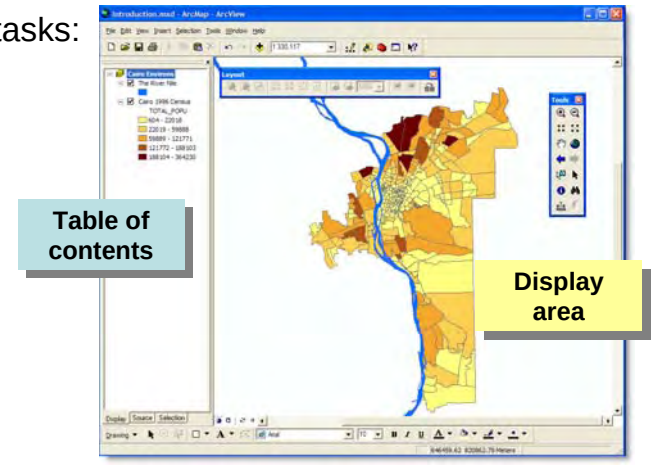


What is ArcGIS?

GIS is defined as a “computerized information system for the management of spatial (geographic) data”. Using GIS you can create, manage, analyze and present geographic information. ArcGIS is an easy to use GUI based application that provides all the tools needed to perform the data processing tasks described in the Cadastral Operations methodology. ArcGIS is fully documented with on-line help and web based resources. If you have any questions about ArcGIS during the course please feel free to ask your instructor.

ArcMap

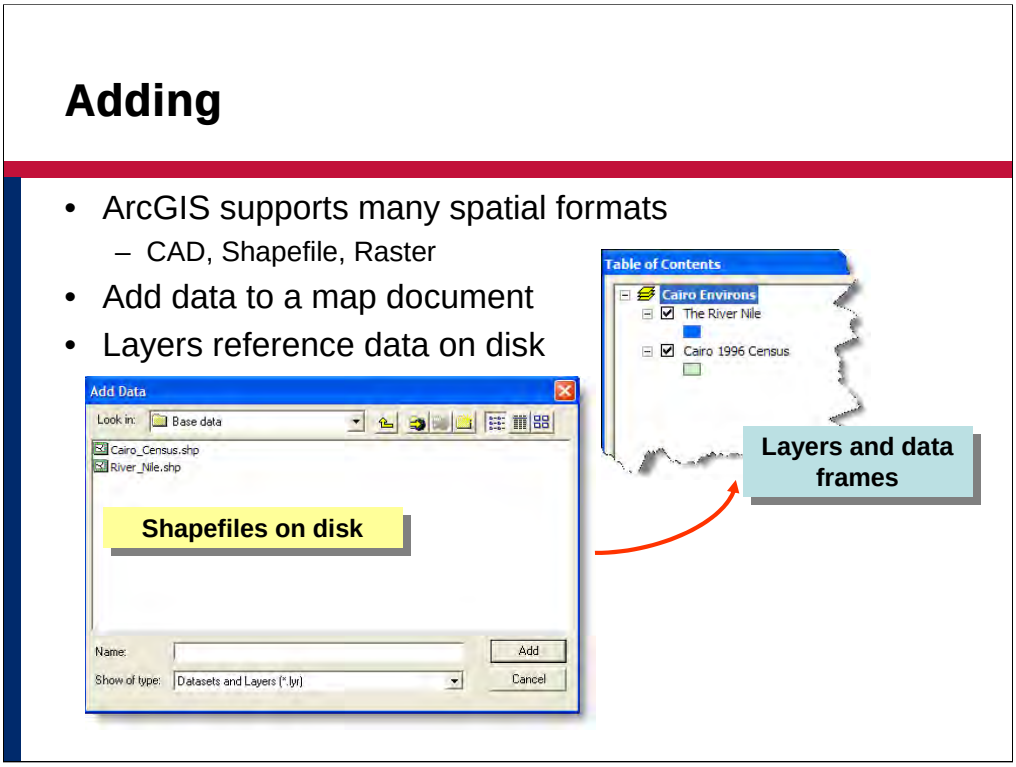
- Visualization application
- For map-based tasks:
  - Displaying
  - Symbolizing
  - Editing
  - Querying
  - Analysing
  - Charting
  - Reporting
  - Presenting



ArcMap

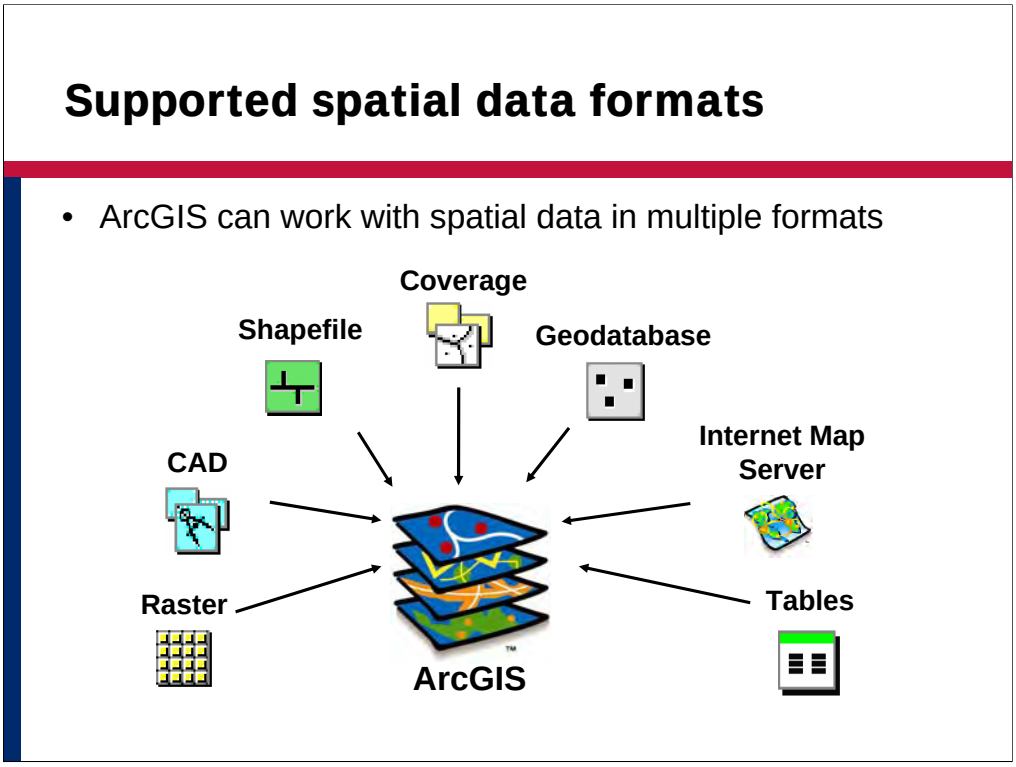
ArcMap is the primary display application, you will use this the majority of the time to add data, symbolize data (i.e. create thematic maps), edit data, query data (select features by attribute or location); create charts, reports and layouts (maps) for printing, plotting or export. layers. You can export layouts to TIFF, BMP and many graphic file formats to share maps with non-GIS users.

ArcMap comprises a table of contents, display area and toolbars. The table of contents (TOC) lists all the layers or themes of geography you are working whilst the display area shows features contained in the layers. Use ArcMap toolbars to navigate around the base map, add data, save your work and create layouts.



Adding

You can add many different spatial data formats to a map document – CAD data, shapefiles and geodatabase feature classes. When you add data to a map document you create a layer – a layer references the source data on disk. Once a layer has been added it can be symbolized, queried and edited. Layers are organized by data frames or containers of spatial information. In the slide above Cairo Environs is a data frame, it is identified by the three yellow stacked layers.

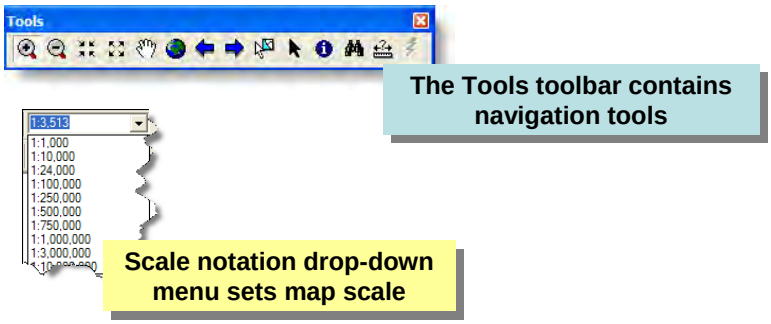


Supported spatial data formats

Currently, there is not a standard format for GIS data.Various GIS software manufacturers and other organizations, such as government agencies, have continually searched for more efficient and versatile digital formats to store geographic information. ArcGIS has the advantage of seamlessly supporting all of the ESRI formats: shapefiles, coverages, grids, the geodatabase and data served over the internet by ArcIMS or ArcGIS Server. In addition ArcGIS also supports the three most common CAD file formats (DXF, DWG and DGN), as well as a variety of common image file (Mr. SID, BSQ, BIL, etc) and tabular formats (MS Access tables, DBF and text files). The ability to work with so many different formats without needing to convert them is a tremendous advantage.

Navigating

- Tools for zooming in/out, panning viewing to scale

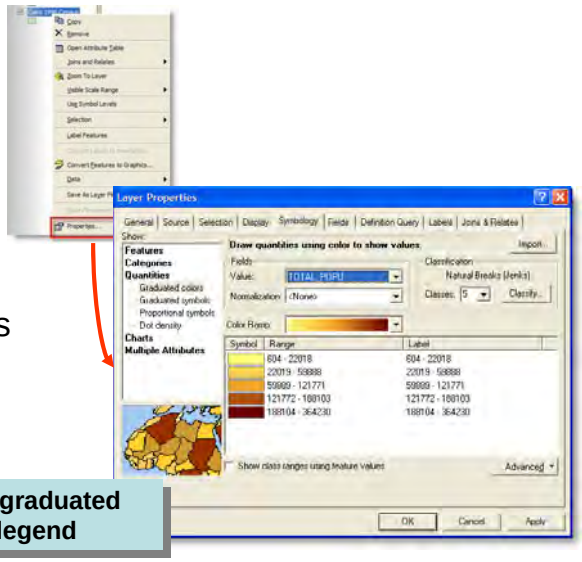


Navigating

Use the Tools toolbar to zoom in and out, zoom to previous/next, pan and zoom to the full extent of all layers in the data frame. You can also use the scale notation drop-down menu to zoom in and out. You can either you a predefined scale or enter a scale yourself e.g. 1:500. You can use the navigation tools in the Layout view allowing you to create maps for printing and plotting of fixed scale as required by ESA.

Symbolizing

- Property of the layer
- Select legend type
  - Unique values
  - Graduated colors
  - Graduated Symbol
  - Pie Chart
  - Dot Density...
- Set legend properties



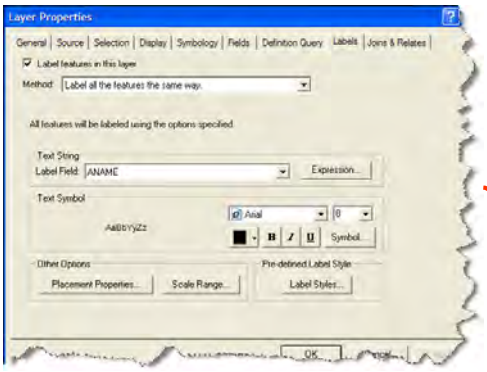
Creating a graduated colors legend

Symbolizing

You can create thematic maps (maps which are symbolized in such a way as to present information) using the Symbology tab in the Layer properties dialog box. First choose a legend category: Features, Categories, Quantities, Charts or Multiple Attributes then a legend type. Use Categories for descriptive values and Quantities for numeric values. For example under Categories choose Unique Values to give each feature with a unique descriptive value (e.g. district name) a unique symbol. Under Quantities choose Graduated Colors to assign a gradation of colors to numeric values with the deepest color representing the greatest numeric value.

Labeling

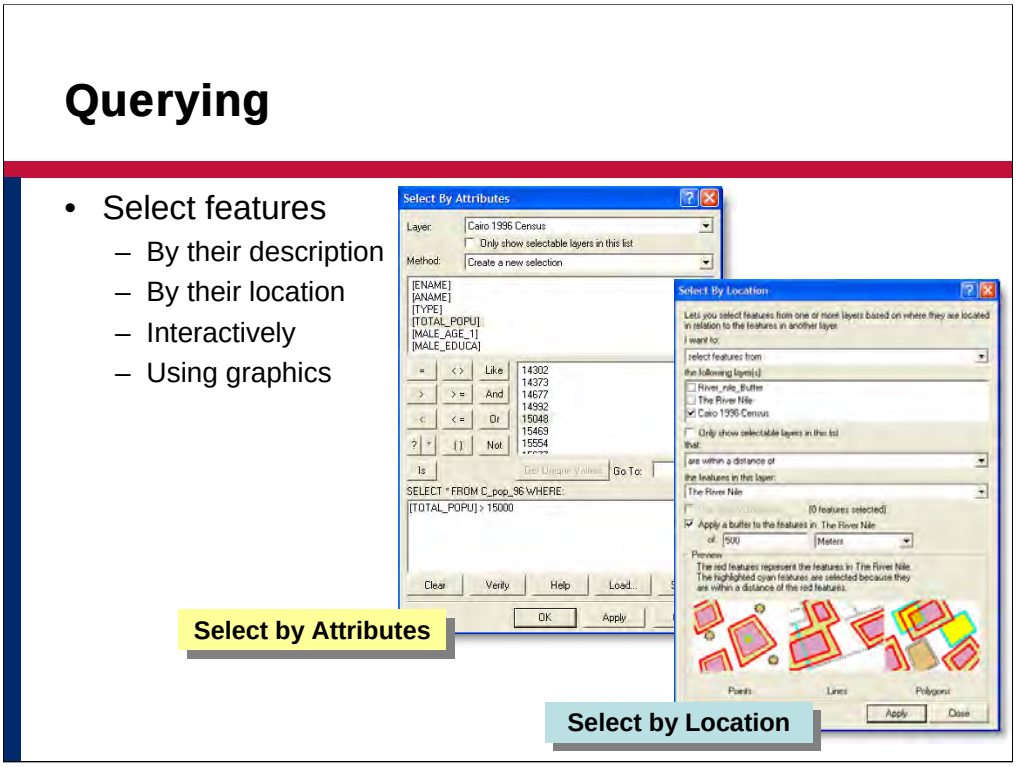
- Add text to map
- Based on feature attributes
- Set label properties



Labeling districts by Arabic name

Labeling

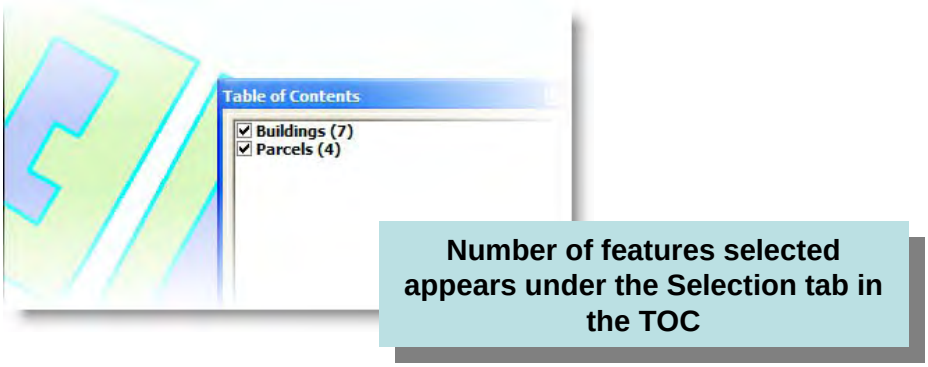
You can label (add text to) features by selecting an attribute and setting the properties for the label. In the example above district names are shown in Arabic. Labels are dynamic that is they are repositioned every time you zoom in and out. There are rules governing the placement of labels too, which makes for a clear uncluttered display. If you do not want text moving around the display – for example you want a fixed location for a street name you can create annotation. Annotation is described in more detail in Section 6: Preparing the Cadastral Index Map.



Querying

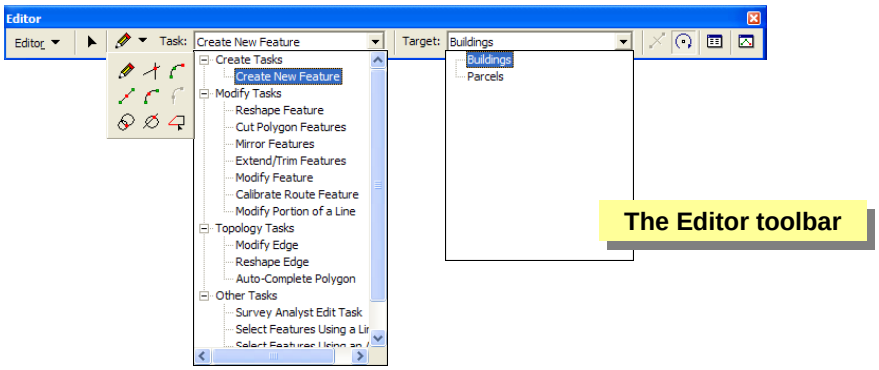
You can select features in a number of different ways, by their description using a Structured Query Language (SQL) statement (e.g. Population > 50,0000), by their location (e.g. find all properties within 50 meters of a road), interactively by using the mouse/cursor or by using a graphic drawn in the display.

Selected features are displayed in cyan. To determine how many feature have been selected either open the layer's attribute table or click on the Selection tab at the bottom of the map document's table of contents:



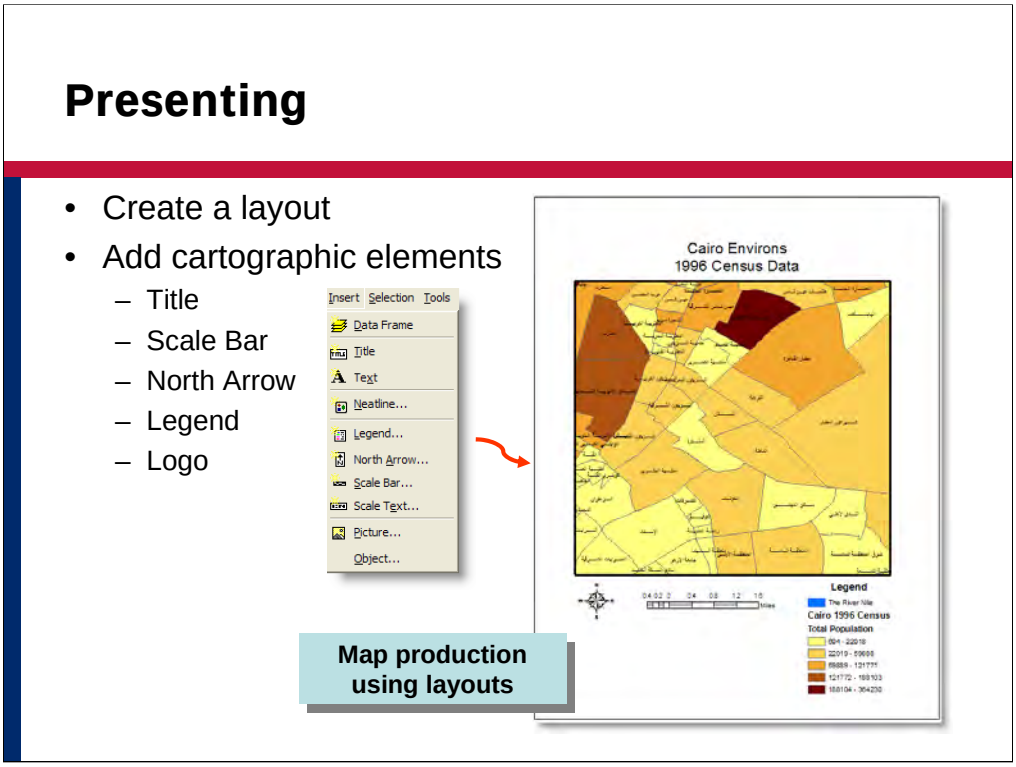
Editing

- Select editable layer
- Set edit task
- Use sketch tools



Editing

Editing is covered in some detail in this course, suffice to say that in ArcMap you use the Editor tool bar to start an edit session, specify the editable layer and set an edit task. To perform an edit task you use a sketch tool (the default sketch tool is the pencil). For example to draw a new parcel boundary choose to start editing, set the editable layer to parcels, the edit task to create new feature and use the sketch tool to draw a parcel outline in the display. When you have finished your edits you can save your work and stop editing.

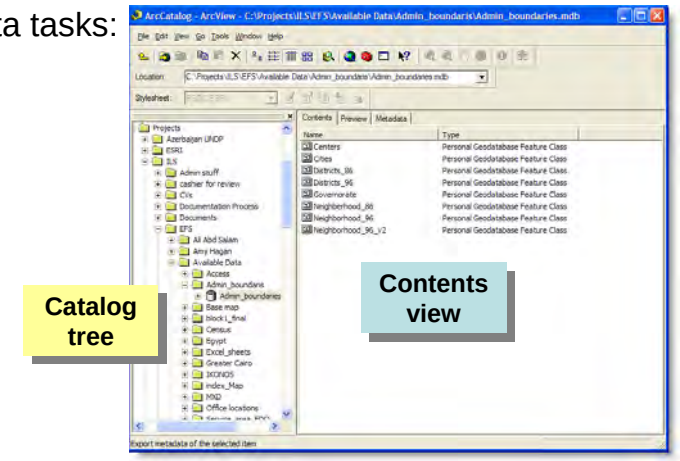


Presenting

Using layouts you prepare cartographic products for printing, plotting or export (for example to PDF files). To switch to the Layout view choose Layout View from the View menu or click on the Layout View button at the bottom of the map document's display area. To insert a cartographic element click the Insert menu and choose the type of element to add. All elements are dynamic, for example if you zoom out the scale bar will adjust itself. In addition the map in the layout view is 'live' i.e. using the Tools toolbar you can zoom in and out or pan the data frame to set the correct extent of the map you want to print.

ArcCatalog

- Data management application
- For spatial data tasks:
  - Creating
  - Renaming
  - Deleting
  - Moving
  - Searching
  - Previewing

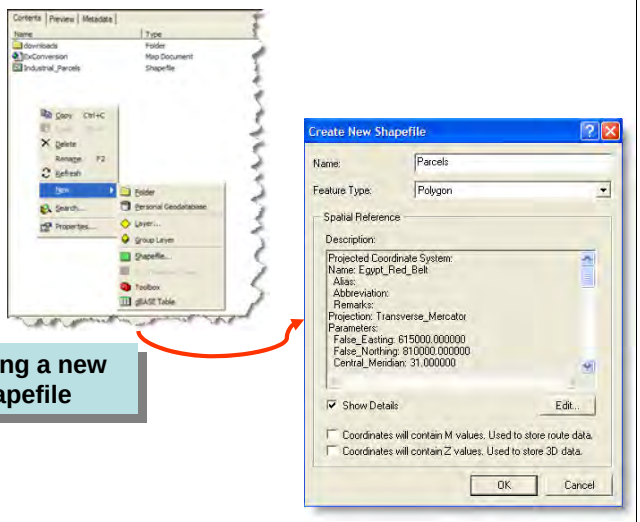


ArcCatalog

ArcCatalog is the data management application. Use ArcCatalog exclusively for the management of geographic information – do not use Windows Explorer. Using ArcCatalog you can create new spatial data, move, copy, rename and delete data, as well as search and preview data before its use.

Creating

- Choose spatial format
- Set properties
  - Name
  - Geometry
  - Spatial reference
  - Attributes



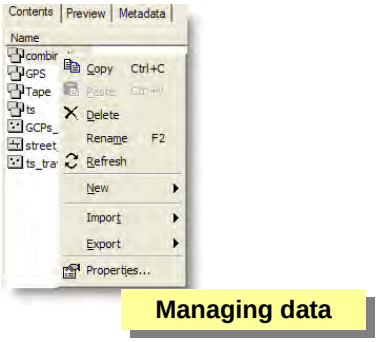
Creating a new shapefile

Creating

Use ArcCatalog to create new data, be it spatial or tabular. When creating new spatial data you can create either shapefiles or personal geodatabase feature classes. Irrespective of which type of spatial data you choose to create you must name the new dataset, set its geometry type (point, line or polygon) and its spatial reference. You can also fields to the dataset's attribute table to store descriptive information. Once you have created a new feature class or shapefile in ArcCatalog you must edit it in ArcMap.

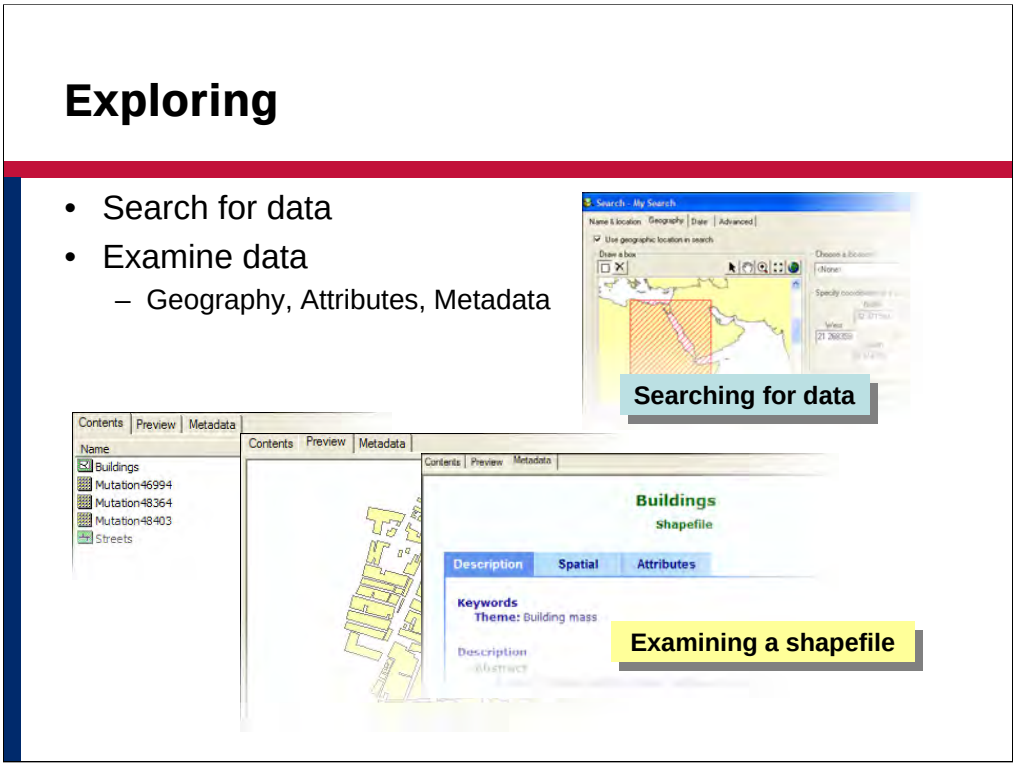
Managing

- Copy
- Rename
- Move
- Delete
  - No recycle bin!



Managing

Use ArcCatalog exclusively for the management of spatial data, you can copy, rename, delete and move data. In addition you can create and delete folders on disk. Remember there is no Recycle bin so deletions cannot be undo

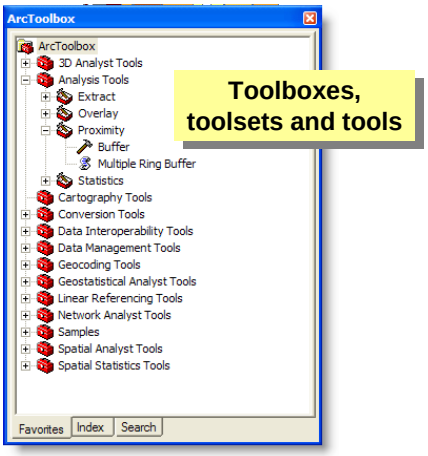


Exploring

Using ArcCatalog you can search for geographic data by name and location, geography, date and metadata. Search results are returned as shortcuts which behave like data, you can drag and drop a shortcut into ArcMap without knowing where the source data is. You can also examine data before using it – under the Contents tab you can view the contents of folders and geodatabases, under the Preview tab you can examine the features and attributes of a feature class or shapefile and under the Metadata tab you can examine descriptive information about the data.

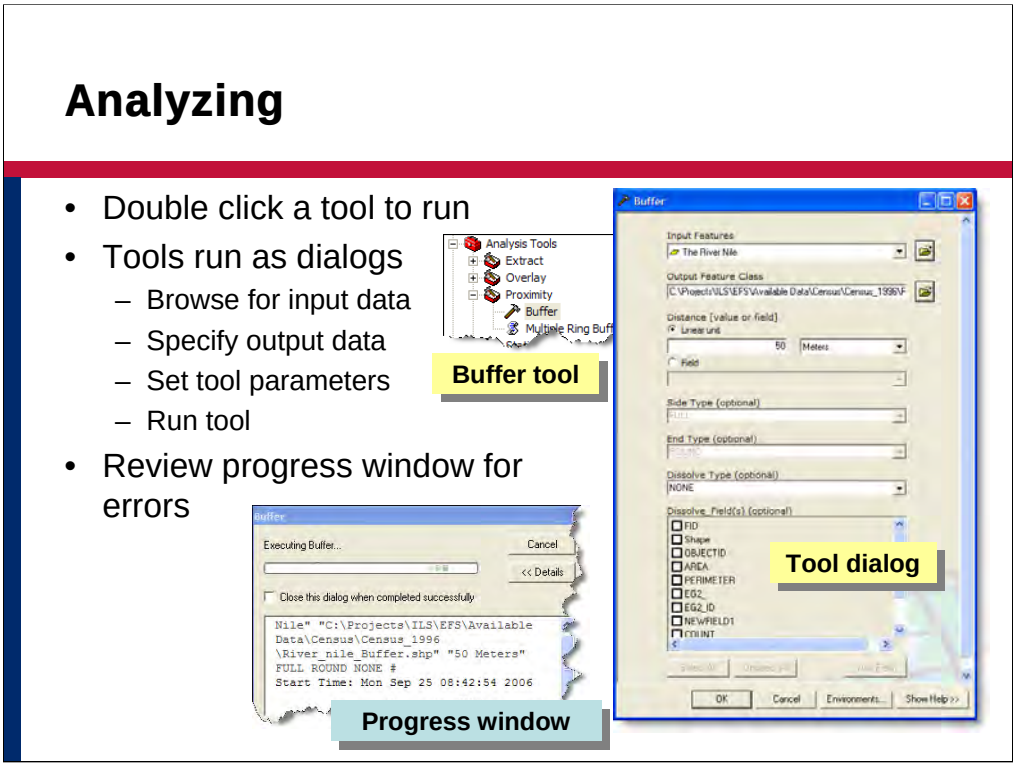
ArcToolBox

- Data analysis and automation application
- For spatial analysis tasks:
  - Clipping
  - Merging
  - Buffering
- Dockable window in ArcMap/ArcCatalog



ArcToolBox

ArcToolBox is used for data analysis as well automation of repetitive tasks. Commonly used tools include clipping (a cookie cutter operation), merging (combing data together) and buffering (creating concentric rings around features). ArcToolBox is a dockable window that can be added to either ArcMap or ArcCatalog.



Analyzing

To run a tool, first find the tool in ArcToolBox. If you do not know where to find a tool, use the Search tab at the bottom of the ArcToolBox window. To run a tool simply double click on it (tools have a hammer icon next to them). Most tools run as dialog boxes requiring that you identify an input dataset, and output data location and tool parameters. Depending on the tool being run will determine the parameters required. The slide above shows the buffer tool, which requires you enter a buffer distance. When the dialog is complete click the OK button to run the tool and review the progress window for any errors.

Exercise 1

- Start ArcMap
- Open a map document
- Symbolize a layer
- Start ArcCatalog
- Examine a feature class
- Start ArcToolBox
- Run a tool

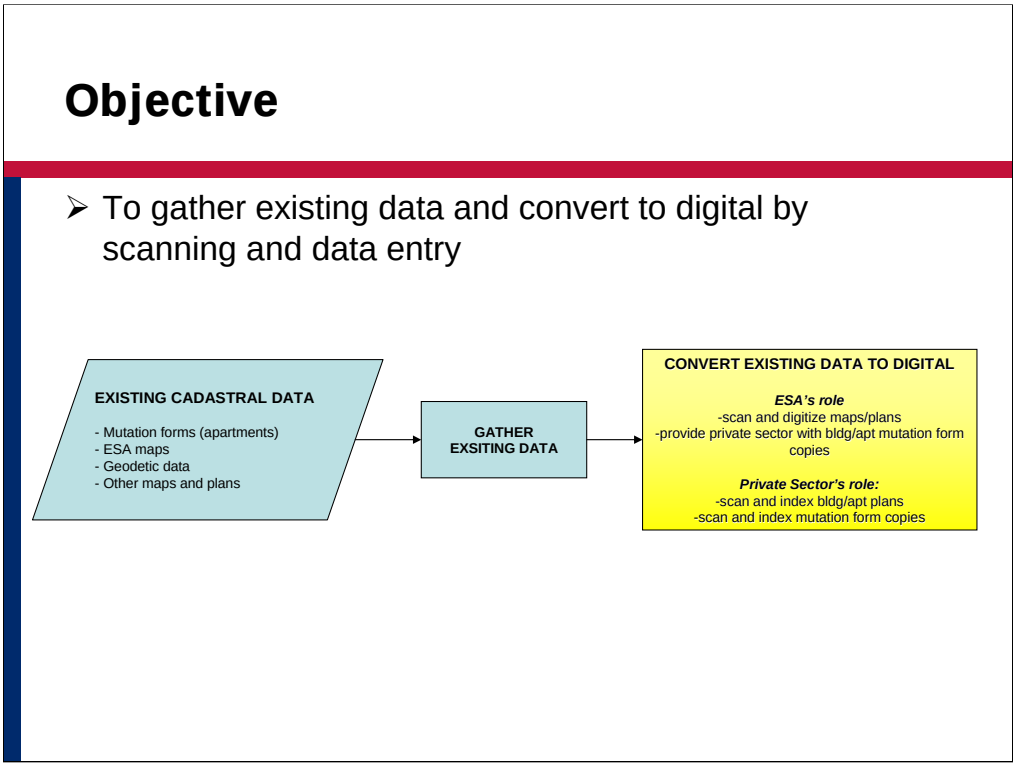
Section 3:
Collection, scanning and indexing

Section overview

- Data sources
- Scanning
- Indexing

Section overview

The use of existing data assists in the creation of the cadastral index map as not all areas need to be surveyed. This section covers where to find existing data, its assessment, scanning and indexing.



Objective

Rather than collect information from scratch, the methodology proposes that existing data sources be used to partially construct a cadastral index map. A large amount of information relating both land parcels and buildings is held by ESA District Offices and Municipalities, amongst others. The first activity within the preparatory phase will be the collection and evaluation of this information and to whether it should be included and if so to convert the data into digital format (if required). Where gaps exist these will be filled with new survey work. Existing mutation forms will also be scanned and indexed.

Egyptian Survey Authority

- EDO
  - Mutation forms
  - Development (Partitioning) Project Plans
  - Building Unit Plans
- EPO
  - Cadastral Maps
  - Development (Partitioning) Project Plans
  - Control Network data
  - Cadastral Numbering

Egyptian Survey Authority

EDO (ESA District Office)

Mutation forms are used to record property transactions and provide diagrams of land parcels, common areas within buildings under multiple ownership and individual apartments. Mutation forms are created in a hierarchical manner and are a link between existing registered deeds and a spatial description of property objects. Individual mutation forms are slightly larger than A4.

Development (Partitioning) Project Plans are created by development companies and individuals undertaking subdivision.

Building Unit Plans are plans which show the internal details of individual apartments and are usually only available for new communities.

EPO (ESA Provincial Office)

Cadastral Maps for new communities are generally maintained in AutoCAD.

Development (Partitioning) Project Plans are created by development companies and individuals undertaking subdivision.

Control Network Data are low order control points for cadastral surveys and can be used in field survey work.

Cadastral Numbering a list of cadastral numbers is maintained by the EPO.

ESA HQ

- Geodetic control
  - Existing control points
  - Datum conversion parameters
- Cadastral map data
  - Existing cadastral maps

ESA HQ

Geodetic Network Data – The Department for Geodesy, Triangulation and Control, which comes under the Mapping Affairs Central Department, is responsible for managing and maintaining all geodetic infrastructure for Egypt's vertical and horizontal control networks. This department may possess details information about the GPS stations to be the basis for the coordinate system that will be used by the surveyor to densify the network required within the target area to be surveyed and/or mapped. The department is also responsible for developing and disseminating control network transformation parameters and equations so that all cadastral data is on the common coordinate datum of NED-95. The coordinate values and description cards can be obtained from the ESA Geodetic Department.

Cadastral Map Data – The ESA Map Store holds a repository of cadastral maps for many areas of Cairo at 1:500 to 1:2500 scale. Maps for the selected area to be surveyed should be collected to identify the property boundaries determined when the last survey was completed.

Municipalities

- Land use types and patterns
  - Residential and Government land
- Street names and public areas

Land use patterns

Municipalities

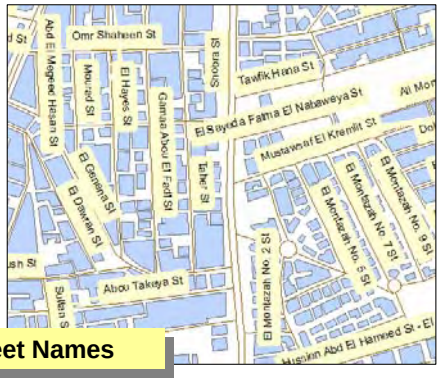
Data relevant to land registration and held by the municipalities includes:

Land Use Plans that show land use patterns and to some extent ownership information (e.g. whether it is residential or governmental land)

Municipal Property Data which indicates municipal property boundaries, public use areas and approved road and street locations and names.

Physical Planning

- Street names
  - New names
  - Changes to names
- To confirm property address



Physical Planning

Street names (current and old) are held by Physical Planning and can be used to confirm property addresses.

Other Government Agencies

- Land ownership
- Plans of buildings and properties
- Names of properties
- For reference purposes

Other Government Agencies

Many other government agencies own land as well as properties and buildings, plans and names of which will be useful for reference purposes. Examples include the New Communities Agency.

Private Companies and Individuals

- Developments by private companies
  - Records of owners
- Individual ownership claims
  - *Sanad el-Melkyah*
  - *ORFI* contracts
  - Notarized documents

Notarized Deed

Private Companies and Individuals

Developers hold plans and maps of their developments which can be used to create cadastral data. This data is typically already in digital format (e.g. AutoCAD) and can relatively easily be combined with new data. For individuals any of the following can be used in determining ownership (in descending order of preference):

Registered Deed or Publicized contract

Registry Office extract or notarized documents

ORFI or Unregistered contracts

Adverse possession the acquisition of title to property through possession without the owner's consent for a certain period of time (by law 15 years in Egypt)

Tax statements or tax (*MUKALAFA*) registers

Testimony

Utility bills in order of importance, telephone or electricity, gas

Data assessment

- Decide whether to use data
  - Use only maps and plans with relevant features
  - Minimum acceptable scales
  - Control Points required
  - Age and condition

Data assessment

Existing locational information of land parcels must be sourced from paper based maps and plans and a scale of 1:500 or better. Existing digital data must have been created through methods with an accuracy that is equal to, or better than the graphical equivalent of 0.25m at 1:500 (0.5mm at map scale). The smallest scale from which data can be is sourced is 1:5,000. If maps and plans do meet these minimum requirements they should not be used and field surveying will be required.

On maps being scanned you should be able to identify a minimum of 2 (preferably 3)control points (often referred to as *Ground Control Points* or *GCPs*), known locations that have real world coordinates associated with them. If no control points can be identified then a field survey will be required to establish these. The control points are needed to ensure that data can be brought under a common survey reference network.

Data assessment form

- Record whether maps/plans can be used
- Indicate if survey work is required

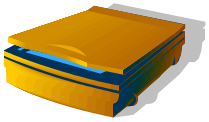
Source	*Location*	*Scale/ Age*	*GCPs*	*Field Work needed?*	*Include in GIS?*
Developers plan	Mokattam, Block A	1:5,000 1985	Yes	No	Yes
Old cadastral map	Mokattam, Block C	Unknown 1934?	No	Yes	No

Data assessment form

Use a data assessment form to log data that has been gathered and record key information about it – its scale, age (if known), whether there are any visible GCPs and whether field work is needed, this information should be passed to the survey team so that they can program survey work as needed.

Scanning

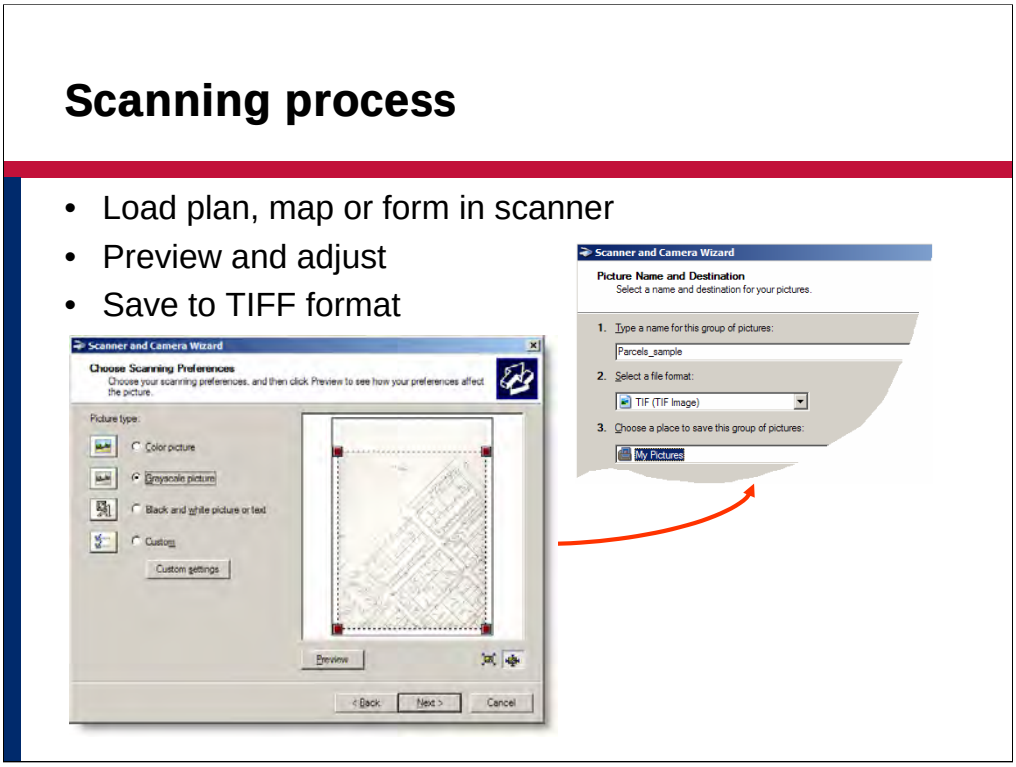
- Maps and plans up to A0
  - Digitize features from raster data
- Mutation forms up to A3
  - Index key attributes using RDBMS



Scanning

Only maps and plans with relevant information should be scanned (i.e. those showing buildings and parcels). Maps and plans should be scanned using an A0 scanner, mutation forms using an A3 scanner.

Once mutation forms have been scanned they should be indexed i.e. key details should be recorded in a relational database management system (RDBMS) such as MS Access.



Scanning process

To scan a map, plan or form, make sure it is face down and flat on the scanner, choose to preview the document before scanning so that you can be sure it is being scanned correctly.

Maps, plans and mutation forms should be scanned as TIFF files (Tag Image File Format CCITT Group 4 compression standard).

The graphics above show the Scanner and Camera Wizard in Windows XP, note that you may be using different scanning software but the process will be exactly the same.

File naming convention

- Mutation forms - mutation form number
  - Mutation5677723
- Maps - map sheet
- Apartment/Buildings plans - address
  - Apartment no + Building no + address

File naming convention

Scanned TIFF files should be named after the number of the mutation form preceded by ‘mutation’ as shown above. Maps should be named by map sheet number. Apartment/Building plans by address (Apartment #, Building # and address).

Indexing mutation forms

- Key attributes to be recorded:
  - Property location
    - Governorate name, Town name, District name, etc…
  - Original contract details
    - Name of contract party, type of transaction, transaction year, etc…
  - Transactions against property
    - Grantor, grantee, date of contract registration, transaction year, etc…

Indexing mutation forms

Mutation forms contain key attribute information that needs to be indexed. The key attributes to be recorded are listed on the following pages and relate to the property object, initial and subsequent transactions. Property sketch details will not be indexed.

Time frame

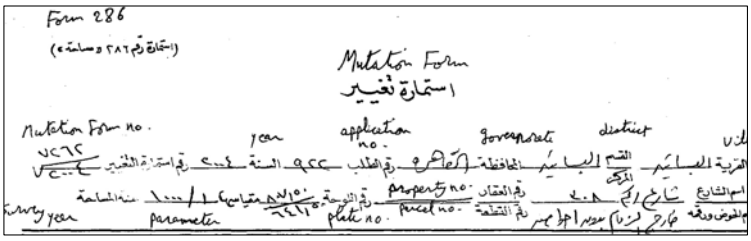
- Estimated number of mutation forms for Mokattam:
  - 2,600 for parcels
  - 1,900 for apartments
- Each indexer should complete 20 mutation forms a day
- Approximate time frame 1 month (10 persons)

Time frame

There are approximately 4,500 mutation forms in Mokattam. Assuming a complement of 10 GIS and Data processing staff indexing (recording) 20 mutation forms a day, all forms should be encoded within 1 month.

Property details

- Property address, district, governorate…



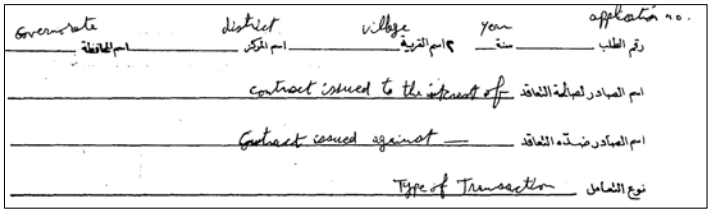
Property address

Property location

Information related to the property that needs to be encoded includes: Mutation form number, Governorate Name, Town (City) Name, District Name, Block Name (if applicable), Block Number (if applicable), Street Name, Land Parcel Number, Building Number (if applicable), Map Sheet number X coordinate, Map Sheet number Y coordinate, Land Parcel Mutation Form Number (this is entered for mutation forms of building common areas and apartments) and Apartment Number (this number is entered in place of building number and land parcel number. It is linked to the land parcel by inclusion of the land parcel mutation form number).

Initial transaction

- Location, date, Grantor-grantee, nature of transaction:



Initial transaction

Initial transaction

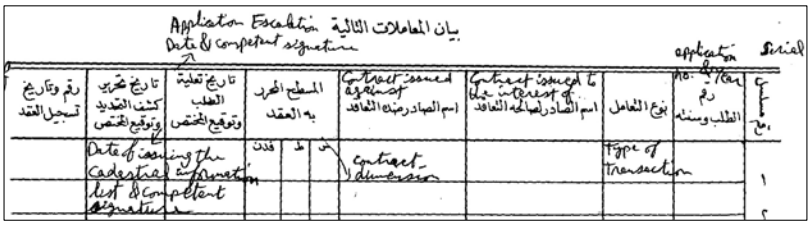
Information regarding the original contract submitted for initial registration of the property object that needs to be encoded includes: Name of contract party that interest is issued against, Name of contract party that interest is issued to, Third Party to contract (if applicable), Transaction Application Number, Transaction Application Year.

Types of transaction:

The following types of transaction may be recorded on the mutation form: Consent Sale, Sale by keeping usufruct right, Seha we Nafaz Prosecution, Seha we Nafaz Verdict, Gift, Will, Formal Pledge List, Possession Pledge List, Formal Pledge List Renewal, Possession Pledge List Renewal, Consent Division, Juridical Division Prosecution, Juridical Division Verdict, Ownership Affirmation Prosecution, Ownership Consolidation Verdict, Expropriation Warning, Expropriation Prosecution, Verdict for Holding an Auction, Inheritance, Consent "Farz wa Tagneeb" (Partitioning and Separation), Consent + division & Particularization, "Farz wa Tagneeb" Prosecution (Partitioning and Separation), "Farz wa Tagneeb" Verdict (Partitioning and Separation), Marginal notation, Publication Amendment (major), Publication Amendment (minor), Completing a Deal (Concluding a Transaction), Particularization, Expropriation decision for public benefit (compensated), Issuance of real estate certificate, Issuance of recent copy of a deed, Consent Sale with pledge, Assignment Prosecution, Will registration

Subsequent transactions

- Grantor-Grantee, nature of transaction, date…



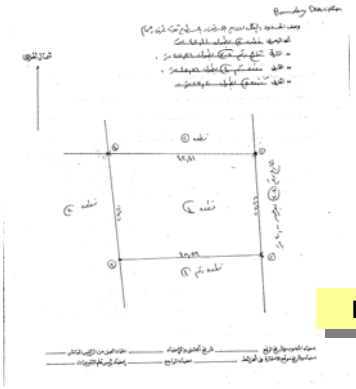
Subsequent transactions

Subsequent transactions

Information related to subsequent transactions carried out against the property object that needs to be encoded includes: Contract Registration Number, Date of Contract Registration, Name of contract party that interest is issued against (Grantor), Name of contract party that interest in issued to (Grantee), Thor party to contract (if applicable), Type of Transaction, Transaction Application Number, Transaction Application Year.

Sketch map

- A property outline and dimensions



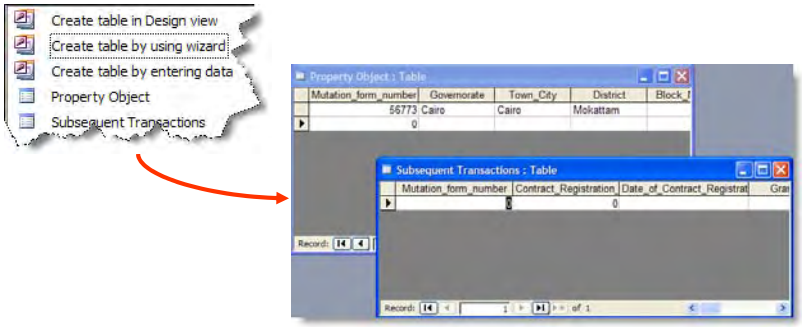
Property sketch

Sketch map

The sketch map (not to scale) records parcel or building dimensions. Information from this page will not be indexed, rather it will be linked to the parcel/building that it is associated with using hyperlinks in ArcGIS see Section 6: Preparing the cadastral index map for more details.

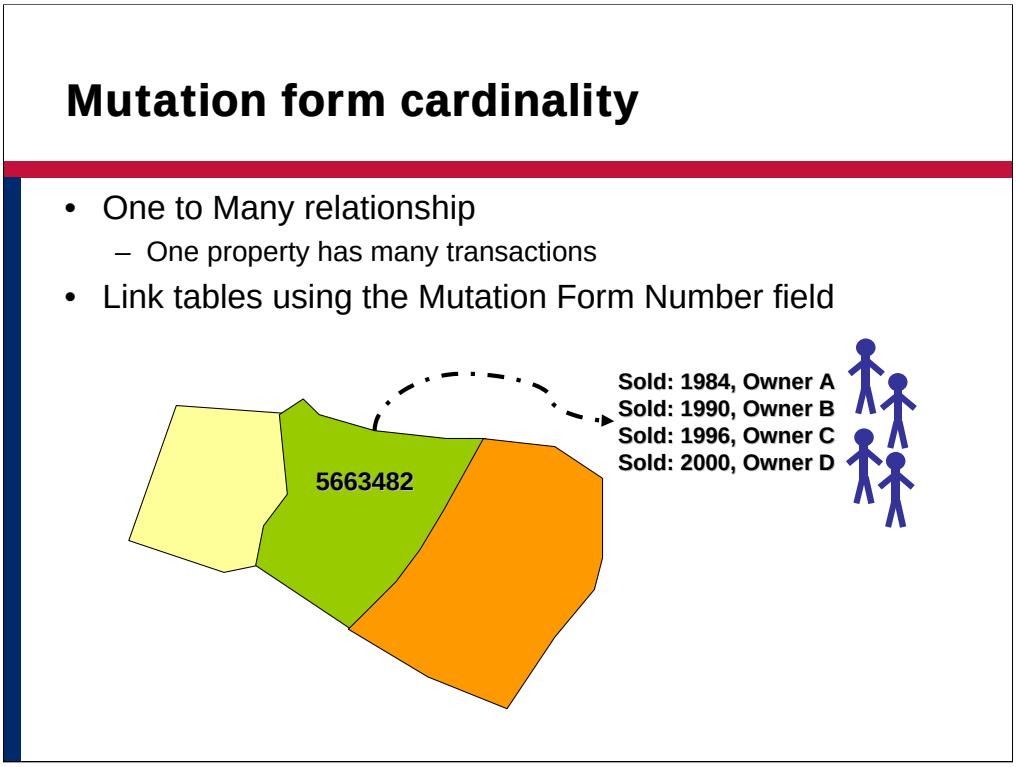
Creating a Mutation forms database

- Use MS Access to create two tables:
  - One for property object and initial transaction (*Property Object*)
  - One for subsequent transactions (*Subsequent Transactions*)
- Add fields and define data types



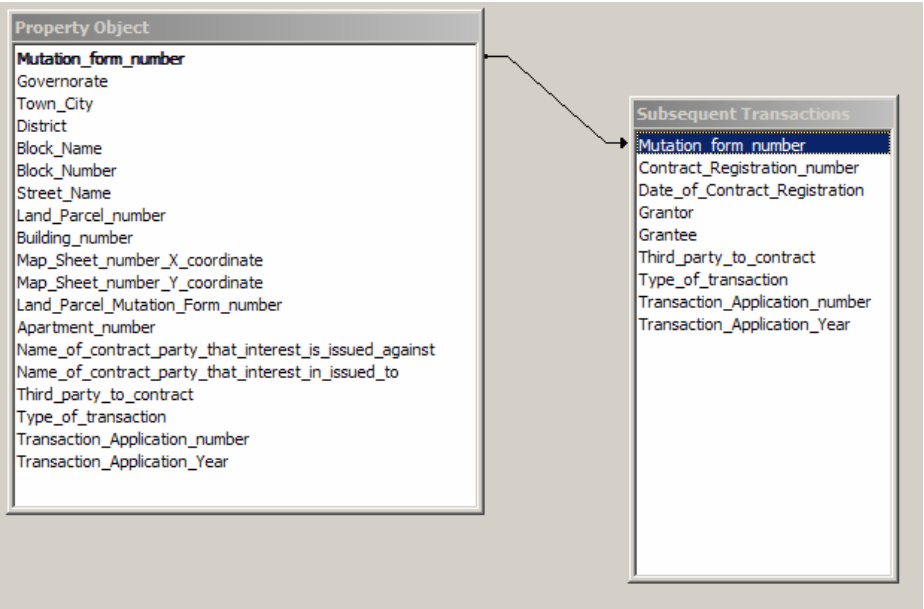
Creating a Mutation forms database

Create the mutation forms database in MS Access. First create a new database called ‘Mutation Forms.mdb’. Next create two tables one for the property object and the initial transaction that caused the mutation form the be created in the first instance and another for subsequent transactions.



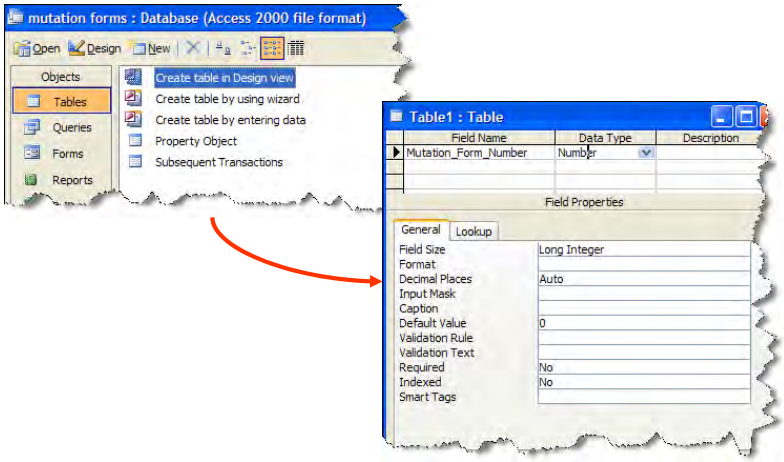
Mutation form cardinality

Cardinality is the the correspondence or equivalency between rows in table. For example, if one row in a table corresponds to three rows in another table the cardinality is one to many (1:M) as in the case of a property (one object or row a the property object table) and sales transactions (many objects or rows in the subsequent transactions table). You can link the tables together using the common field 'Mutation form number' as shown below:



Creating new tables

- Add fields and define properties



Creating new tables

In MS Access choose to ‘Create a table in Design view’, add the fields (appearing in the next slide) and define their properties e.g. whether the field is to store numbers or text and the field width. The required fields for the Property Object and Subsequent Transactions tables are described in more detail in the course exercises.

Required fields

Name	Type	Size
Mutation_form_number	Long Integer	4
Governorate	Text	100
Town_City	Text	100
District	Text	100
Block_Name	Text	100
Block_Number	Long Integer	4
Street_Name	Text	100
Land_Parcel_number	Long Integer	4
Building_number	Long Integer	4
Map_Sheet_number_X_coordinate	Double	8
Map_Sheet_number_Y_coordinate	Double	8
Land_Parcel_Mutation_Form_number	Long Integer	4
Apartment_number	Long Integer	4
Name_of_contract_party_that_interest_is_issued_against	Text	200
Name_of_contract_party_that_interest_in_issued_to	Text	200
Third_party_to_contract	Text	200
Type_of_transaction	Text	200
Transaction_Application_number	Text	50
Transaction_Application_Year	Text	50

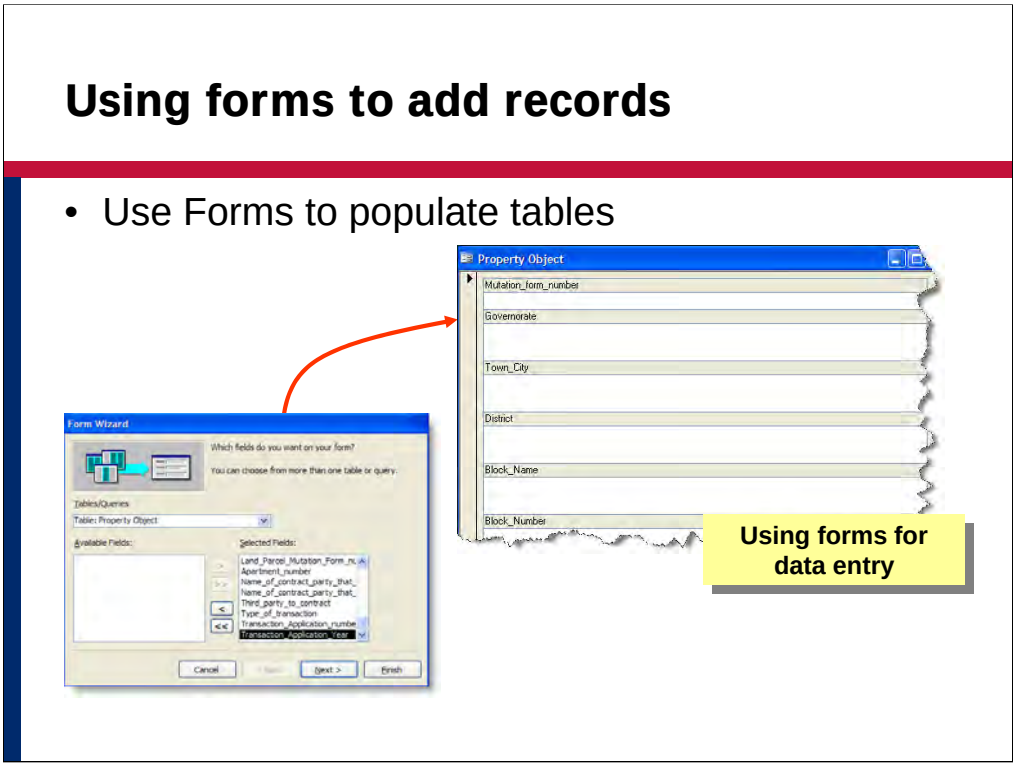
Property Object table's fields

	Type	Size
Transaction_ID	Long Integer	4
Mutation_form_number	Long Integer	4
Contract_Registration_number	Long Integer	4
Date_of_Contract_Registration	Date/Time	8
Grantor	Text	200
Grantee	Text	200
Third_party_to_contract	Text	200
Type_of_transaction	Text	200
Transaction_Application_number	Long Integer	4
Transaction_Application_Year	Text	50

Subsequent transactions table's fields

Required fields

The slide above shows the field names, data types and sizes of the fields in each table. Each table has the common field Mutation Form Number. You will notice field names have underscores instead of spaces, this is to ensure the tables are read correctly in ArcMap although you can have spaces between words for fields in MS Access.



Using forms to add records

To populate the Property and Subsequent Transactions tables create a form using the Design Wizard. Selecting a justified form will ensure all field names will be visible in the form. This is the easiest way to add records to your table.

Exercise 2

- Create a new database
- Create tables
- Add fields
- Define field properties
- Index key mutation form attributes

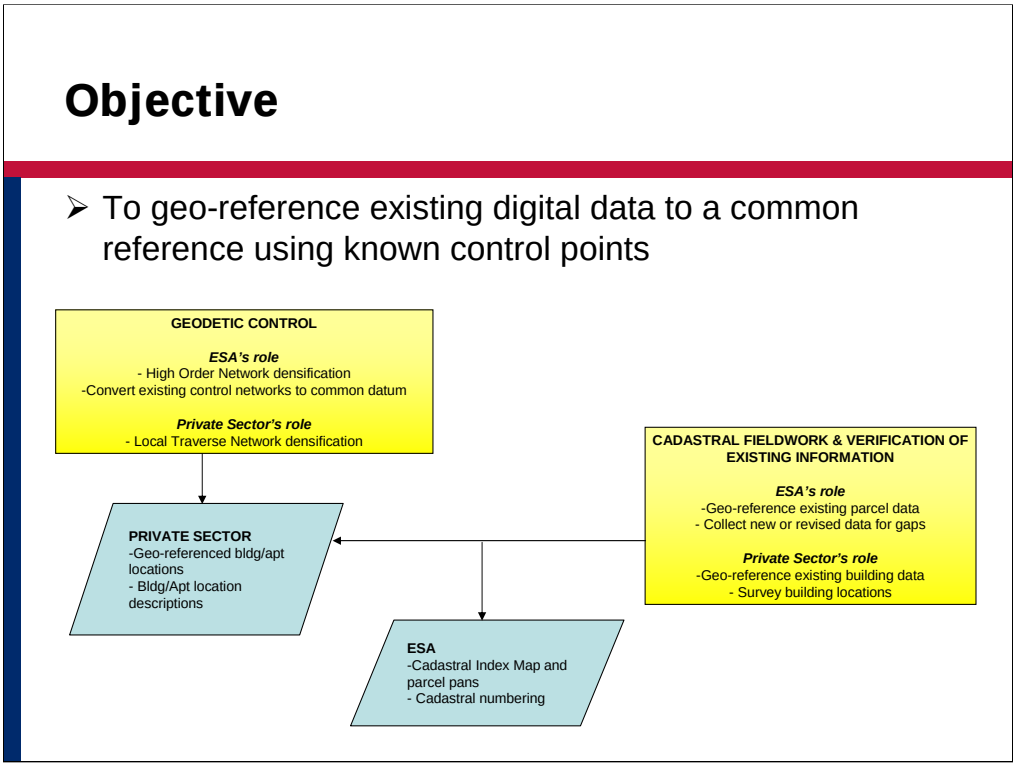
Section 4:
Geo-referencing data

Section overview

- Transforming raster data
- Transforming vector data
- Adjusting vector data

Section overview

Whether it is scanned raster data or existing vector data, if the coordinates are incorrect the data must be geo-referenced to a common reference so that all layers align correctly. This section describes the different steps followed and the tools available in ArcGIS that can be used to perform this task.



Objective

The objective of this section geo-reference existing digital data to a common reference using known control points collected using GPS or Total Station, available from ESA or on the data itself.

Spatial adjustment options

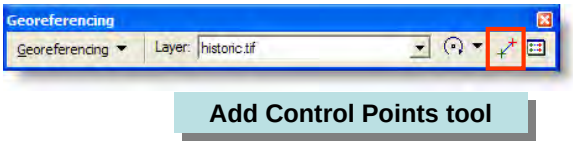
- Local coordinates to ETM?
  - Use a transformation
- Misalignment between features on imagery and map
  - Use rubbersheeting

Spatial adjustment options

Depending on the problem with your data will determine what spatial adjustment solution should be applied. The most common situation you will encounter is data in local coordinates which must be transformed to ETM to be of any value and before it can be combined with new data acquired from field surveying. Minor inconsistencies in data (e.g. boundaries surveyed using GPS and Total station) can be corrected using Rubbersheeting, whilst misalignment along map sheet edges can be corrected using Edge snapping (see Section 6: Creating the Cadastral Index Map for more details). These problems should only be encountered with existing data, new data will be acquired directly to ETM and have minimal or no errors.

Georeferencing overview

- For raster data
- Use the Georeferencing toolbar
- Identify control points
- Apply transformation

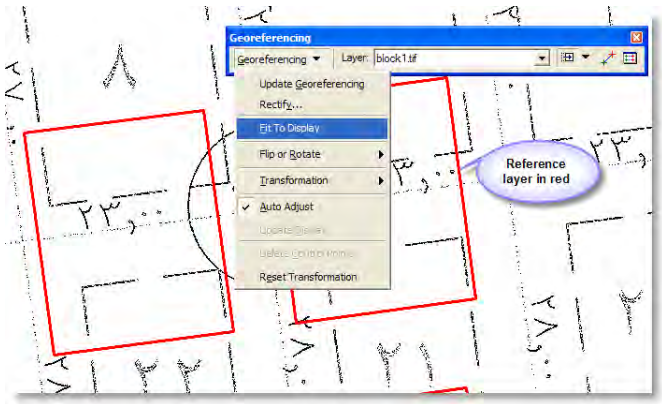


Georeferencing overview

To georeference raster data recorded in a local coordinate system – for example maps that have been scanned, use the Georeferencing toolbar in ArcMap. You can assess the success of the transformation by viewing the link table. An acceptable RMS is based on the scale of the source data. Refer to the slides on Spatial Adjustment in this section for more details.

Getting started

- Select image to work with
- Fit image to display
  - Scales image to a reference layer



Getting started

First align the raster data in the general vicinity reference layer. From the Georeferencing toolbar select the raster layer you want to georeference from the Layer: drop-down menu. From the Georeferencing drop-down menu choose Fit to Display. The raster layer will now appear in the same area as the reference layer (it will not be an exact match). You can also use the Flip or Rotate tools to move the raster layer as needed so that it more closely fits the reference layer.

Adding control points

- Use Add Control Points tool
  - Identify point on image ①
  - Identify identical point on reference layer ②

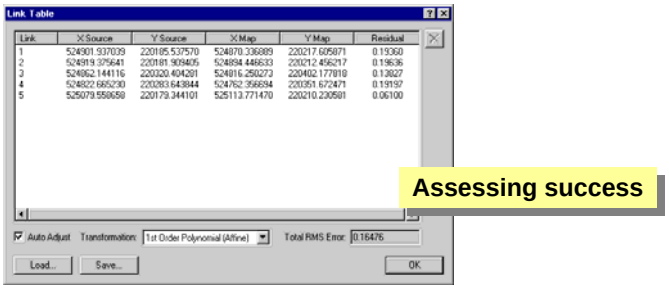
Adding control points

Adding control points

You add control points as follows (you should add at least 3). Using the Add Control Points tool click at a location on the image. The location on the image layer will be identified by a green cross. Press the Esc key to remove a link while you're in the process of creating it. Next click on the corresponding location on the reference layer. Note: It is best to zoom in so that you can see these locations as clearly as possible. The location on the reference layer will be identified by a red cross. If Auto Adjust is ticked on, as you add control points the image will be transformed or warped. Warping uses an affine transformation to shift, scale, and rotate your raster using a minimum of three links. Any more than three links introduces errors, or residuals, that are distributed throughout all the links. In practice, add more than three links. Given only three, if one link is positionally wrong, it has a much greater impact on the transformation. Thus, even though the mathematical transformation error may increase as you create more links, the overall accuracy of the transformation will increase as well.

Assessing success

- View errors in Link table
  - Shows image coordinates and map coordinates
  - Reports residual (individual) and total error



- Save georeferencing information with image

Assessing success

Click the View Link Table tool to evaluate the transformation. You can examine the residual error for each link and the overall RMS error. If you're satisfied with the registration, you can stop entering links, or you can delete an unwanted link from the Link Table dialog box.

To update the image's georeferencing and choose Update Georeferencing from the Georeferencing drop-down menu. A world header file with the *w* extension will be written to the image directory (e.g. a JPEG world file is *.JGW and a TIF world file is *.TFW) which records the image's spatial reference ensuring it sits correctly in terms of geography whenever added to a map document in future.

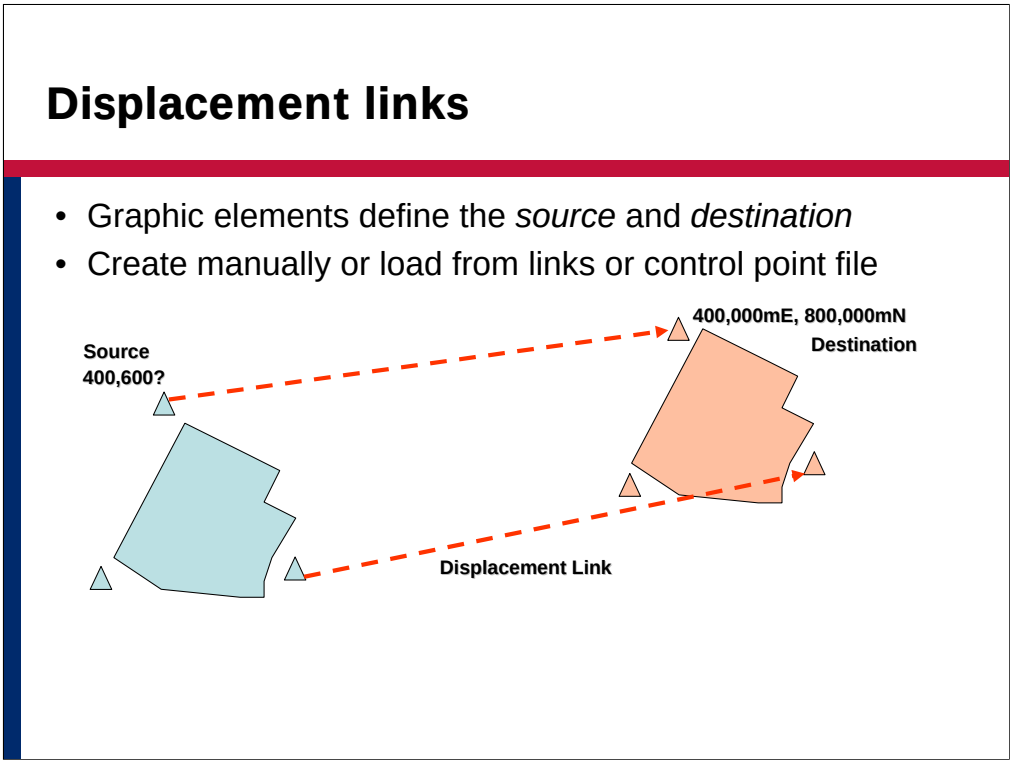
Spatial adjustment overview

- For vector data
- Use the Spatial Adjustment toolbar
  - Must be editing
- Identify displacement links
- Select adjustment method
  - Transformation, Rubbersheeting or Edge snapping

Add Displacement Link tool

Spatial adjustment overview

To georeference vector data use the Spatial Adjustment toolbar. You must be editing the source data. First add displacement links. Once you have added displacement links select the adjustment method to use, if you are performing a transformation you can assess the accuracy of that transformation by viewing the link table.

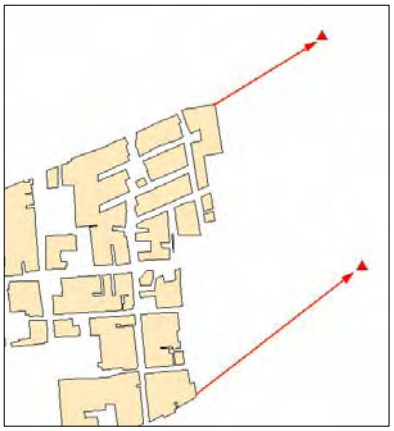


Displacement links

A link is a displacement vector that represents a source location to a destination location. There are three ways you can add displacement links (i) interactively, use the mouse to locate source and destination coordinates; (ii) using a Control Points file, a text file which contains a displacement link ID and destination coordinates (X,Y), in which case you will be required to identify the source coordinates interactively; (iii) using a Link File, a text file which contains a displacement link ID, source and destination coordinates (X,Y). Links are graphic elements in a map and are always displayed as arrows with the arrowhead pointing towards the destination. You can change the symbol, size, and colour of displacement links from the Adjustment Properties dialogue from the Options command on the Spatial Adjustment menu. The Spatial Adjustment toolbar has tools to manually add a displacement link, to modify an existing link, and a tool to automatically add multiple links between two selected features. The current snap environment is honoured when manually adding displacement links.

Adding links manually

- Define source and destination coordinates interactively
- Snap environment is honoured when adding links



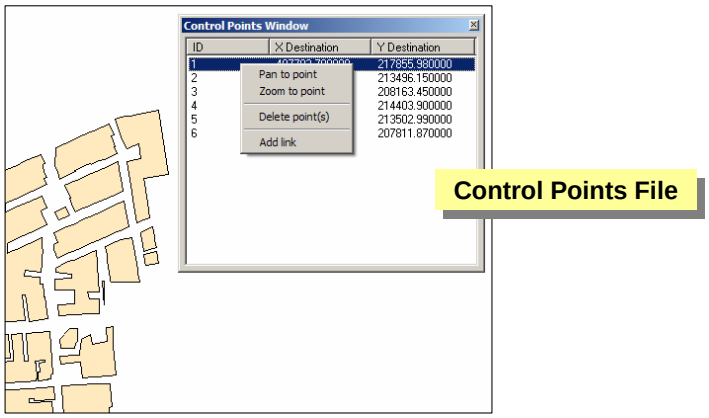
Displacement link tool

Adding links manually

Use the New Displacement Link tool to add links manually, make sure you get the sequence the right way round, click on a source location then a destination location. A new displacement link will be added. You can change the symbology of the displacement link (choose Spatial Adjustment > Options… and click on the current displacement link symbol to change it). To delete displacement links use the Select Elements tool to select a link, then press the Delete key on the keyboard. To save coordinates placed manually choose Spatial Adjustment > Links > Save Links File….

Using a Control Points file

- Text file contains destination coordinates
- Define source coordinates interactively

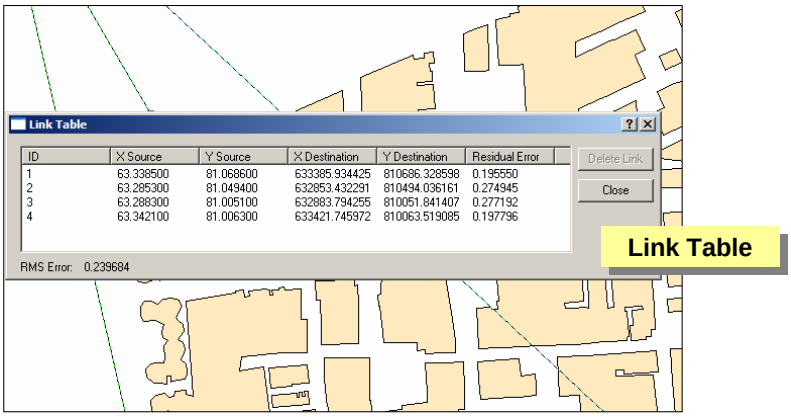


Using a Control Points file

You can also create links based on a control points file. A control points file contains the X and Y destination coordinates and may contain ID values for each record. When a control points file is opened, the Control Points Window dialog will open and display the coordinate locations. These locations will become destination points for new displacement links. Double-clicking or right-clicking and choosing Add link will create a link starting at the destination coordinate, and then you can manually add the source location.

Using a Link file

- A text file contains source and destination coordinates
- Displacement links added automatically

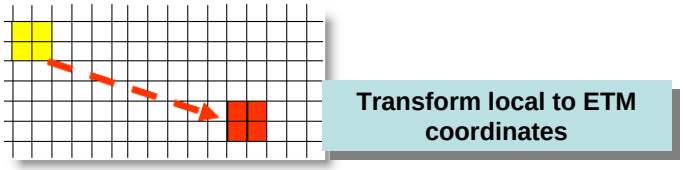


Using a Link file

You can also create links from coordinates saved in a link file. A link file is a text file that contains a list of X, Y source and X, Y destination coordinates. A link file can be comma, space, or tab delimited and may contain ID values that precede each record. When you open a links file from the Links submenu, the source and destination displacement links will be automatically created based on the coordinate locations in the link file.

Transformation

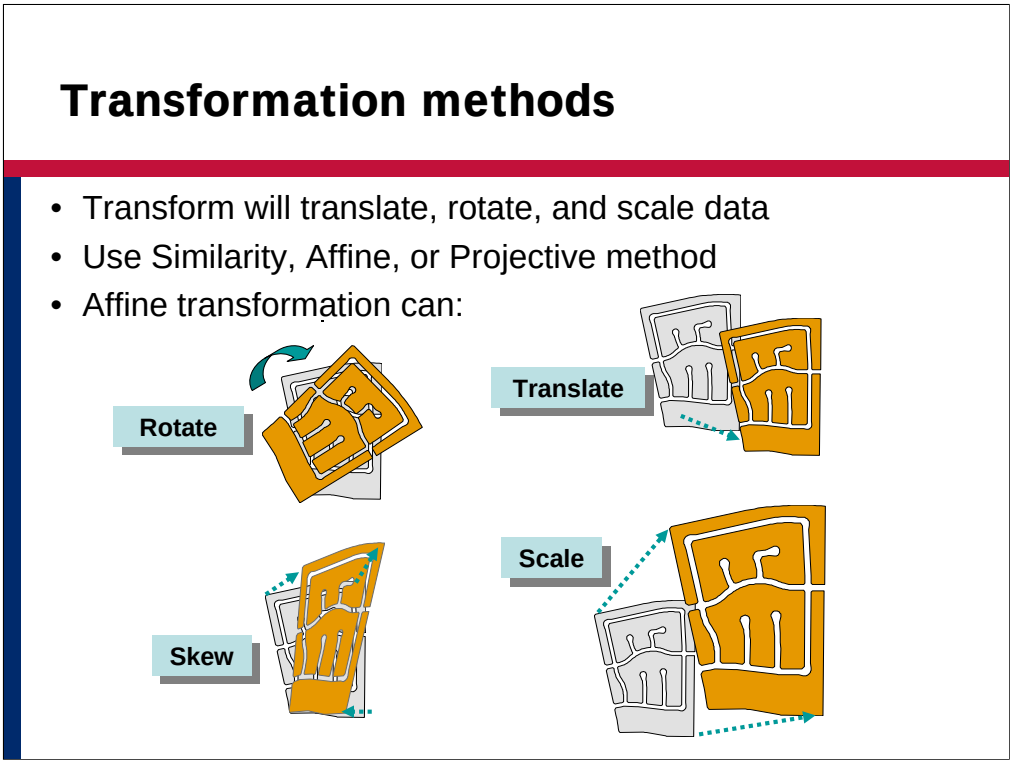
- Adjustment applied equally to all features in a layer
- Used to change from one coordinate system to another



- Features are scaled and moved
- Relative location preserved

Transformation

Transformation is used to fit datasets together. It applies a consistent combination of rotation (spinning), translation (moving), scaling (making the data bigger or smaller) to the entire layer or selected features in the layer. Since every part of the layer undergoes the same transformation the relative location of each point to the others is preserved. Depending on the transformation used determines whether data is scaled, rotated and translated or scaled, rotated, translated and skewed (parallel lines remain parallel). In order to be able to perform a transformation both source and destination coordinates are required. The error of the transformation method can be assessed by means of the Root Mean Square Error (RMS).



Transformation methods

Depending on the method used to transform your data from one coordinate system to another, the transformation may translate or shift features in coordinate space, scale features in size, rotate, or skew them. ArcGIS supports the three transformation methods summarised below. The ArcGIS Help provides more information on the mathematical functions used for the transformations.

Similarity

This method is also sometimes referred to as an orthogonal or two-dimensional linear conformal transformation. It is commonly used to adjust data between two similar coordinate systems; for example, to change the map units of data from one linear unit to another. This method will translate, rotate, and scale features. At least two displacement links are required for this four parameter transformation.

Affine

This method expands on the similarity transformation by allowing two scale factors instead of one, and will allow features to be skewed while being rotated. There is a minimum of three links required to perform this six parameter transformation. Transforming digitised data to real world coordinates is a good example where this transformation is applicable, as it allows for the small distortions such as stretch, shrink, and skew that occur to paper and other media that are digitised.

Projective

This is a specialised transformation used to transform coordinates digitised directly off high altitude aerial photography or aerial photographs of relatively flat terrain. It is an eight parameter transformation and requires a minimum of four links to perform.

Transformation accuracy

- Acceptable levels of RMS (average figure in metres)

Scale of map/data	*Acceptable RMS*
1:1,000	0.2
1:5,000	1
1:10,000	2
1:25,000	2.5

- Acceptable error is larger for smaller map scales
- Only reported for transformations

Transformation accuracy

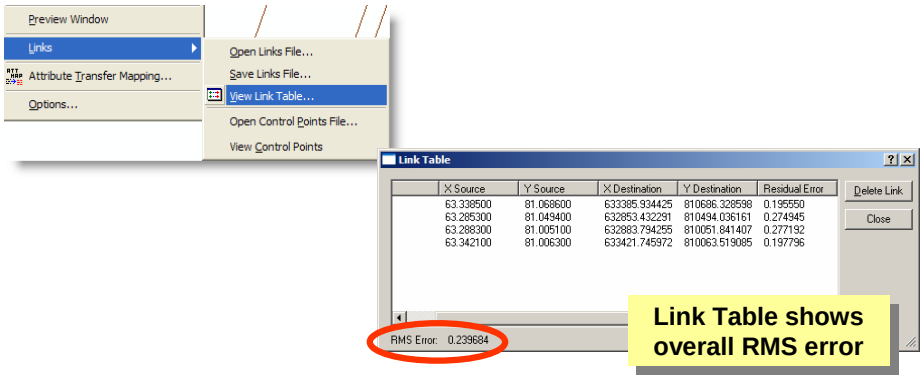
Use the RMS reported in the table above to determine whether the transformation has achieved an acceptable level of accuracy. An acceptable RMS increases with scale. An RMS error is only reported for transformations not rubbersheeting or edge matching.

Root Mean Square Error

A root mean square error (RMS) describes the deviation that will occur when the transformation is applied to the input and the output coordinate systems. The error is determined using the least squares regression method. The transformation parameters are a best-fit between the source and destination control points. If you use the transformation parameters to transform the actual source control points, the transformed output locations won't be an exact match to the true output control point locations. This is called the residual error; it is a measure of the fit between the true locations and the transformed locations of the output control points.

Assessing the RMS

- View the Link Table
- Can assess error before performing adjustment
- Delete links contributing largest error

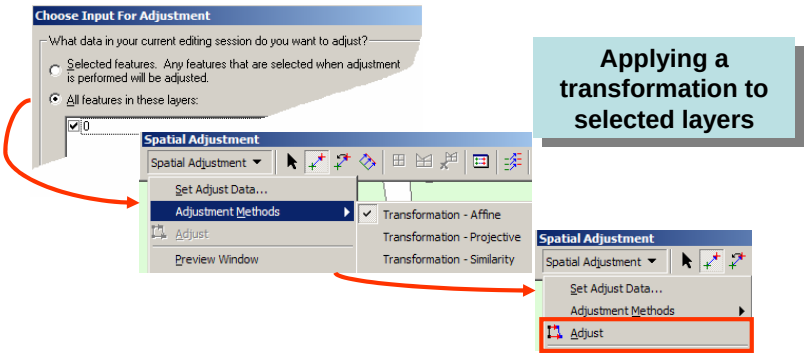


Assessing the RMS

To see the overall RMS of the transformation, choose Spatial Adjustment > Links > View Link Table. Assess the residual for each point and the overall RMS error and determine whether the transformation is acceptable. To delete displacement links which are contributing the greatest error select them in the table and click the Delete Link button or press the Delete key on the keyboard.

Performing a transformation

- Select layer that adjustment will be applied to
- Select Adjustment Method
- Apply adjustment

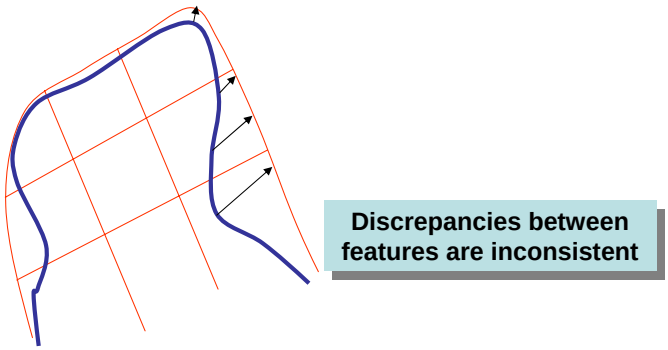


Performing a transformation

Once you have added displacement links you are ready to perform a transformation. First specify which data can be adjusted either (i) any selected features or (ii) all features in specific layers. Next choose a transformation method: Affine (the default), Projective or Similarity. Use Affine for vector data derived from scanned maps and plans and Similarity for CAD data from the New Communities or ESA. You will not use Projective which is used specifically for data digitized from aerial photography. Lastly choose Adjust from Spatial Adjustment menu to adjust the data. If this option is greyed out then you have not added enough displacement links for the selected transformation method or no features are selected.

Rubbersheeting

- Features are stretched, straight lines preserved
- Different transformations in different parts of the map
  - Some points move a small distance, others further

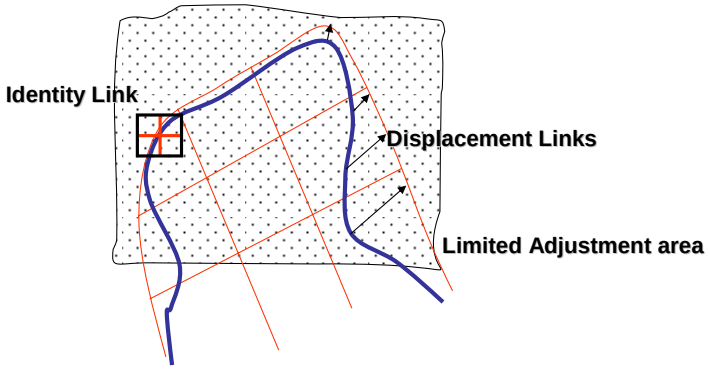


Rubbersheeting

Geometric distortions commonly occur in data. They may be introduced by imperfect registration in map compilation, lack of geodetic control in source data, or a variety of other causes. Rubbersheeting corrects flaws through the geometric adjustment of coordinates as such the relative locations of points, unlike a transformation, are not maintained, as some points move a small distance others further.

Performing Rubbersheeting

- Place Identity Links – fixed locations
- Define adjustment area – features move within this area
- Add displacement links – source/destination coordinates



Performing Rubbersheeting

An Identity Link is a link whose source and destination coordinate are the same. Identity links act like nails to hold specific locations in place. After an adjustment, displacement links become identity links. Identity links can also be added manually with the Identity link tool on the Spatial Adjustment toolbar. The Limit Adjustment Area tool allows you to draw a polygon around the features you want to adjust. This allows you to limit your adjustment to the area covered by the added polygon. Features outside the area will not be adjusted. At least one displacement link is required to perform the rubbersheeting adjustment. Rubbersheeting can be performed on a selected set of features to fit them to another set of features. For example, a lakeshore in one layer could be rubbersheeted to match a more accurate boundary in another layer. You can also perform rubbersheeting on all features in a feature class or feature dataset to another control dataset. That dataset could be a raster image as in the graphic above, a CAD drawing, locations specified interactively, coordinates in a text file, or coordinates interactively entered into a table.

Exercises 3, 4 & 5

- Exercise 3
  - Geoference raster data
- Exercise 4
  - Convert CAD data to shapefile format
  - Start Editing
  - Load Links file
  - Transform layer
- Exercise 5
  - Start Editing
  - Load Control Points file
  - Rubbersheet features
  - Use Editing tools to correct residual misalignment

Section 5:
Processing cadastral data

Section overview

- Data creation
- Heads up digitizing
- Tracing
- Conversion

Section overview

This section describes how to create new data in ArcGIS using heads up digitizing, tracing and data conversion. Once buildings and parcels have been captured they will then be assigned a property identifier.

Objective

- To capture and attribute buildings and parcels by means of digitizing and data conversion

Objective

The objective is to capture parcels and buildings, attribute the features and create a cadastral database for the Mokattam area.

Data processing options

- Existing data
  - Heads up digitizing
  - Table digitizing
  - Data conversion
- New data
  - Heads up digitizing
  - Data Conversion

Data processing options

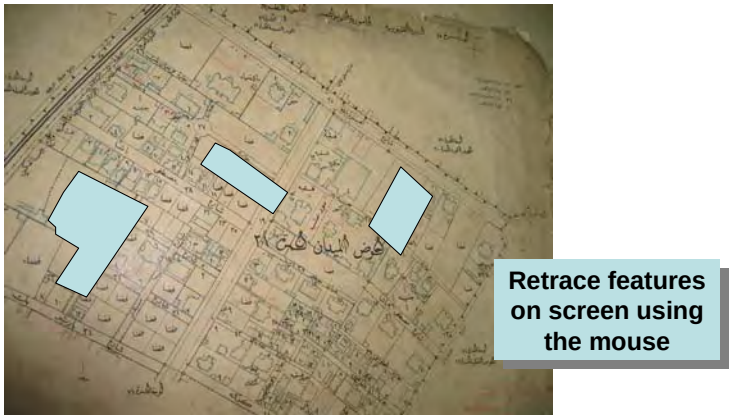
Existing data can be processed in different ways depending on its format and geometry:

- If data is either raster or vector line format it can digitized by means of heads up digitizing. You will be required to create a new feature class before digitizing.
- If the data is in analogue format it can be digitized using a table digitizer. You will be required to create a new feature class before digitizing.
- If the data is vector polygon format but is not in an ESRI spatial format it can be converted (assuming it is supported, see Section 2: ArcGIS Refresher for more details). You will not need to create a new feature class, the conversion process will create one for you automatically.

New data in AutoCAD format will be processed by heads up digitizing or data conversion.

Heads up digitizing - raster

- Retrace features on raster data
  - Trace line's accuracy based on operator's ability

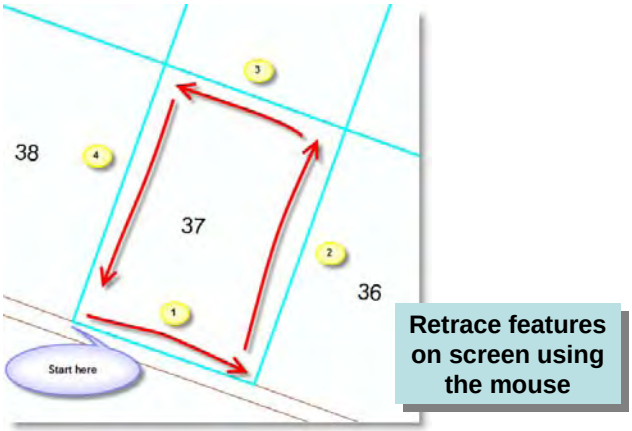


Heads up digitizing - raster

Once maps and plans have been scanned the raster data will be converted to vector data by means of heads up digitizing (this will also be the method used to capture features from aerial photograph or satellite imagery). Using the mouse, the cells in the raster data representing building footprints or parcel boundaries and simply re-drawn to create polygons. The accuracy of the polygons created are only as good as the ability of the operator since they can only visualize draw lines.

Heads up digitizing – vector line

- Trace lines to create polygons
  - Trace line is exact



Heads up digitizing – vector line

Tracing vector data is more accurate as you actually snap to the line being traced. In ArcGIS you select the lines to trace and simply follow them to construct a polygon, this method of heads up digitizing is the most accurate of all. *Note:* You will use this method to create polygons from new field survey data as well if it has been captured as polylines.

Table digitizing

- Retrace features using a puck
  - Trace line's accuracy based on operator's ability

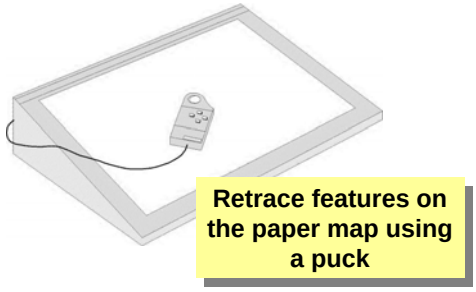


Table digitizing

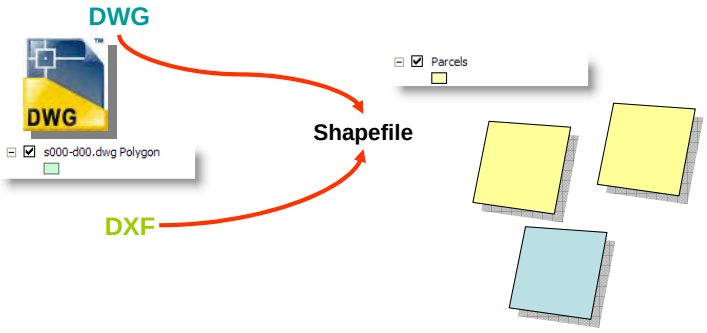
If all that is received is paper maps, then you can consider table digitizing rather than scanning. To digitize from paper maps, first asses the map quality if it is acceptable affix the map firmly to the digitizing table it should not move. Next configure the digitizer puck buttons. You should configure one of the buttons to perform a left mouse-click so you can digitize points and vertices of lines. You will want to configure another button to perform a left double-click to finish digitising lines or polygons.

Next establish control points (or registration points) on the paper map. Identify a minimum of four known points. If your paper map has a grid or a set of known points on the ground you can use these. Otherwise choose known real-world features such as road junctions and mark them on the map. Give each one a unique number and ensure you know the actual ground co-ordinates. Choose places that are as far from each other as is practicable.

Finally register the paper map. Registering the map involves recording the ground co-ordinates for each of the control points you identified.

Data conversion

- Use data conversion tools if CAD data represents properties as polygons

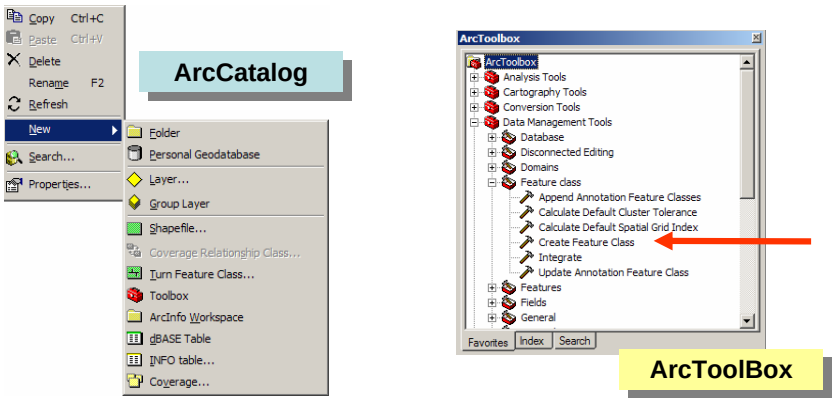


Data conversion

Data held in AutoCAD format (DWG or DXF) will be converted to an directly to an ESRI spatial format (e.g. shapefile) *only* if parcels/buildings are represented as polygons (i.e. closed polylines). If the properties are represented as polylines then the lines will be traced.

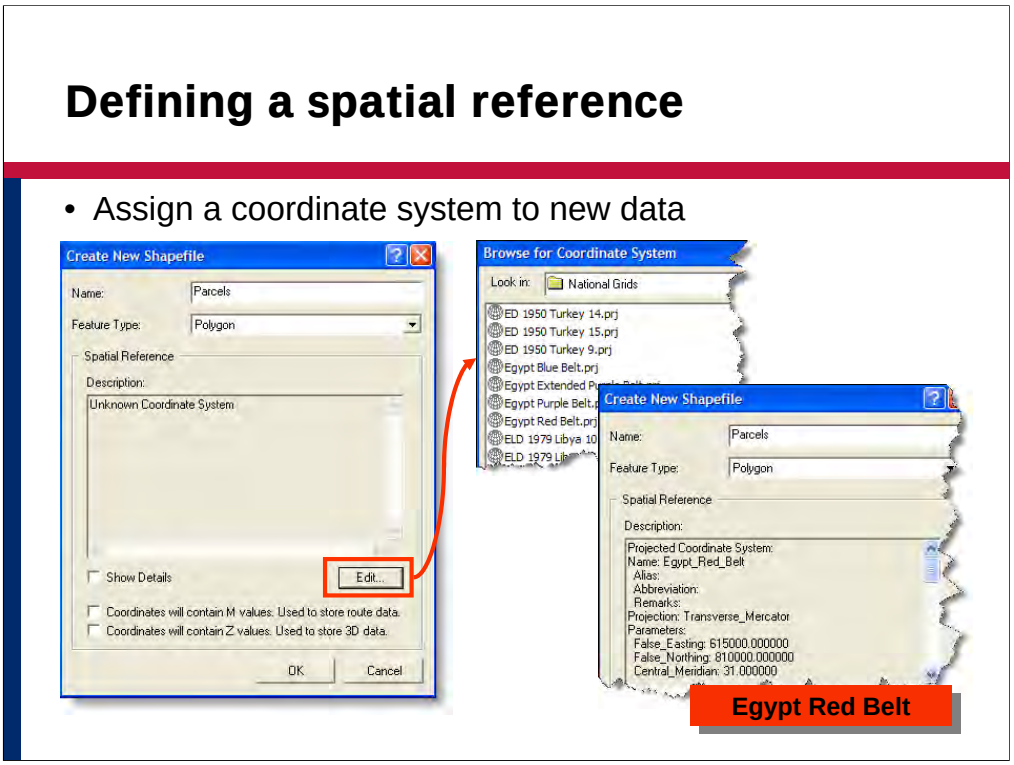
Creating a new feature class

- Create new feature class in ArcCatalog or ArcToolBox
- Specify spatial format, geometry type, spatial reference



Creating a new feature class

You can create a new feature class in either ArcCatalog or ArcToolBox; when creating a new feature class specify the spatial format (i.e. shapefile or personal GDB feature class), a geometry type (i.e. point, line or polygon) and spatial reference (e.g. ETM). To create a new shapefile in ArcCatalog right click on a folder (e.g. C:\TEMP) and choose New > Shapefile…. from the context menu. To create new data in ArcToolBox navigate the Data Management Tools > Feature Class toolset and double click on the Create Feature Class tool.



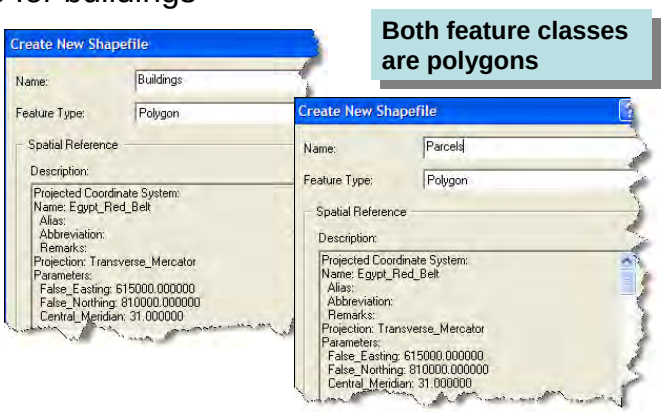
Defining a spatial for reference

Having created your new feature class, you can define its spatial reference. Whenever you create a new feature class its spatial reference is set to 'Unknown'. To assign a spatial reference to a new shapefile click the Edit… button in the Create New Shapefile dialog box. In the Spatial Reference Properties dialog box click the Select… button. In the Browse for Coordinate Systems dialog box choose Projected Coordinate Systems > National Grids > Egypt Red Belt.prj. The parameters of the ETM are as follows:

```
Projection: Transverse_Mercator
False_Easting: 615000.000000
False_Northing: 810000.000000
Central_Meridian: 31.000000
Scale_Factor: 1.000000
Latitude_Of_Origin: 30.000000
Linear Unit: Meter (1.000000)
Datum: D_Egypt_1907
Spheroid: Helmert_1906
```

Required feature classes

- One for parcels
- One for buildings

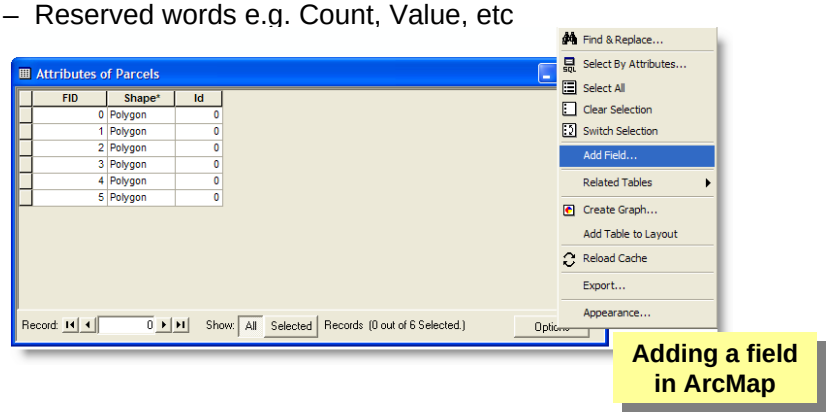


Required feature classes

You will create two feature classes, one for buildings and one for parcels. These are both polygon features classes and will be assigned Egypt_Red_Belt.prj projected coordinate system. The Buildings feature class will contain building footprints and apartments and the parcels feature class will contain parcel boundaries.

Adding fields

- Must not be editing
- Specify name, data type and width for field:
  - Name must be unique
  - Reserved words e.g. Count, Value, etc

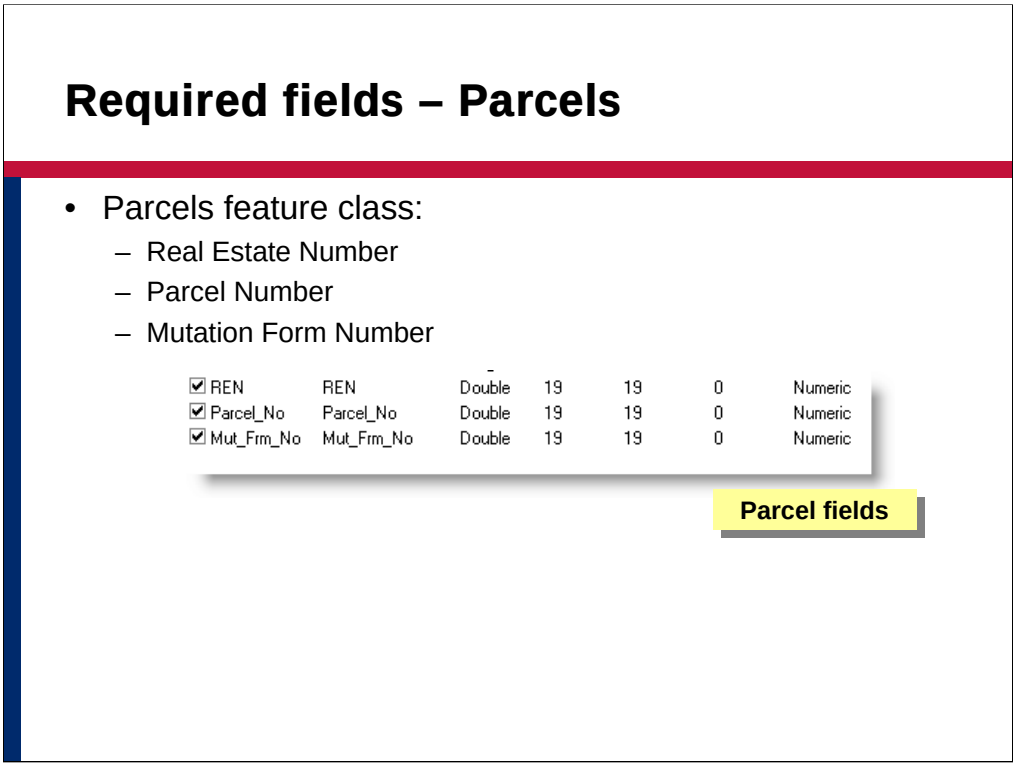


Adding a field in ArcMap

Adding fields

To add fields make sure you are not editing the source data. In ArcMap right click on the Layer and choose ‘Open Attribute Table’ from the context menu. In the Table window click the Options… button and choose Add Field… from the pop-up menu. If the option Add Field… is greyed out either you are editing the source data or you do not have write permission on it. When you add a field give the field a unique name and set its properties. Be careful though, once you have added a field you cannot change its properties. Certain names are reserved e.g. Count, if you try to use these words you will be prompted to use an alternative e.g. Count_.

Note: Field names can be a maximum of 10 characters in shapefiles, any longer and the name will be truncated, however, you can always use an alias to make the field name more understandable.



Required fields - Parcels

The Parcels layer will require the following fields (the field name added to the attribute table is shown in brackets): Real Estate Number (REN), Parcel Number (Parcel_No) and Mutation Form Number (Mut_Frm_No). Remember you can set an alias to make these fields more meaningful.

The graphic above shows the field names, data types and widths for these fields. The Real Estate Number (REN) will be used to store the new property number being developed by ESA/MSAD.

Required fields - Buildings

- Buildings feature class:
  - Real Estate Number
  - Mutation Form Number
  - Parcel Number
  - Building Number
  - Building Name
  - Apartment Number
  - Street Name
  - District
  - City
  - Status

☑ REN	REN	Double	19	19	0	Numeric
☑ Mut_Frm_No	Mut_Frm_No	Double	19	19	0	Numeric
☑ Parcel_No	Parcel_No	Double	19	19	0	Numeric
☑ Build_No	Build_No	Double	19	19	0	Numeric
☑ Build_Name	Build_Name	String	100	0	0	
☑ Apt_Name	Apt_Name	Double	19	19	0	Numeric
☑ Str_Name	Str_Name	String	100	0	0	
☑ District	District	String	100	0	0	
☑ City	City	String	100	0	0	
☑ Status	Status	String	50	0	0	

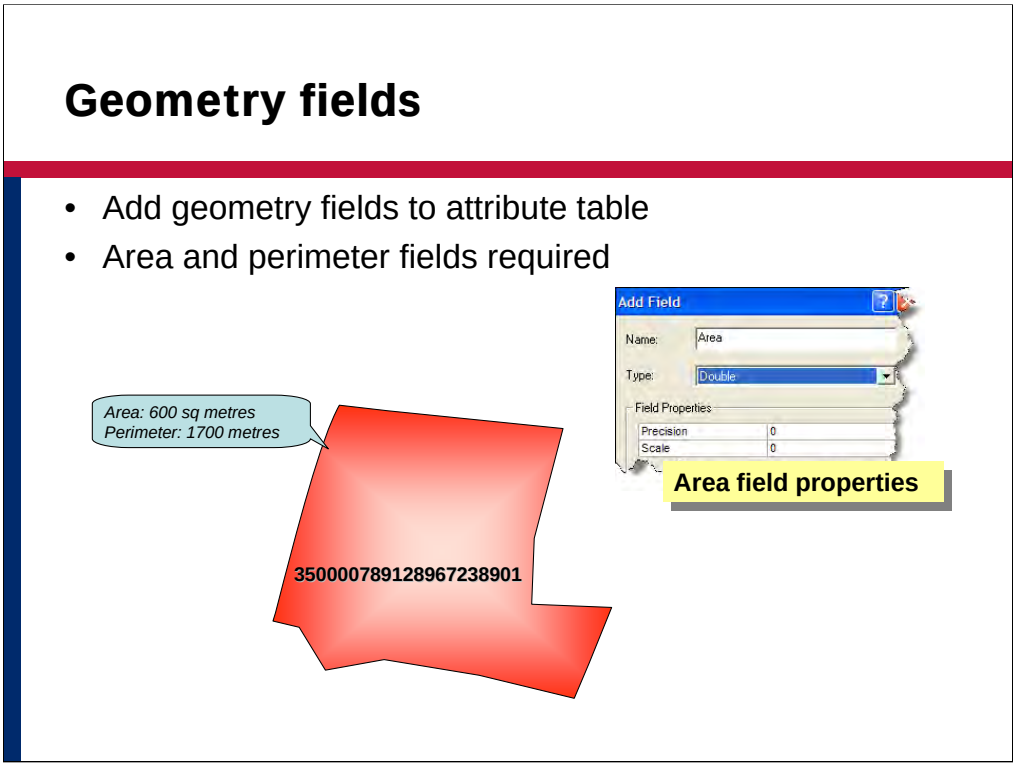
Building/apartment fields

Required fields – Buildings

The Buildings layer will require the following fields: Real Estate Number (REN), Mutation Form Number (Mut_Frm_No), Building Number (Build_No), Building Name (Build_Name) Apartment Number (Apt_No), Parcel Number (Parcel_No), Street Name (Str_Name), District, City and Status (e.g. Occupied, Unoccupied, Under Construction). Remember you can set an alias to make these fields more meaningful.

The graphic above shows the field names, data types and widths for these fields. The Real Estate Number (REN) will be used to store the new property number being developed by ESA/MSAD.

Communal areas in buildings should be given an apartment number of -99. Cadastral Index maps must show major buildings' name, hence the field Building Name which can be used for labeling (see Section 6: Creating the Cadastral Index Map for more details).

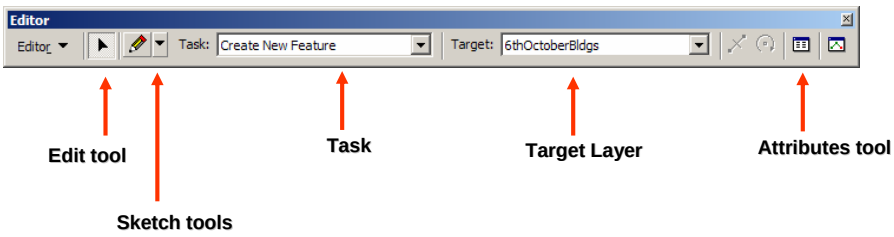


Geometry fields

If you create shapefiles you must add area and perimeter fields to track geometry. Use the field calculator to calculate these values (see the slide Calculating Geometry Values in this section for more details). The data type of geometry fields should be double (double precision, real number). *Note:* that the area and perimeter figures calculated for apartments will not be correct as the polygons are indicative of ownership not the actual representation of the apartment's dimensions. If you make a mistake defining these geometry fields, they must be deleted and added again. Whenever edit features in a shapefile you must re-calculate geometry figures, this is not done for you automatically.

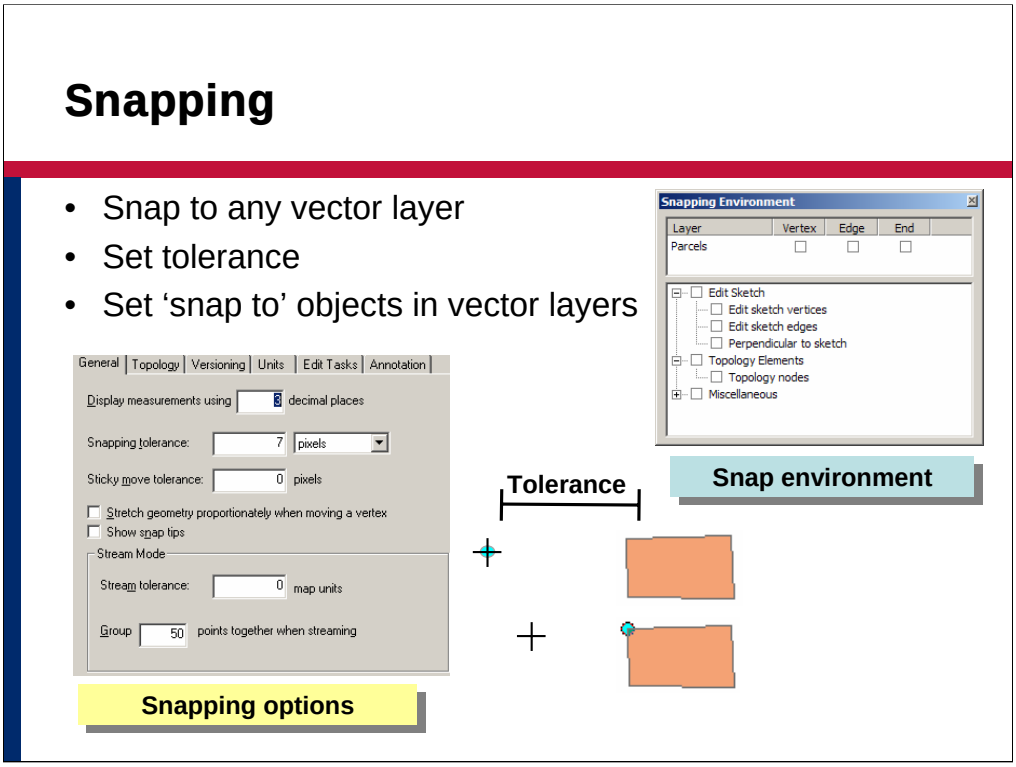
Editing in ArcMap

- Start an edit session
- Use Editor toolbar to set:
  - Target layer (layer in which edits are being made)
  - Task (what is being done)
  - Sketch tool (how to draw features)



Editing in ArcMap

If you have started an edit session (in the Editor toolbar choose Editor > Start Editing) and the layers come from more than one storage location (i.e. more than one personal geodatabase or network file directory), you will be prompted to select the single data source to edit. Once you have started an edit session you can set the snap options. To begin editing set the target layer – the layer in which features are being captured, the task – which controls how the sketch tool will work and a select sketch tool – which determines how a feature will be drawn from the Sketch tools drop-down list.



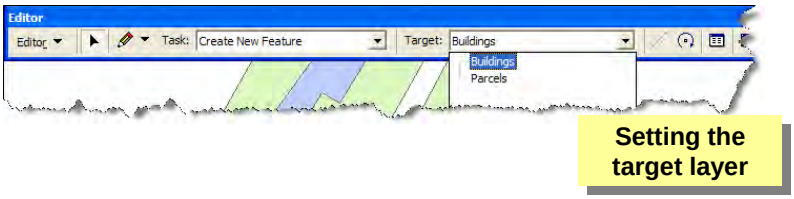
Snapping

Snapping automatically moves your pointer to the location or orientation (parallel or perpendicular) of a feature. This prevents you from having to click the exact coordinate of a feature in order to connect the feature you are editing. The snapping tolerance is the distance the pointer must be to a feature before it snaps to that location. You can set the snapping tolerance in map units or pixels through Options from the Editor menu. There are two general varieties of snapping in ArcMap: **Layer snapping**: Moves your pointer to the location of a feature's edge, vertex, or endpoint. You can decide which, if any, of these options will be available for snapping. **Sketch snapping**: When adding a sketch, this option will snap your pointer to a location perpendicular to the previous sketch segment. The snapping can be overridden if you move your pointer far enough.

Setting the proper tolerance for snapping is sometimes a trial and error process. You should try the default tolerance first and then change it in small intervals until you settle on one that is appropriate to the data and your needs

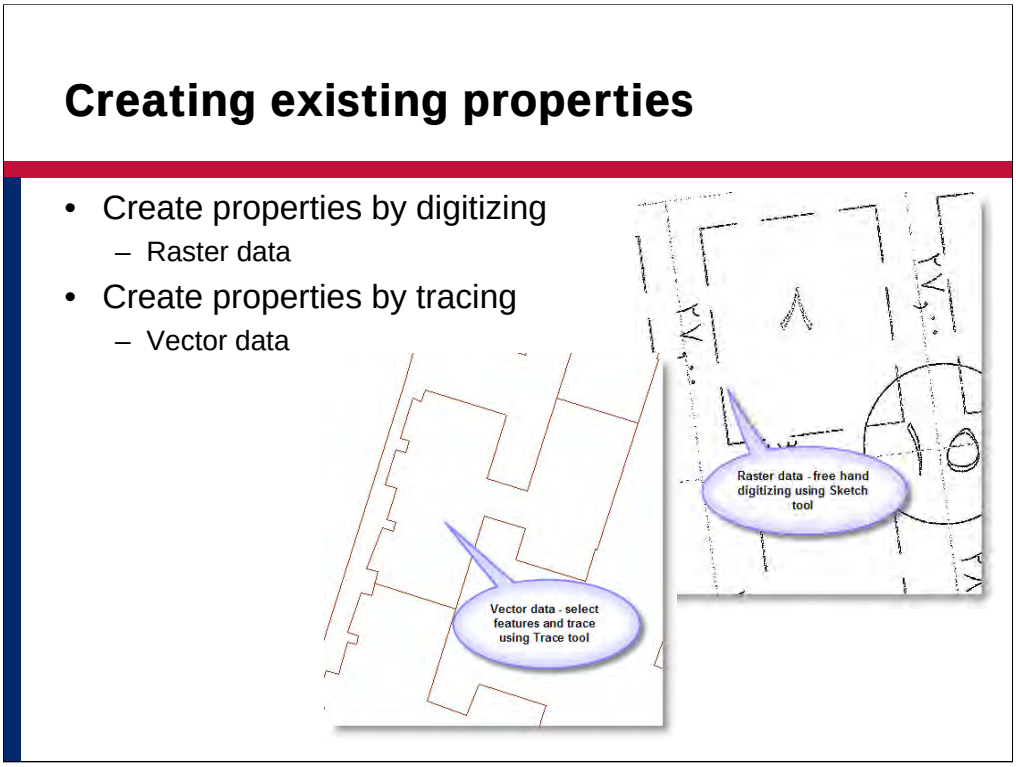
Setting the target layer

- Set before digitizing features
  - Parcels or Buildings



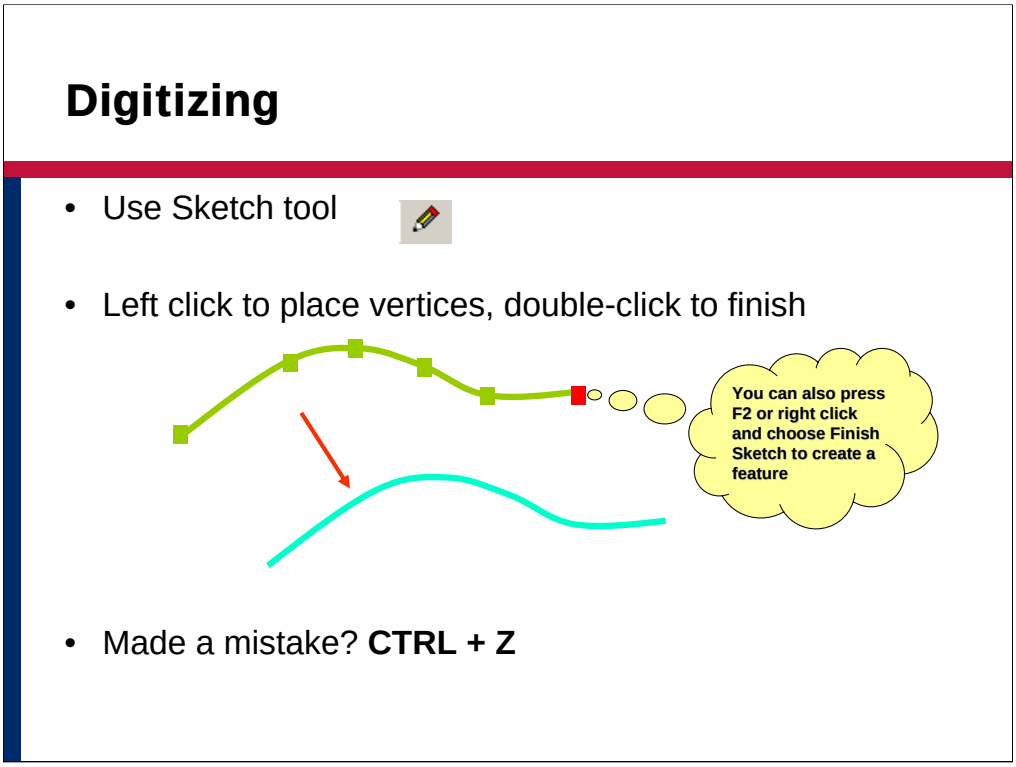
Setting the target layer

Make sure you set the target layer before digitizing, from the Target: drop down menu choose either Parcels or Buildings. Once the target layer has been set all edits will be made to this layer. You can switch between layers at any time when digitizing using the drop-down menu.



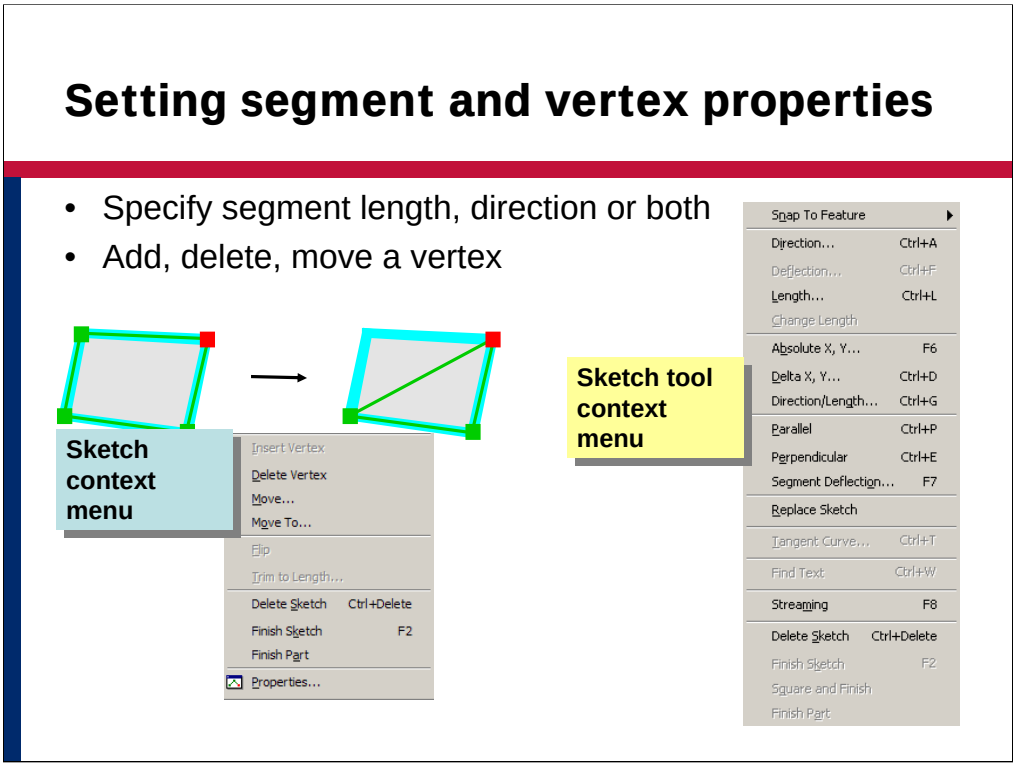
Creating existing properties

There are two methods you can use to create new properties (parcels and buildings). If you are working with raster data you will use the Sketch tool to create new polygons. If you are working with vector data you will use the trace tool.



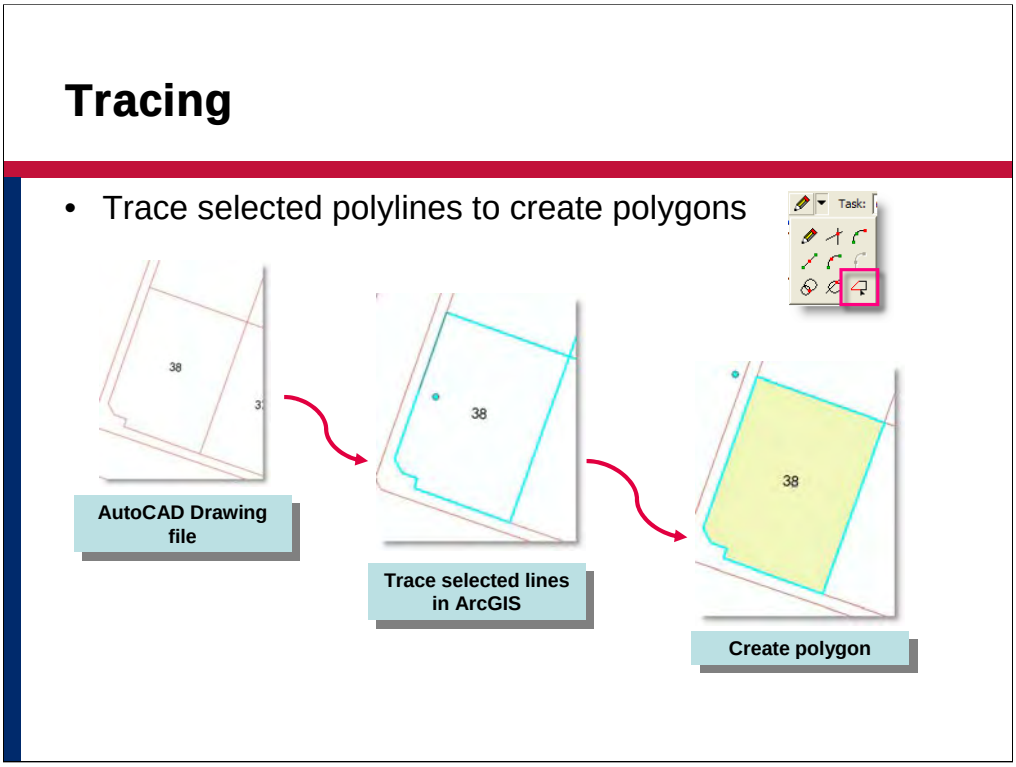
Digitizing

Use the Sketch tool to approximate lines appearing on a scanned image (i.e. perform heads up digitizing from raster data). To start a sketch click once with the left hand button of the mouse and place additional vertices (green boxes) by continuing to click the left hand button of the mouse. The more vertices you place the accurate the line or boundary you are digitizing To finish the sketch and create a polygon, double click the left hand button of the mouse, press the F2 key on the keyboard or right click the mouse and choose Finish Sketch from the context menu. If you make mistake whilst digitizing press the CTRL + Z keys on the keyboard. Each time you press CTRL + Z you remove a vertex that has been placed.



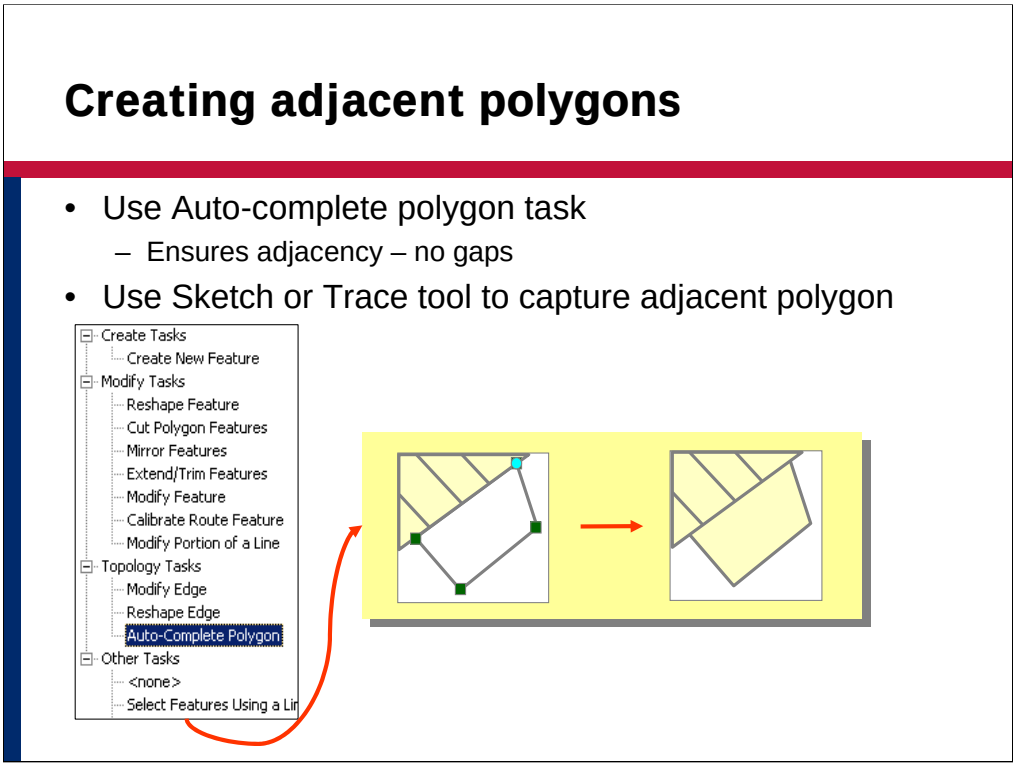
Setting segment and vertex properties

When using the Sketch tool, you can access the Sketch tool context menu by right-clicking the mouse away from the sketch you are creating. The context menu has options for placing the vertices and segments specifically where you want them. For example, you can set a segment to be a certain Length (using any unit of measure e.g. ft, km, in, m) or Direction (angle based counter clockwise from the horizontal) or both; create a vertex at a specific x,y co-ordinate location (Absolute X, Y…) or make a segment parallel or perpendicular to another feature (Parallel, Perpendicular). The Sketch context menu works more directly with the sketch as a whole. With this menu, you can: Add vertices, Move vertices, Delete vertices, Switch the direction of the sketch, Reduce the length of the sketch and display the properties of the sketch.



Tracing

Using the Trace sketch tool you can trace selected lines to create polygons. Use the Edit tool in the Editor toolbar to select the lines to trace (use the SHIFT key to select more than one line). From the Sketch tools drop-down list select the Trace tool. Click once anywhere on a selected line to start a trace line. You do not need to click the left hand button of the mouse at any time, simply keep moving. You will see a thin black line representing the trace line. To finish a trace line double click the left hand button of the mouse. A polygon feature will be created.

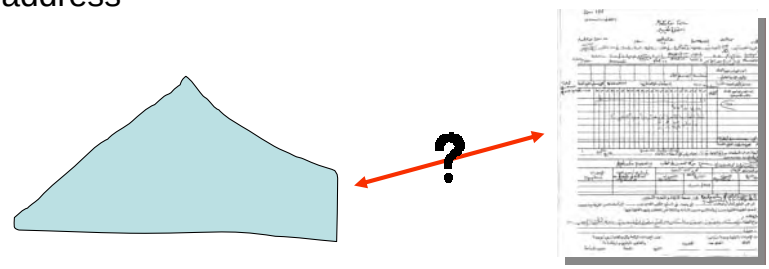


Creating adjacent polygons

The Auto Complete Polygon task will allow you to add a polygon to the edge of existing ones without having to sketch a duplicate boundary between them. Using this task you sketch all the polygon boundaries except the one common to the other adjacent polygon(s).

Describing properties

- Existing features *may* be described by a mutation form
  - Details held in mutation database will be linked to the property
- A parcel's mutation form found by Land Parcel Number
- A building's mutation form found by Land Parcel Number or address

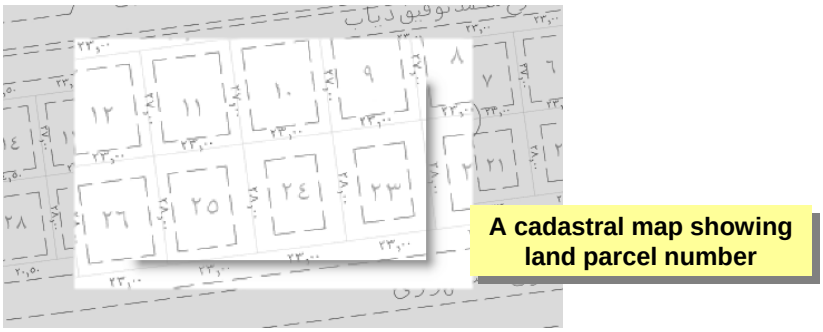


Describing features

Existing features may be described by mutation form, if the process of registration has begun, but this does not mean the property has been registered, this would have to be confirmed with the REPD office. The Parcel number and Building address can be used to locate mutation forms held by the EDO. This process is described in the following slides.

Attributing parcels

- Record land parcel number from ESA cadastral map



- Use Land Parcel Number to search for mutation form

Attributing parcels

Existing cadastral index maps should have land parcel numbers on them. You can use the land parcel number to find the parcel's mutation form at the EDO.

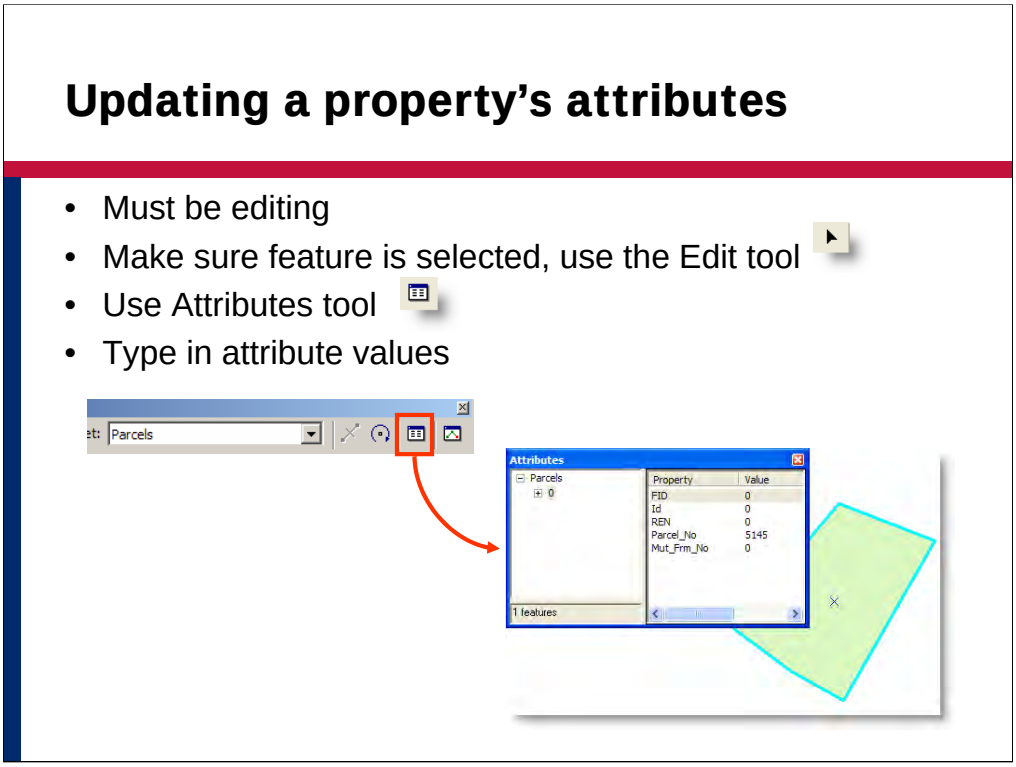
Attributing buildings

- Search for building's mutation form
  - Using Land Parcel number
  - Using Building address

Land parcel, common area and building mutation forms

Attributing buildings

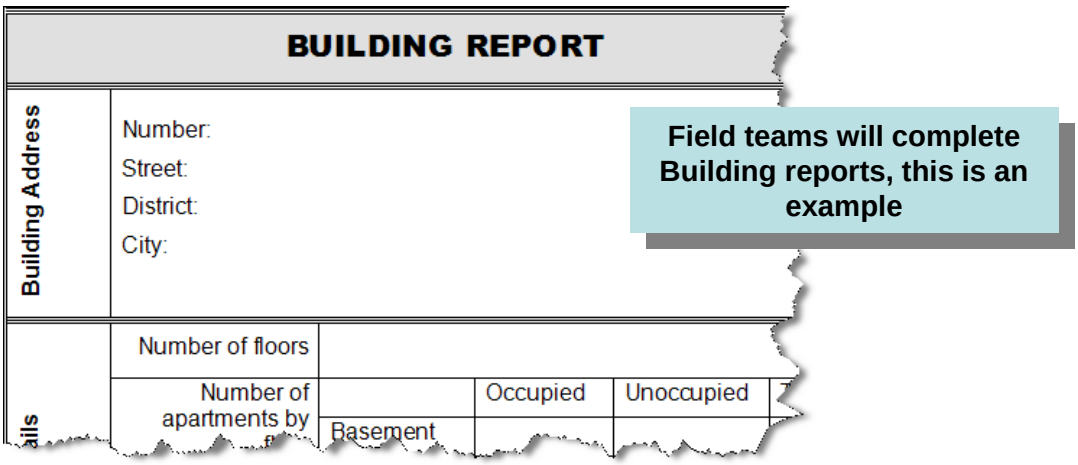
You can use the land parcel number of the parcel that the building sits within to search for the building's mutation form in the EDO or you can use the building's address to search for its mutation form if this information is written or recorded on the existing cadastral index map.



Updating a property's attributes

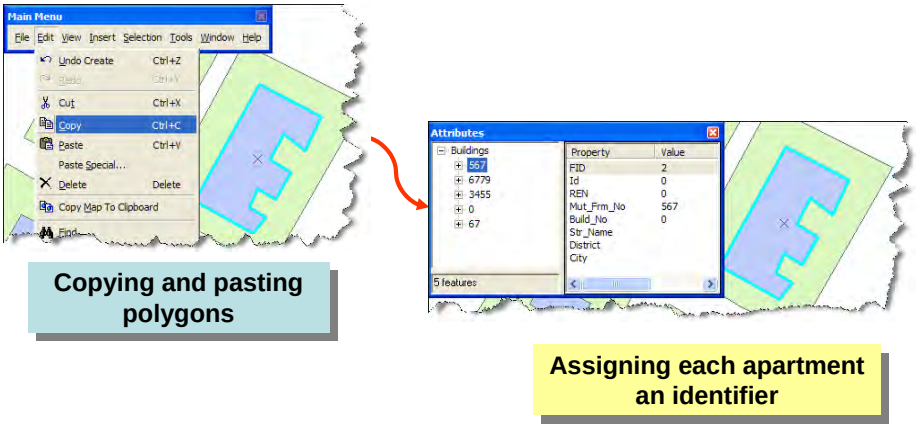
Once you have found a mutation form for a parcel or building you can update its attributes. To update a property's attributes make sure you are editing, use the Edit tool to select the feature or features of interest and click the Attributes tool in the Editor toolbar. Under the Value column in the Attributes dialog box, click next to attribute (or field) to update, type in a value and press the Enter key on the keyboard. Make sure you choose to save your edits before quitting.

Note: to add an address to new buildings use the Building Report completed by the Field Survey teams:



Capturing apartments

- Copy and paste ‘ground floor’ polygon

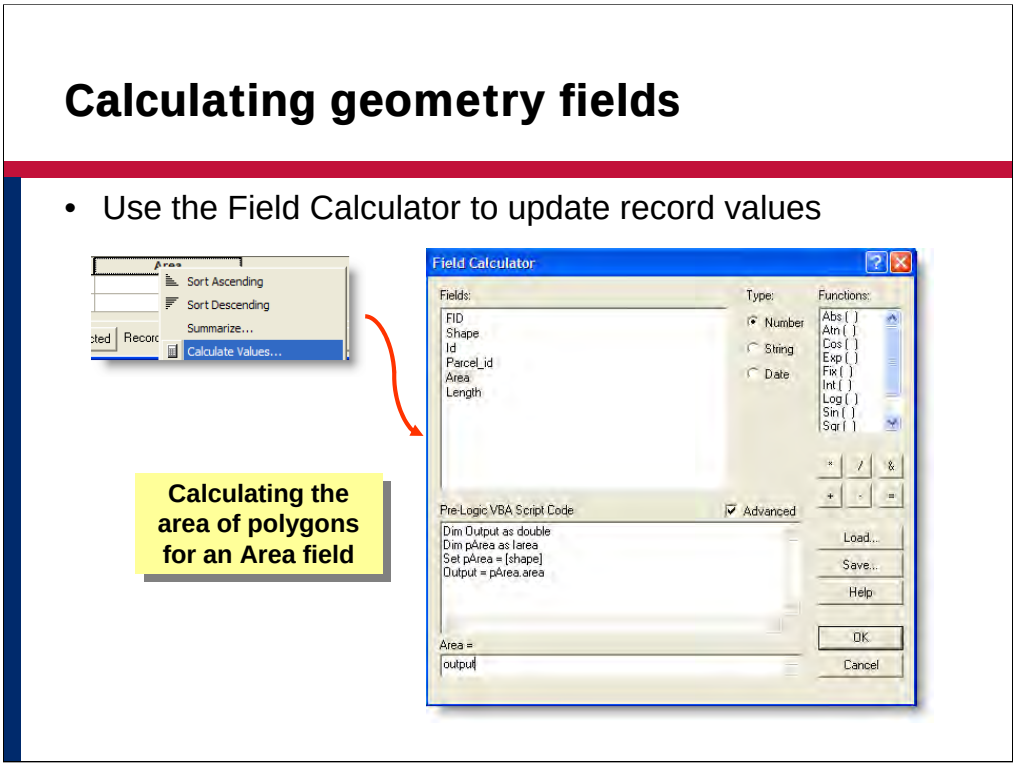


Copying and pasting polygons

Assigning each apartment an identifier

Capturing apartments

Dealing with apartments might seem problematic, the easiest way is to copy and paste the ground floor communal area for each apartment that has a mutation form associated with it. It is important to emphasize that the polygon representing the apartment is indicative only, i.e. it shows that there is an area of ownership it is not meant to represent the apartment’s exact dimensions or area, it is the mutation form that depicts the dimensions of the apartment and the associated communal area (although not to scale).

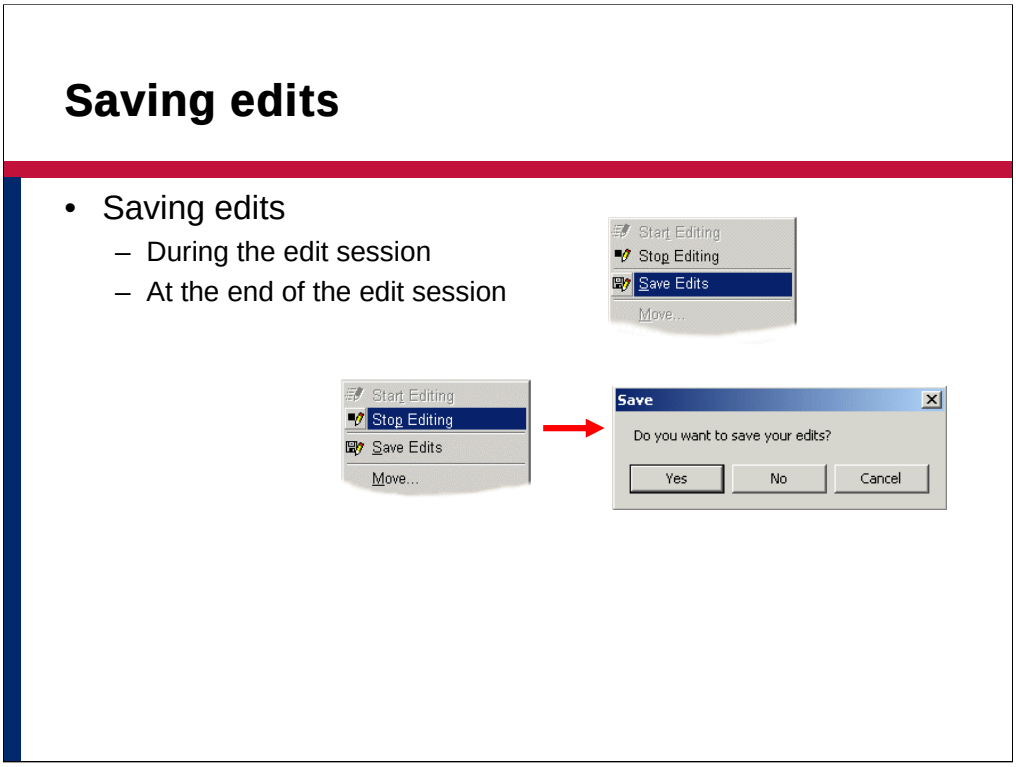


Calculating geometry fields

If you create a shapefile you must calculate area, perimeter and length fields to track geometry. Every time you edit a feature you must re-calculate the geometry fields. In the Field Calculator click the help button to access sample code for simple calculations, you can copy and paste this code into the field calculator. For example to calculate the area of a polygon right click on the Area field and choose Calculate Values from the context menu. In the Field Calculator dialog bix check the 'Advanced' option. Type this code into the 'Pre-Logic VBA Script Code' box:

```
Dim Output as double
Dim pArea as Iarea
Set pArea = [shape]
Output = pArea.area
```

And then type `Output` in the 'Area =' box. Click the OK button to update the area of the polygon. The figure will be in square meters (the units of the ETM).



Saving edits

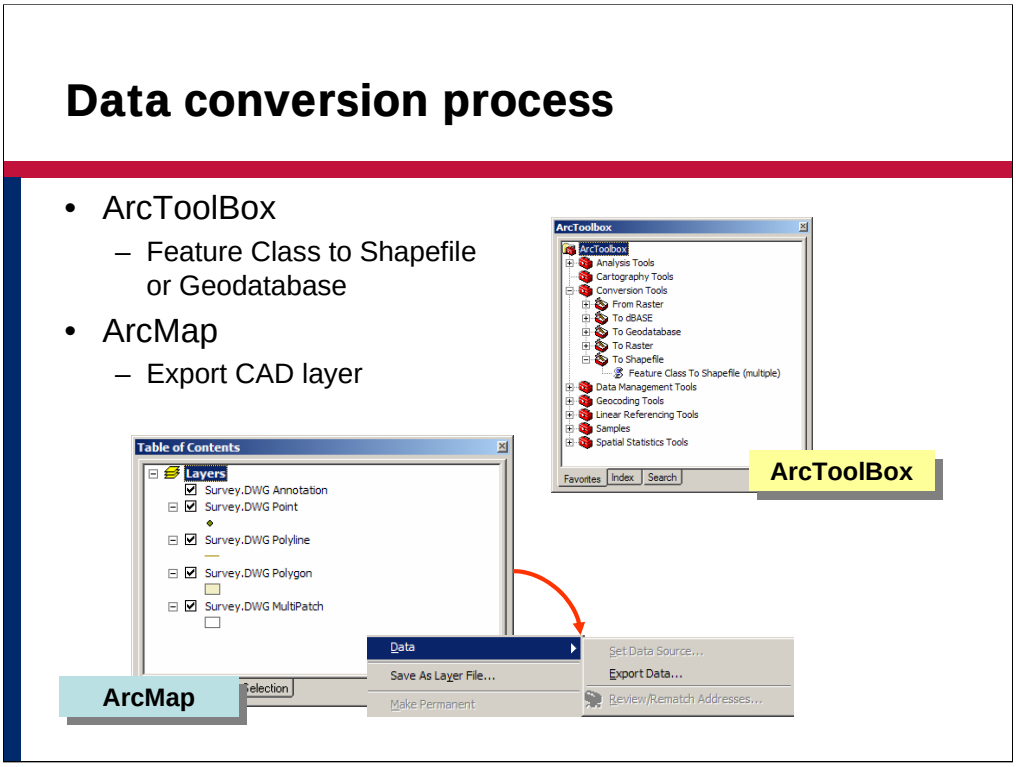
In ArcMap, you begin, end, and save edit sessions using the Editor menu on the Editor toolbar. When ending an edit session, ArcMap will prompt you to save your edits. If you do not save, your edits will not be committed back to the edit layer.

Processing new data

- Field surveying teams will generate AutoCAD drawings
- Already georeferenced to ETM
- Using Trace tool if properties recorded as polylines
- Convert drawing file if properties recorded as polygons

Processing new data

Survey crews will gather parcel outlines and building footprints using Total Station and Hand Laser distance tools. All data collected in the field will be processed using AutoCAD. Polygons can then be created using the Trace tool described in this section if data is provided as polylines or converted (see next slide) if provided as polygons. *Note:* Field data will directly georeferenced to ETM in the field and will not need to be transformed in ArcGIS.



Data conversion process

You can convert CAD data to a shapefile or personal geodatabase feature class in ArcMap, ArcCatalog or ArcToolbox. To export the CAD layer from ArcMap, right click on the layer and choose Data > Export Data… from the context menu (this is the easiest way to convert CAD data, you simply specify an output directory location and format). You can then add the required fields and edit data on conversion as described in this section.

To convert CAD data in ArcToolBox use the Feature Class to Shapefile or Feature Class to Geodatabase tool.

Exercises 6, 7 & 8

- Exercise 6
  - Convert CAD to shapefile
  - Create new feature class
  - Start Editing
  - Trace CAD polylines
- Exercise 7
  - Create new feature class
  - Digitize satellite imagery
- Exercise 8
  - Capture apartments
  - Attribute apartments

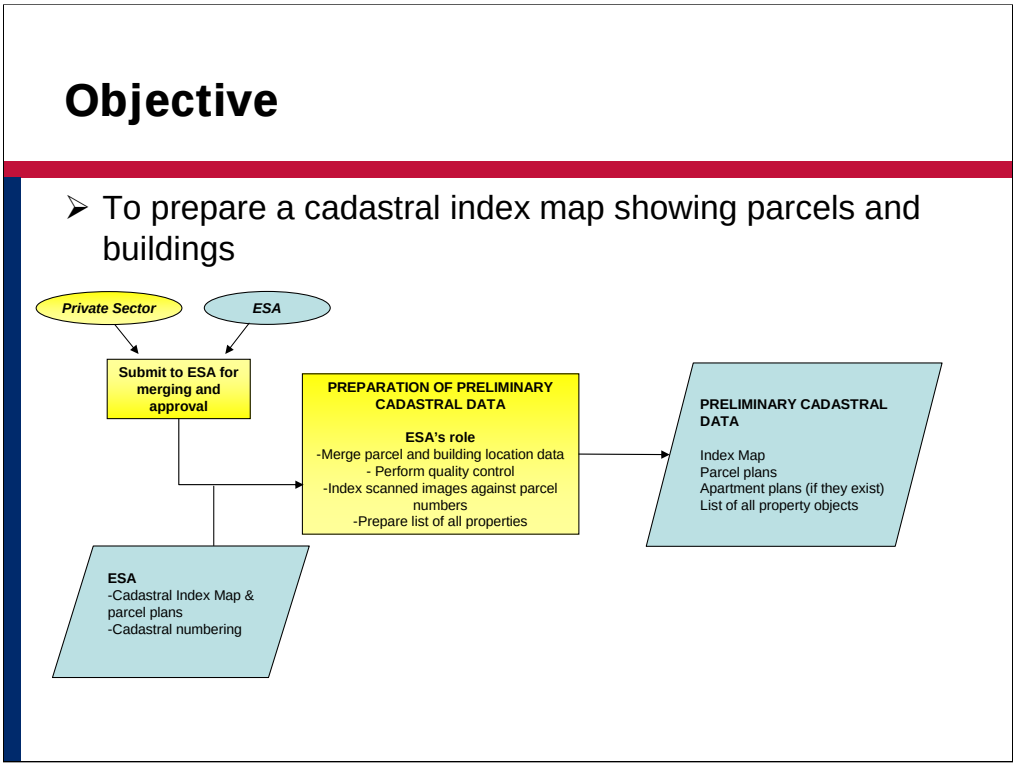
Section 6:
Preparing the cadastral index map

Section overview

- Edge matching
- Merging data
- Hyperlinks and joins
- Producing a cartographic product

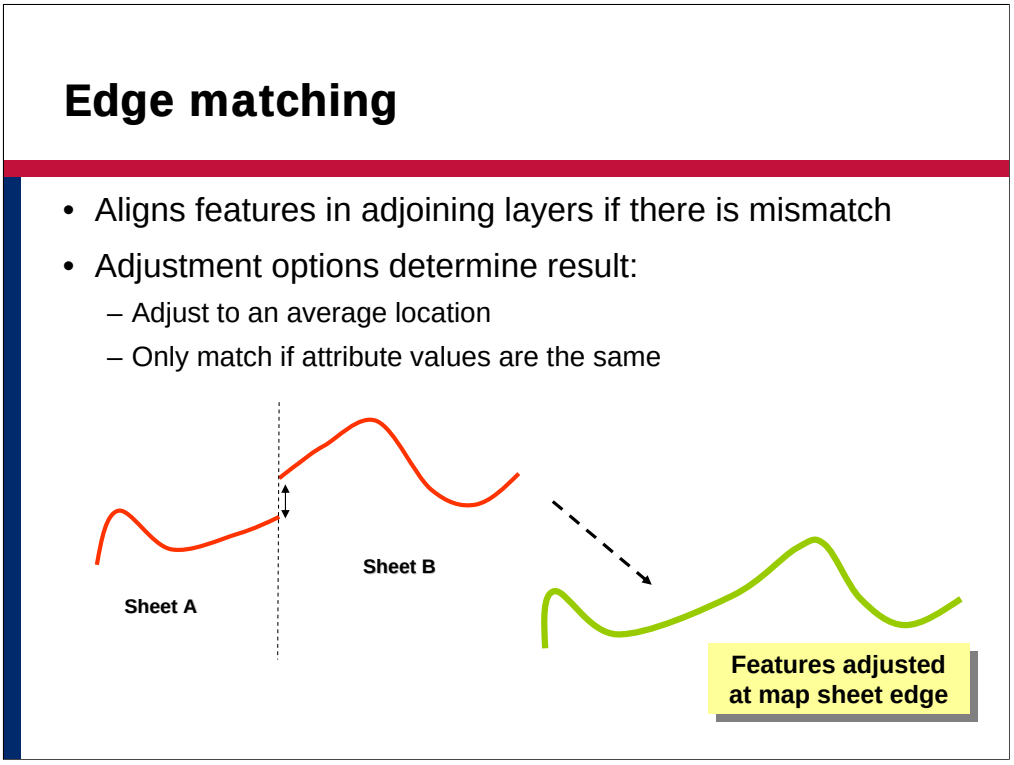
Section overview

This section covers the steps followed to create the cadastral index map namely edge matching, merging of data, establishing hyperlinks, using joins and relates and the cartographic process.



Objective

The objective is to prepare a cadastral index map by merging field data with existing data, gathered by ESA and the private sector and performing quality control.



Edge Snapping

Edge snap (edge matching) uses rubber sheeting to match features along the edges of layers. If you are combining data from different sources, features may not align perfectly along the borders. The edge snap adjustment can be used to move the features in a source layer to match those in a target layer or to adjust to the midpoints of the links. When performing an edge snap, you can add displacement links manually, from a file, or automatically using the Edge Snap tool on the Spatial Adjustment toolbar. The Edge Snap tool allows you to drag a box over the source and target features to be edge matched. Links will be automatically added between source and target features that are within the current snapping tolerance set for the edit session.

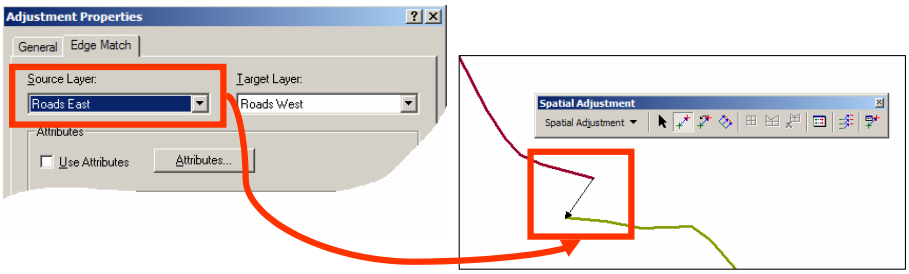
The Edge Snap adjustment method requires more property settings than other methods. Properties can be set in the Edge Match panel of the Adjustment Properties dialogue box (options command on the Spatial Adjustment pull down menu).

When using the Smooth edge snap method, vertices at the link source point are moved to the destination point. Remaining vertices are also moved, giving an overall smoothing effect. When using the Line edge snap method, only the vertices at the link source point are moved to the destination point. The remaining vertices on the feature remain unchanged.

You have the option to specify one link per destination point and to prevent duplicate links. The Spatial Adjustment tool supports the ability to use attributes to enhance the edge matching process. Based on the Attribute Transfer Mapping dialog box, you can match fields between the source and target layers and use common attributes to define the edge match. This function can help ensure the accuracy of the edge match.

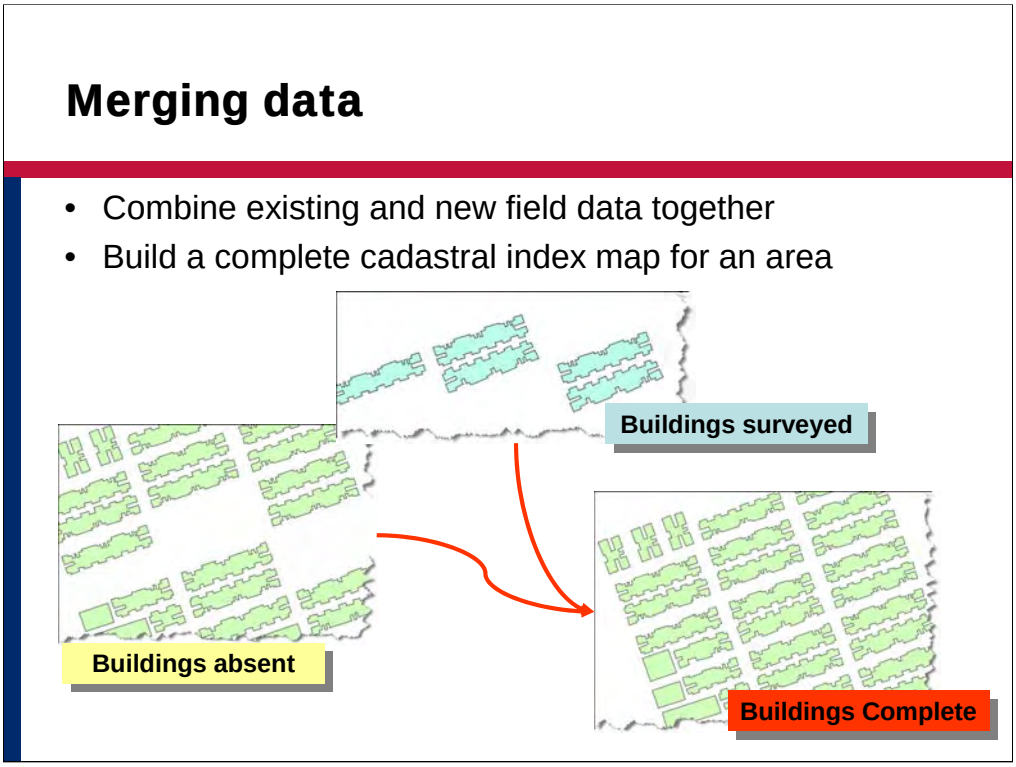
Performing Edge matching

- Specify features which move – based on accuracy
- Set source and target (destination) layer
- Specify options - match options, line options
- Add displacement links (source -> target)



Performing Edge Snapping

To perform edge snapping you must be editing and using the Spatial Adjustment tool (refer to Section 4: Georeferencing Data for more details). First specify which features will move, for example you may specify that features in the less accurate layer can move – if you know which layer is less accurate, or you may decide that both layers are as inaccurate as each other and therefore features in both layers can move. Next set the source and target layers making sure when you add displacement links that you adhere to the source/target layers set. Options can be set when performing edge matching – you can use attributes to determine whether displacement links can be added or not, if attribute values are the same a displacement link will be added, otherwise it will not. Once data has been checked for a consistency along map sheet edges it can be combined together.



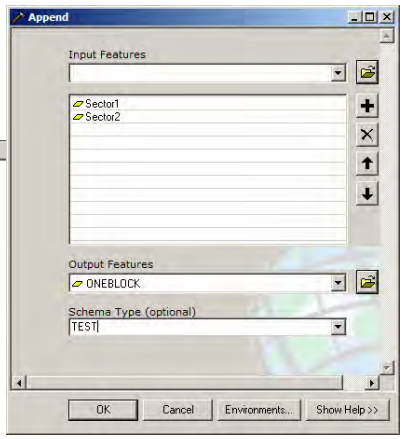
Merging data

Data collected in the field and existing data will be combined together to create a complete picture of cadastral information for the pilot area. In addition data collected by the private sector (buildings) will also be combined with data collected by ESA (parcels). Before merging data together, it should be checked for consistency using the Edge snapping tools.

Merging in ArcToolBox

- Use Append (9.0)
  - Create empty feature class first
  - Output fields must be same as input

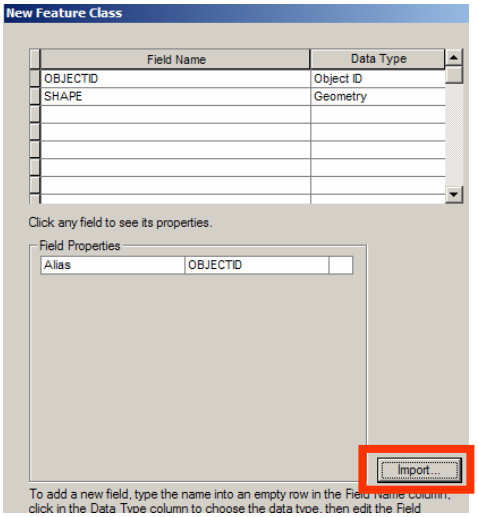
Name	Alias
Shape_Length	Shape_Length
Shape_Area	Shape_Area
No_F_A	No_F_A
No_F_U	No_F_U
No_U	No_U
com	com



- Use Merge (9.1)
  - New feature class created

Merging in ArcToolBox

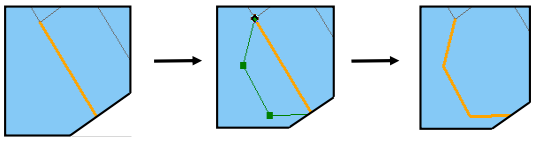
In ArcToolBox use the Append tool (at ArcGIS 9.0) or Merge tool (at ArcGIS 9.1) to combine layers of data together. If you use the Append tool you must create a new empty feature class yourself (you can do this in either ArcCatalog or ArcToolBox). If you use Append make sure the new feature class you create has the same fields as the input feature classes. If you use Merge then a new feature class is created for you. *Note:* When creating a new personal GDB feature class you can import fields (the schema) of another feature class, meaning you do not have to add fields yourself. In ArcGIS 9.1 the Merge tool performs the same task, without you having to create a new empty feature class first.



Edits and corrections

- Corrections and revisions to map data
- Corrections and revisions to attribute information

Reshape

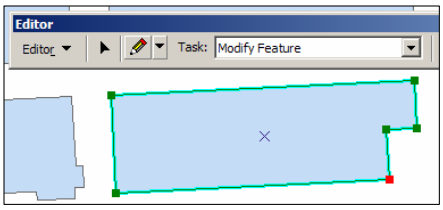


Edits and corrections

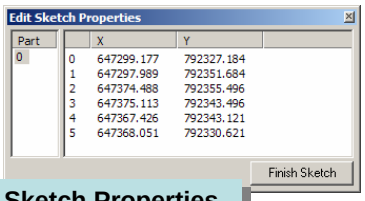
Once boundaries have been finalized the cadastral data will be revised and checked following agreed quality control procedures. Boundaries may be re-shaped or modified, tasks that can be achieved using ArcGIS topology tools. Attributes may be edited to correct any mistakes. All of these actions require that you are editing the source data.

Modifying features

- Use the Modify Feature task
  - Short-cut double click on a feature
- Edit vertices
  - Use context menu or sketch properties tool



Edit sketch vertices to modify a feature



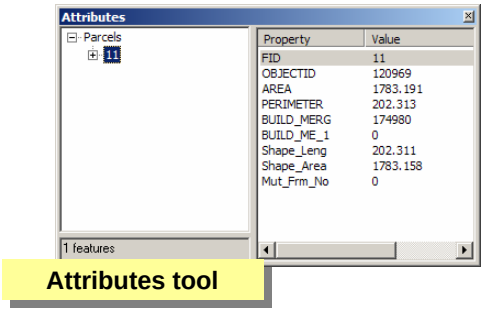
Sketch Properties

Modifying features

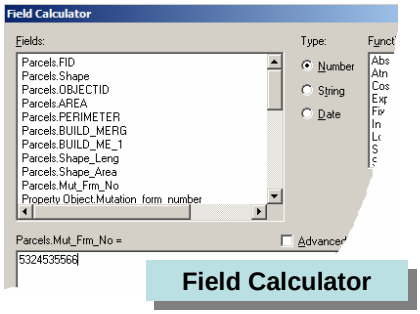
To modify a feature, select it using the Edit tool and set the Task to Modify Feature. Alternatively double click on the feature to edit its sketch. To edit vertices use the Sketch context menu or the Sketch Properties tool.

Modifying attributes

- Correct record values
  - Use Attributes tool in an edit session
  - Use Field Calculator in/outside an edit session



Attributes tool



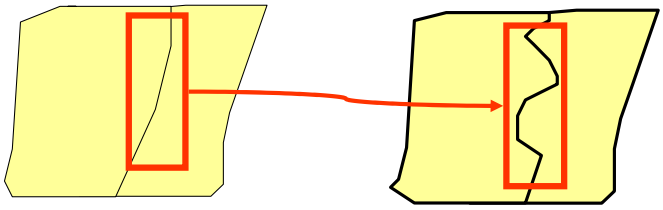
Field Calculator

Modifying attributes

You can edit attributes using the Attributes tool and field calculator in an edit session, or the Field Calculator outside an edit session. The advantage of using the field calculator is that you can globally update record values, the only disadvantage is that you cannot undo your changes as you in an edit session by pressing the CTRL + Z keys on the keyboard.

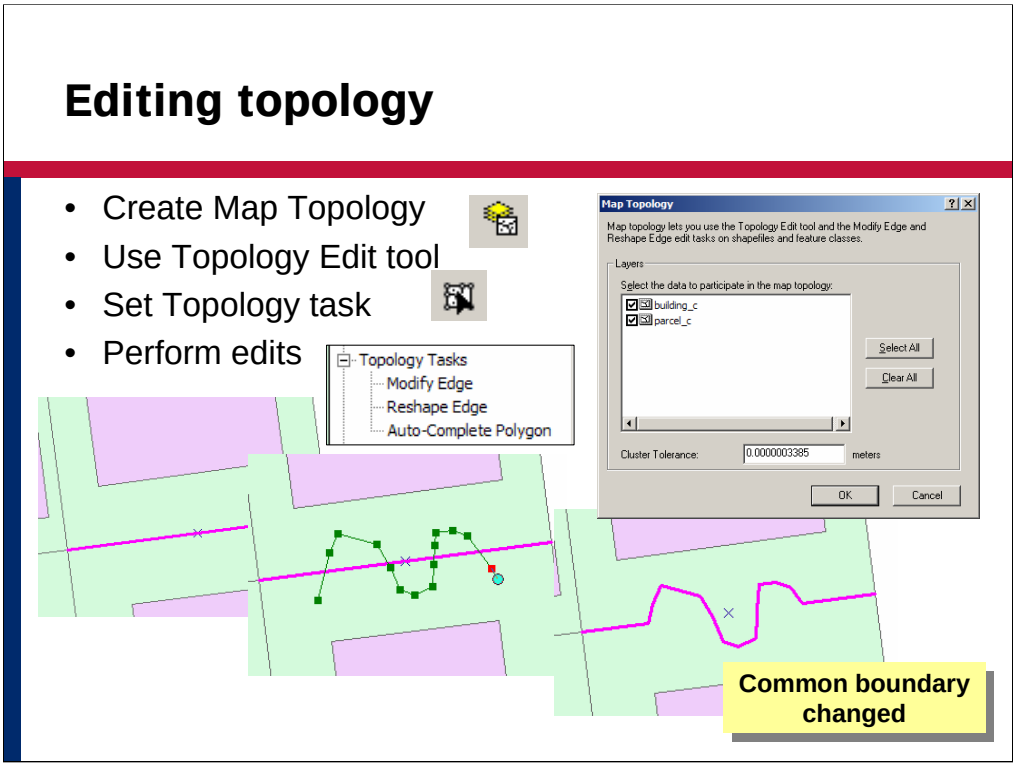
Maintaining relationships

- Topology models relationships
  - Adjacency and coincidence
- Use Topology tools to maintain relationships



Maintaining relationships

Topology is described as the mathematics of relationships which are created when capturing data – for example the Auto-Complete Polygon task ensures adjacency and setting the snapping environment ensures connectivity. During an edit session use the Topology Toolbar in ArcMap to maintain relationships between features i.e. adjacency between polygons and connectivity between lines. For example you may want to edit a shared boundary between parcels, rather than editing each boundary separately you can edit them as if they were the same feature. Similarly if you want to move roads at an intersection it would be easier to move the intersection point and have the roads move as one as well rather than moving each road separately.

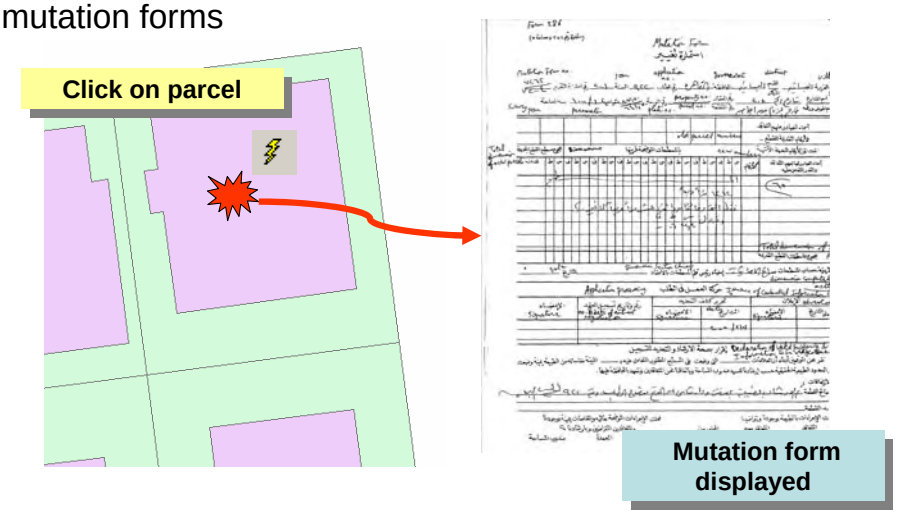


Editing topology

To perform edits to topology first start an edit session. From the Topology toolbar, click the Map Topology tool and specify which layers will be spatial coincident (determined by the Cluster Tolerance in meters) when making topological edits. Next click the Topology Edit tool to select a common boundary (for polygons). The common boundary will be highlighted in magenta. Set a topology task from the Task drop-down list in the Editor toolbar. Next use a sketch tool to draw a new boundary or edit the vertices along that boundary. Once complete press the F2 key on the keyboard and you will see boundaries of adjacent polygons have *both* been changed.

Linking Mutation forms

- Establish a link between properties and scanned mutation forms

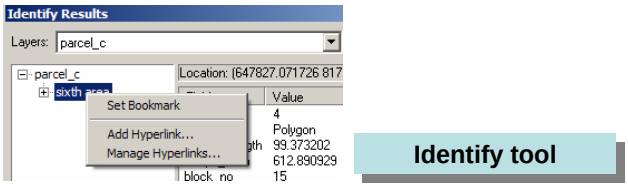


Linking Mutation forms

Linking mutation forms by means of hyperlinks allows you to establish a connection between parcels and scanned documents. Using the Hyperlink tool in ArcMap you can click on a parcel/building and review its associated mutation form.

Creating hyperlinks

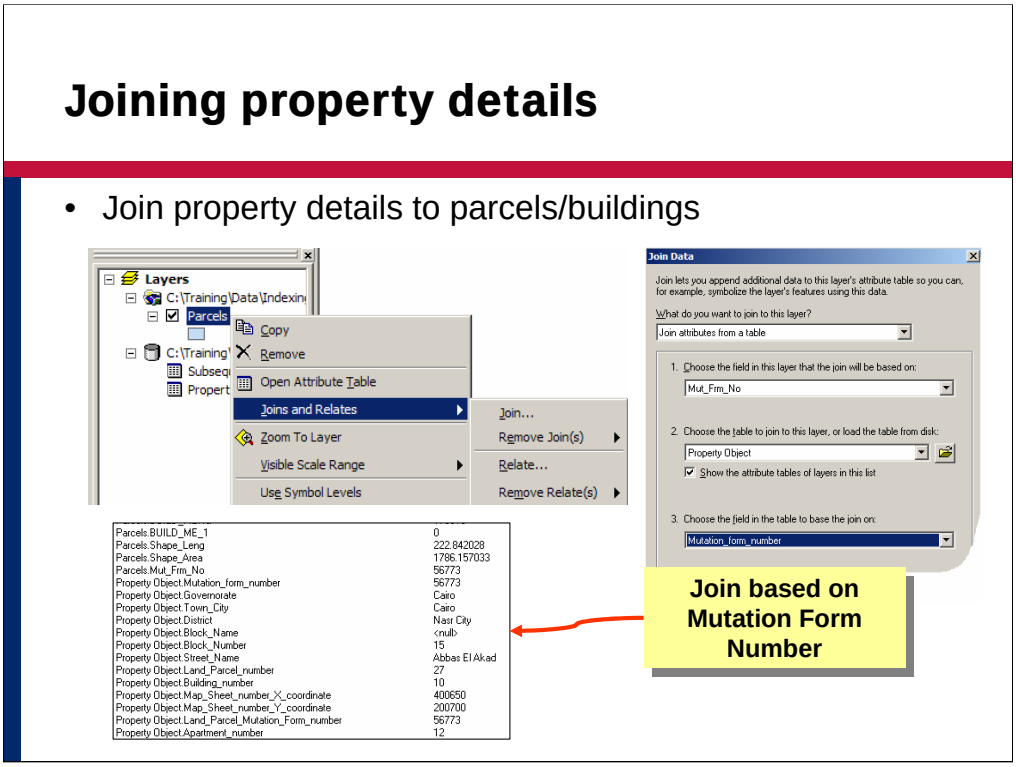
- Dynamically - using the Identify tool



- Permanently - using field in a layer's attribute table

Creating hyperlinks

Hyperlinks can be set in one of two ways (i) dynamically - using the Identify tool. Click on a feature using the Identify tool, then choose to Add a Hyperlink… by right clicking on the value in the left hand side of the Identify Results window. Simply browse for the mutation form to associate and then use the Hyperlink tool to view the document in ArcMap. Hyperlinks created in this way are saved with the map, so if you want someone to see the hyperlinks you have set you must share you map document; (ii) Permanently - by adding a text field to the layer's attribute table and typing in a record value that matches the name and directory path of the mutation form you want to associate with the feature. Under the Display tab in the Layer Properties dialog box you can specify that hyperlinks are supported by the field you have just added, then use the Hyperlink tool to view the document in ArcMap. If you save the layer file to disk then the hyperlink properties are saved too and do not have to be reset.



Joining property details

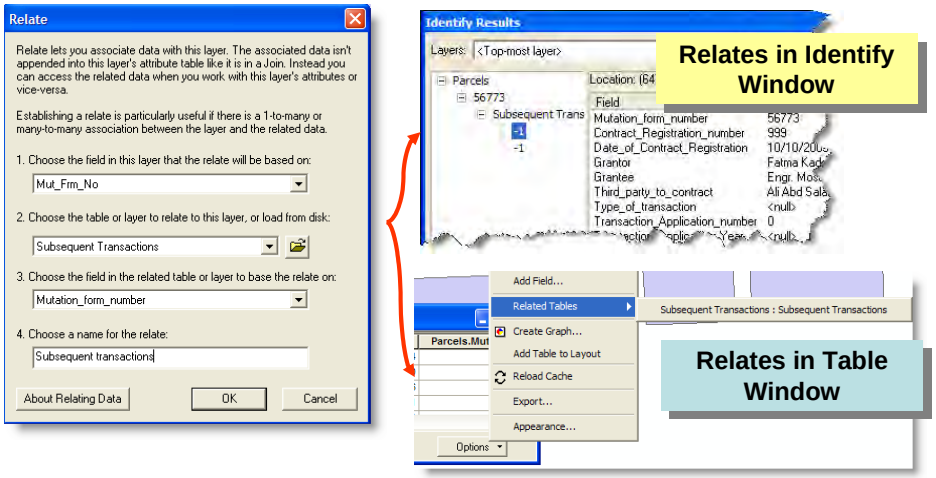
Use the Join and Relate commands to link details held in MS Access to parcels and buildings. In section 3 you saw how to create a database called Mutation Forms with two tables called Property Object and Subsequent Transactions. Each table contained the field Mutation_form_number, you can use this field to link the tables to parcels and buildings which also have a mutation form number field. In ArcMap when performing a Join or Relate field names do not have to be the same, but the data types of the fields must be.

Join

Use Join for 1:1 or M:1 cardinality. Join appends fields from one table to another. You will join the Property Object table to the Parcel or Building layer as one parcel/building has a single address and one initial transaction. To create a Join, right click on Parcel/Building layer and choose Joins and Relates > Join…. In the Join Data dialog box select the common field in the Parcel/Building layer (e.g. Mutation form number) the Property Object table and the common field (e.g. Mutation form number).

Relating subsequent transactions

- Relate subsequent transactions to parcels/buildings

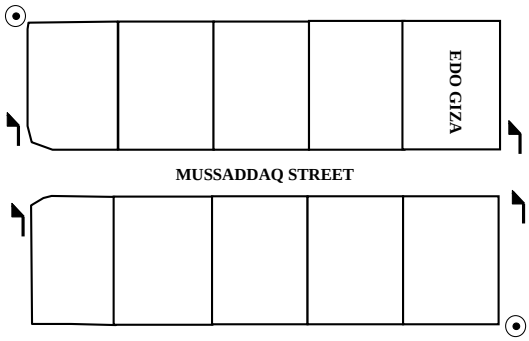


Relating subsequent transactions

Use the Relate for 1:M or M:M cardinality. Relate establishes a relationship between one table and another, but they remain physically separate. You will relate the Subsequent Transactions table to the Parcel or Building layer as one parcel/building can have many transactions associated with it. To establish a relate right click on the Parcel/Building layer and choose Joins and Relates > Relate from the context menu. Select the common field in the Parcel/Building layer (e.g. Mutation form number), the Subsequent Transactions table and the common field in the table (e.g. Mutation form number), optional name the relate. To view related tables for the Parcel/Building layer, select a parcel/building, open the layer's attribute table and click the Options button and choose Related Tables from the pop-up menu. Alternatively use the Identify tool, when you click on a feature the related table will appear in the Identify results window.

The cartographic process

- Preparing the cadastral index map
  - All properties outlines in solid lines
  - All street and major buildings named
  - Symbols follow ESA standards



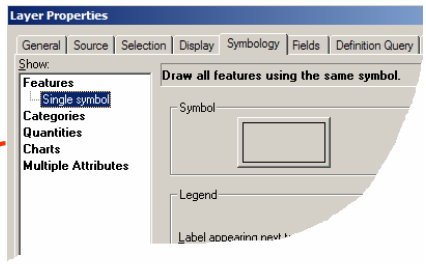
Named buildings, street lamps and control points

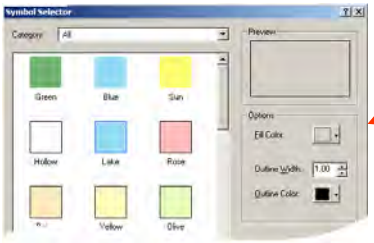
The cartographic process

The cartographic process involves symbolising features on the map using predefined colors and patterns and the use of text to annotate major properties and all streets. There are ESA guidelines that determine symbology and text to be used. The next slides describe how to create a map using ArcMap.

Symbolizing features

- Select a predefined symbol
  - For polygons set outline and fill
  - For lines a line style
  - For points a marker symbol





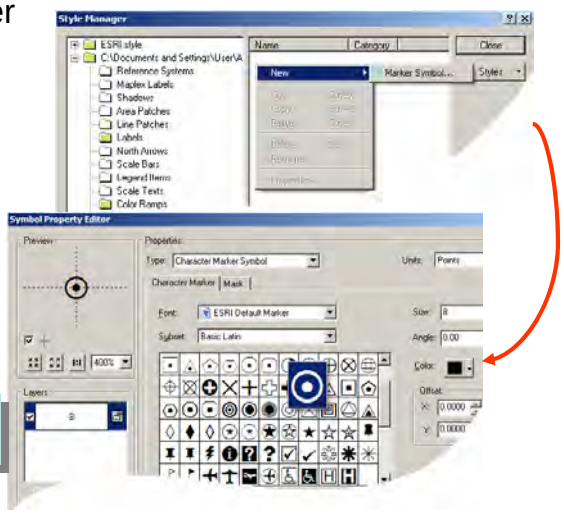
Setting a polygon fill and outline

Symbolizing features

Use the Layer properties dialog box to set polygon, line and marker symbols. Right click on the layer and choose Properties… from the context menu, click the Symbology tab and click on the current symbol to set an alternative, selecting it from the Symbol Selector dialog box.

Creating your own symbols

- Use the Style Manager
- Select symbol type
  - Simple
  - Character
  - Picture
- Save symbols to file



Creating a character marker symbol

Creating your own symbols

You can create you own symbols using the Style Manager, when you create symbols in this way you are either saving them to an existing Style file or you can save them to a new Style file. Style files can be shared amongst users so if you create symbols that you want to share with another person simply make the style file available to them (e.g. by placing it on a network drive)

Labels and Annotation

- Labels are scale independent and dynamic
- Annotation is scale dependent and static

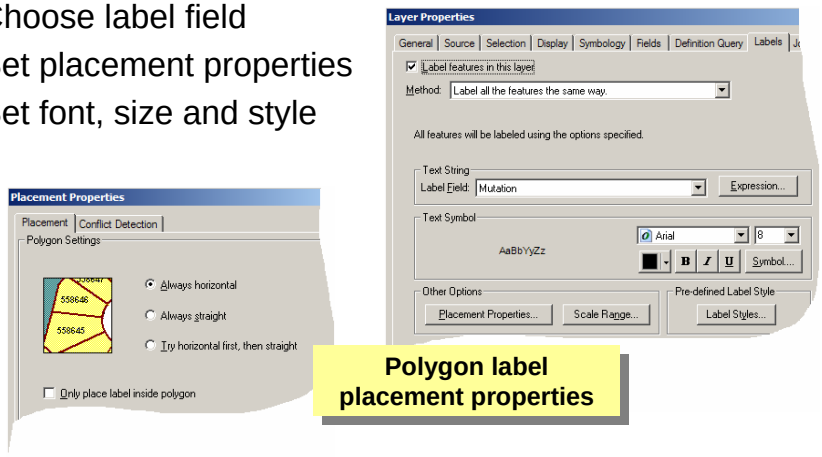
LABELS	ANNOTATION
Scale independent	Scale dependent
Property of the layer	Saved with map or in geodatabase
Dynamic	Static

Labels and Annotation

Labels are a property of a layer, they are scale independent and dynamic, so a map at scale 1:5,000 would have different labels, of the same font size, at a scale of 1:10,000. This may be problematic when producing maps since text should remain in the same place on the map irrespective of its scale. This is what annotation allows you to do. By setting a reference scale in effect you are saying at 1:5,000 text on the map should appear as 12 point Arial font, when you zoom in it gets bigger, when you zoom out it gets smaller, but the text remains static in terms of geography. Generally the process of creating annotation is as follows: label features, set an appropriate reference scale and then convert labels to annotation.

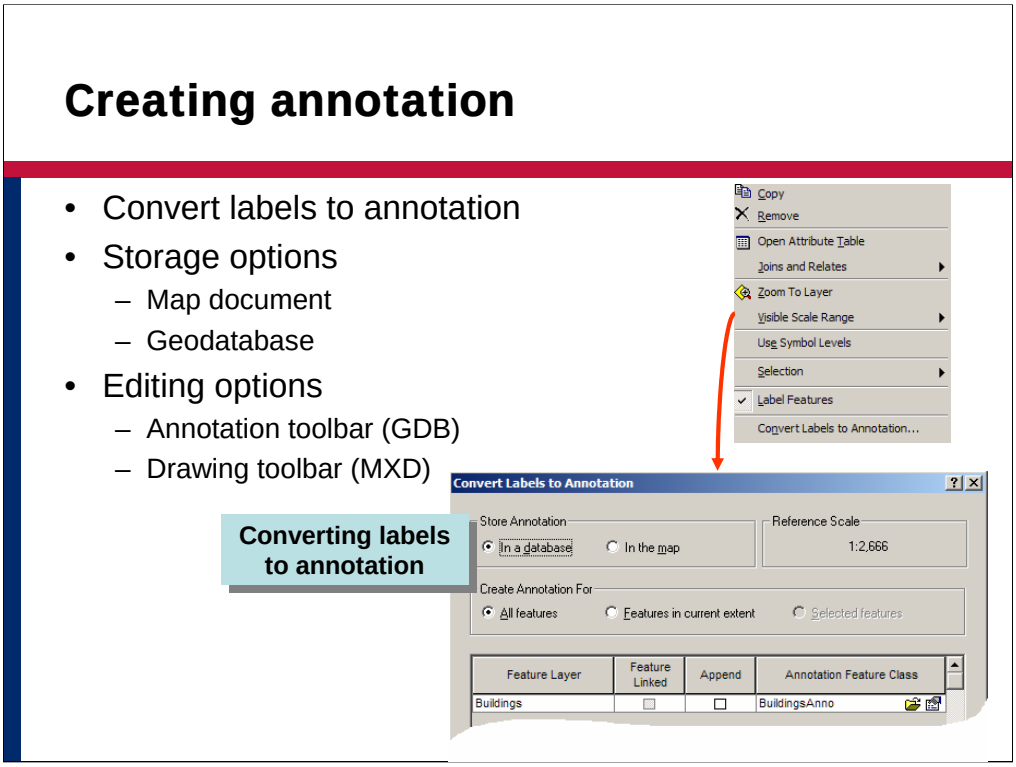
Creating labels

- Use Layer Properties or Label Manager
- Choose label field
- Set placement properties
- Set font, size and style



Creating labels

To label features in a layer either use the Layer Properties dialog box or the Label Manager toolbar. Select a label field and set the placement options. For points labels can be placed using predefined placement positions, on the point, or at an angle (which you can specify or can be set by using the values of a numeric field in the attribute table). For lines labels can be placed above or below the line, at right angles, horizontal or along the direction of the line. For polygons labels can be placed horizontally or along the longest edge of the polygon feature. You can also set ranks and priorities specifying whether labels are more important than features. Finally set a font, size and style for the labels. To label features right click on the Layer in the table of contents and choose Label Features from the context menu.



Creating annotation

To create annotation first choose to create labels, then convert the labels to annotation by right clicking on the layer and choosing Convert Labels to Annotation from the context menu. You can choose to save Annotation to the map document or a geodatabase (shapefiles do not support annotation). The preference is to save annotation to a geodatabase since annotation behaves like another feature class and can be added to any map document. If you save annotation to a map document you must share the MXD (map document) with another person.

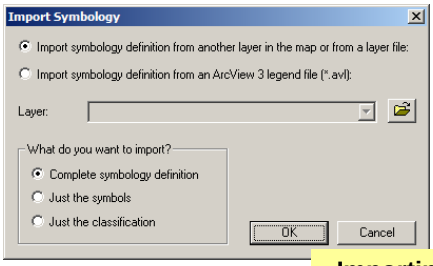
Editing annotation

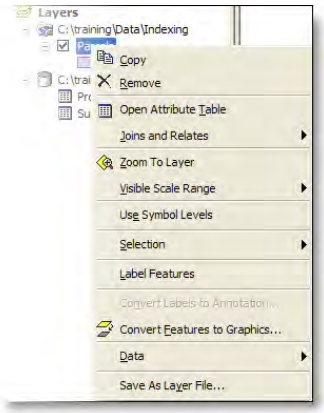
Depending on where annotation is saved determines how it is edited. Annotation in a map document can edited using the Drawing toolbar, annotation in a geodatabase using the Annotation toolbar – you must be editing the geodatabase to use the Annotation toolbar.

The Drawing toolbar

Using layer files

- Layer files store symbology and labelling
  - Ensures standardized symbology for features
- Import symbology from a layer file





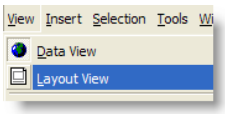
Importing symbology from a layer file

Using layer files

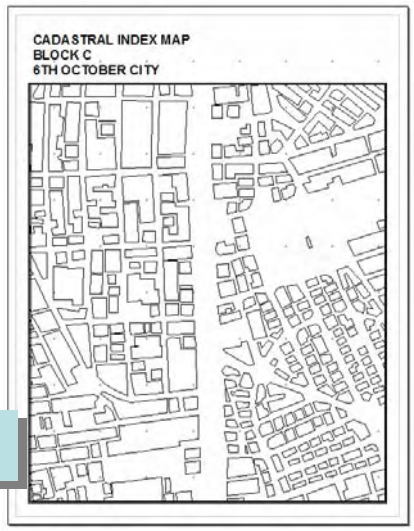
When you save a layer file (*.lyr) to disk you are saving the properties set for a layer. To save a layer file right click on a layer and choose Save as Layer file from the context menu. Layer files behave like any other source data in ArcMap, click on the Add Data tool and navigate to where a layer file has been saved, when added to the map document you will see the symbology and labelling properties set for the layer when it was saved. You can import symbology from a layer assigning symbology to a layer added to your map document. You can also change the source data too, right click on the layer and choose Properties… from the context menu, under the Source tab click the Set Data Source button and navigate to a different data source, the symbology remains the same but the features change. Using layer files makes your job of symbolizing features very easy.

Creating the cadastral index map

- Design in the Layout View



- Set page properties
- Add cartographic elements
  - North arrow, etc
- Print or export



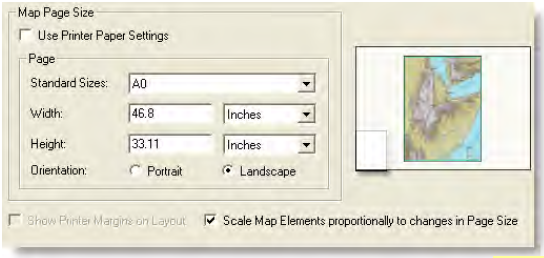
A cadastral index map

Creating the cadastral index map

Design the cadastral index map in the layout view. To switch to the Layout View choose Layout View from the View menu. The layout view presents a virtual page onto which you add cartographic elements, you can create any size map from A4 to A0, and select a portrait or landscape orientation. You can create maps of fixed scale using the Scale notation in the Standard toolbar.

Setting page properties

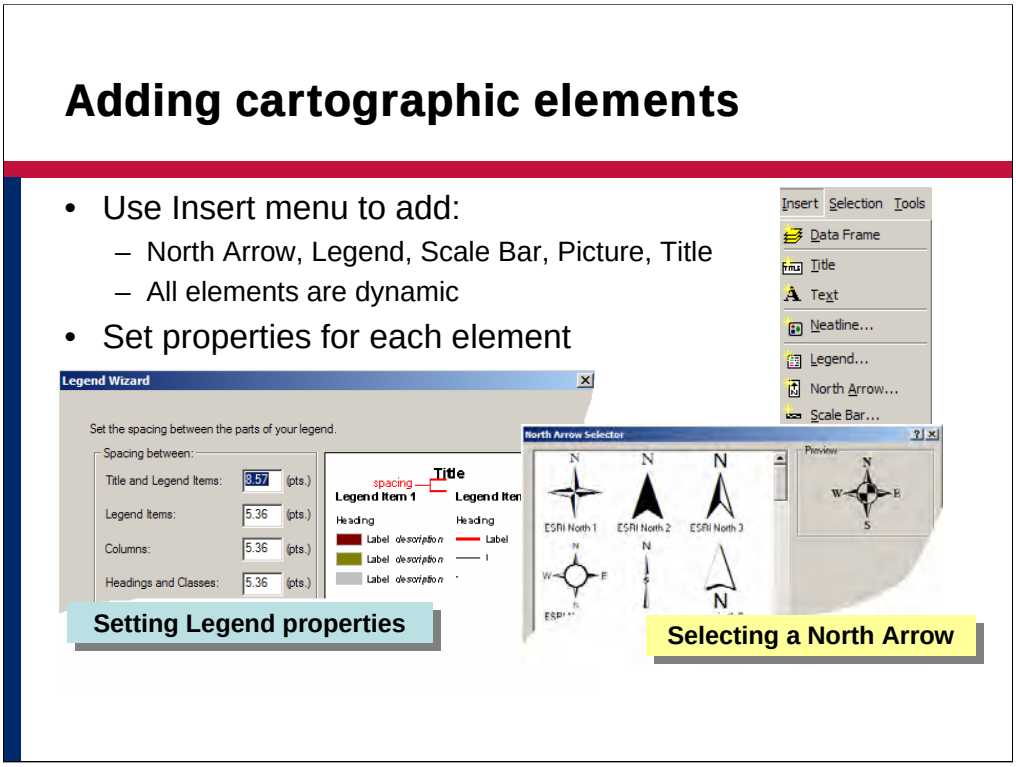
- Can design map up to any size
- Uncheck ‘Use Printer Paper Settings’
- Set page size and orientation



Setting page size irrespective of printer limitations

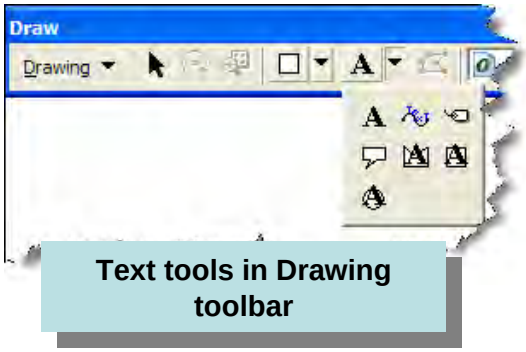
Setting page properties

To set page options choose Print and Page Setup from the File menu. You can design any size map if you uncheck the option ‘Use Printer Paper Settings’ in the Print and Page Setup dialog box as shown above. If you select the option ‘Scale Map Elements proportionally to changes in Page Size’ elements on the map will be scaled when you change the page size from A4 to A0.



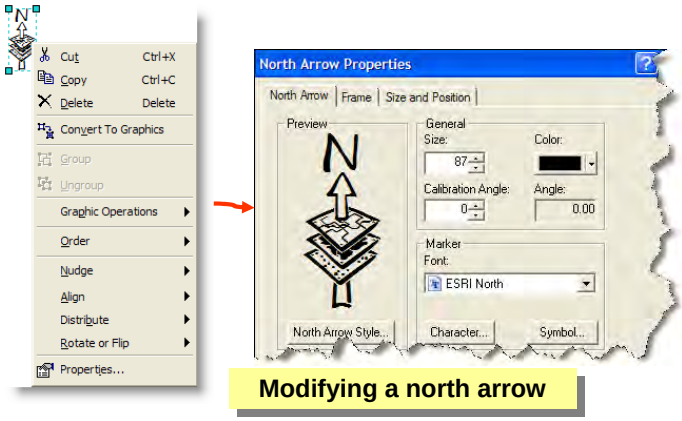
Adding cartographic elements

To add a cartographic element use the Insert menu, make sure you are in the Layout View otherwise this option will be greyed out. When adding a cartographic element you will work with either a wizard or template selection dialog box. Any element added to the layout is dynamic – any changes the element's source object will be reflected in the layout view. You can add north arrows, scale bars, text, pictures and objects (e.g. an MS Excel Spreadsheet). You can also add text from the Drawing toolbar using any one of the text tools:



Modifying cartographic elements

- Changing properties
  - Double click on an element; or
  - Right click and choose Properties…
- Move
- Delete
- Copy



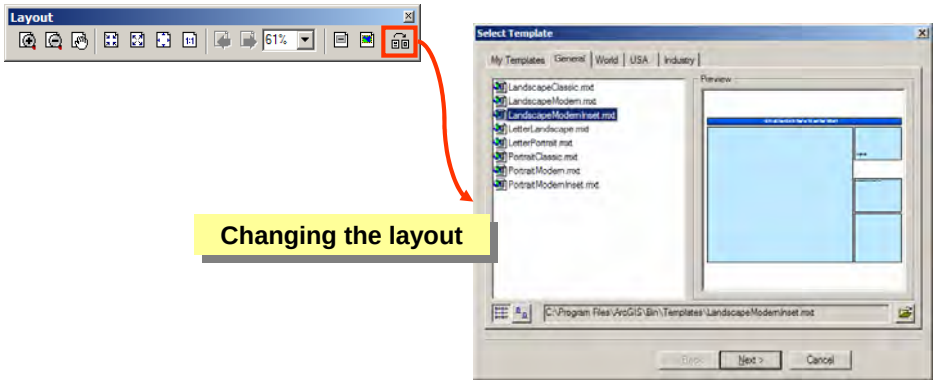
Modifying a north arrow

Modifying cartographic elements

To modify a cartographic element, double click on the element using the Select Elements tool in the Drawing or Tools toolbars, or right click on the element and choose Properties… from the context menu. Change the properties accordingly. To move an element simply drag and drop, to delete an element select it and press the Delete key on the keyboard. You can also copy and paste elements in the layout view.

Using templates

- Predefined map layouts
  - Fixed placement of cartographic elements
- Select template to use after adding data to map document

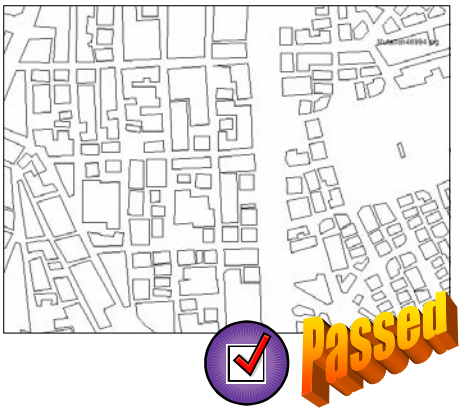


Using templates

Templates allow you to give a standardized look and feel to you maps. Templates are stored as MXT files and are created in ArcMap. In the Layout View design an empty map (i.e. a map that doesn't contain any geographic data), adding frames, legends, north arrows etc. and save the map document to disk not as a MXD but as a MXT file. To use the template create map document switch to the Layout View and click the Change Layout tool in the Layout toolbar and select the MXT file saved to disk.

Review and approval

- Final review to check:
  - Symbology is correct
  - Measurements are correct
  - Text is correct

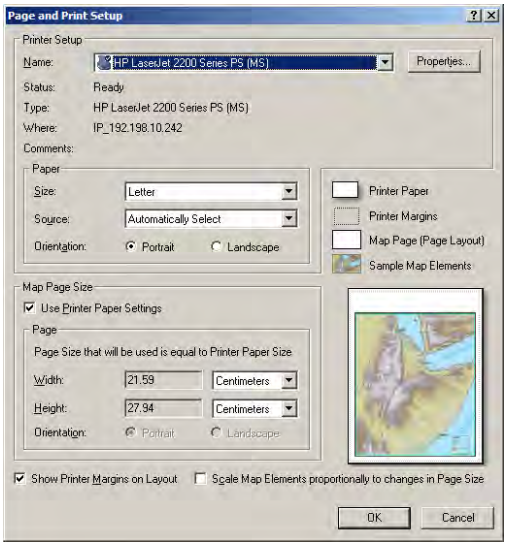


Review and approval

A final review of the cartographic product will ensure it meets ESA standards and can be approved. 25% of the map is assessed for cartographic consistency to ensure that symbols, measurements and text are correct.

Printing and exporting

- Print options
  - Page size, printer
- Export formats
  - TIFF, JPEG, PDF
- Set export options
  - Quality, resolution



Printing and exporting

When the map is ready for printing you can choose to print directly or export the map to one of many supported graphic file formats. If you choose to export to PDF (Portable Document Format) page size is maintained (this is not true of other graphic file formats) and someone can view your map using Adobe's Acrobat Reader, freely downloadable from the internet.

Exercises 9, 10, 11, 12 & 13

- Exercise 9
  - Edgematching
- Exercise 10
  - Merging
- Exercise 11
  - Establishing hyperlinks
- Exercise 12
  - Joins and relates
- Exercise 13
  - Creating a cadastral index map

ANNEX B:

Module B – Course exercises

ESA CADASTRAL OPERATIONS COURSE MODULE B: DATA PROCESSING AND GIS COURSE EXERCISES

EGYPT FINANCIAL SERVICES PROJECT

OCTOBER 2006
This publication was produced for review by the United States Agency for International Development. It was prepared by Chemonics International Inc.

TABLE OF CONTENTS

EXERCISE 1: ARCGIS REFRESHER 3
EXERCISE 2: INDEXING MUTATION FORMS 9
EXERCISE 3: GEOREFERENCING RASTER DATA 16
EXERCISE 4: SPATIAL ADJUSTMENT 20
EXERCISE 5: RUBBERSHEETING 27
EXERCISE 6: CREATING PARCELS FROM CAD POLYLINES 34
EXERCISE 7: HEADS UP DIGITIZING 45
EXERCISE 8: CAPTURE APARTMENTS 51
EXERCISE 9: EDGEMATCHING 55
EXERCISE 10: MERGING DATA 59
EXERCISE 11: ESTABLISHING HYPERLINKS 63
EXERCISE 12: ASSOCIATING MUTATION FORMS 70
EXERCISE 13: MAP PRODUCTION 74

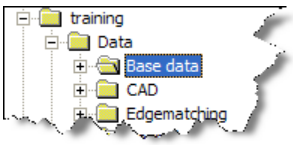
EXERCISE 1: ARCGIS REFRESHER

In this exercise you will be reacquainted with ArcGIS functionality by exploring the two core applications ArcMap and ArcCatalog and ArcToolBox.

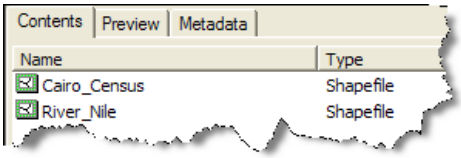
Step 1: Start ArcCatalog and explore a shapefile

- ❑ Start ArcCatalog.

- ❑ In the Catalog tree (left hand pane) navigate to the C:\TRAINING\DATA\BASE DATA folder:

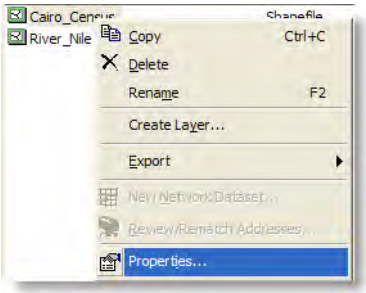


- ❑ In the right hand pane of ArcCatalog notice that there are two shapefiles: River_Nile and Cairo_Census:



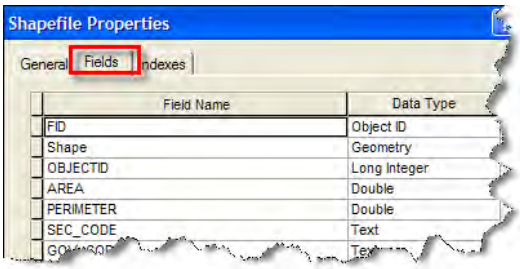
The icon to the left of the shapefile name gives you a clue as to the geometry; in this case both shapefiles are polygons. Next examine the properties of the Cairo_Census shapefile:

- ❑ Right click on the Cairo_Census shapefile and choose Properties… from the context menu:

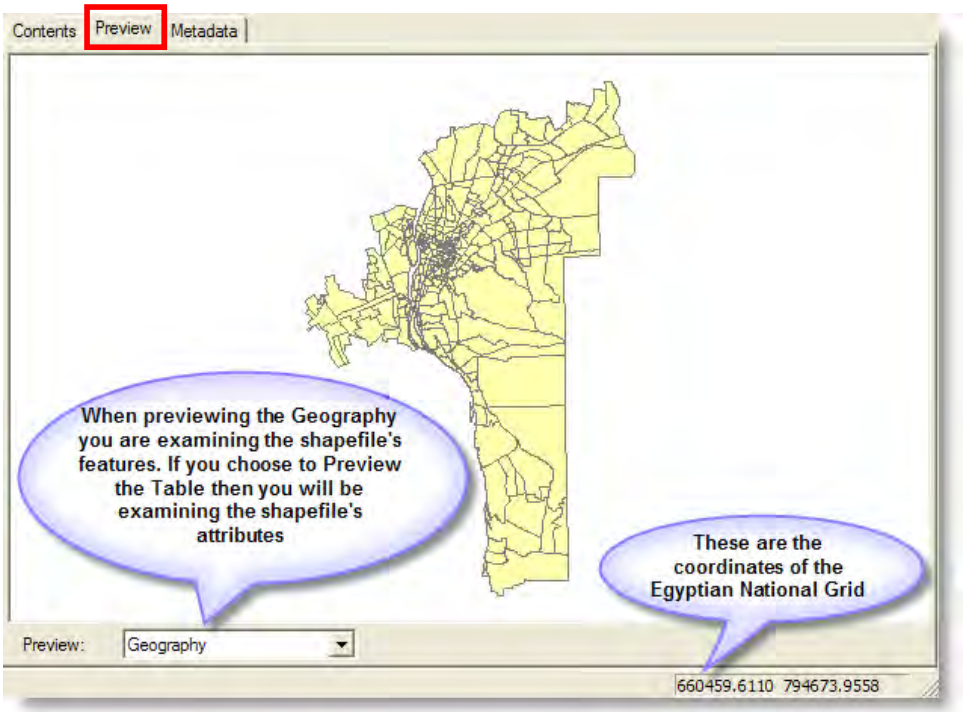


- ❑ In the Shapefile Properties dialog box click on the Fields tab.

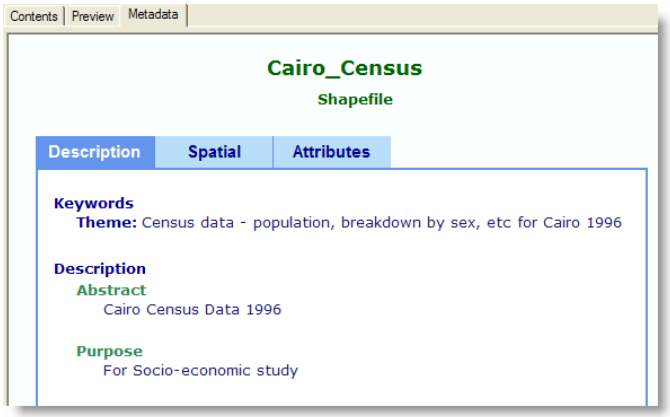
You will see a list of fields (columns) in the shapefile's attribute table. One of these fields is called 'SHAPE':



- ❑ Click on the field 'Shape' and examining the field's properties at the bottom of the dialog box answer the following questions:
- ❑ What is the Spatial Reference of the shapefile? _____
- ❑ What is the geometry of the shapefile? _____
- ❑ Click the Cancel button to dismiss the Shapefile Properties dialog box.
- ❑ In the right hand pane of ArcCatalog, click on the Preview tab. In ArcCatalog you can examine data before using it, previewing (examining) either features (Geography) or attributes (Table):



- ❑ Click on the Metadata tab. Metadata provides some background information about the dataset (if it has been completed):



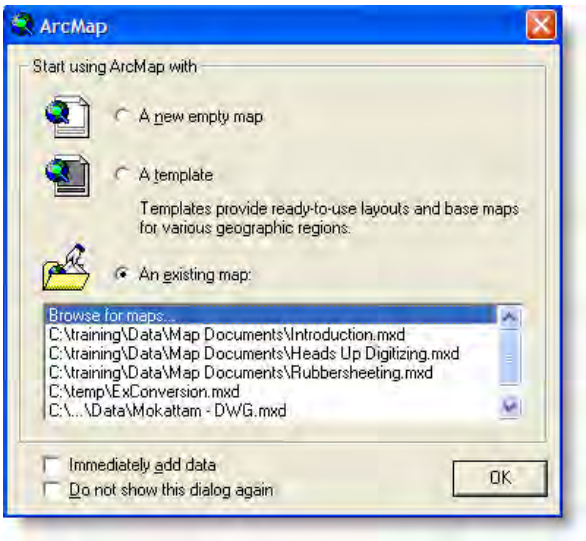
- ❑ What is the Abstract of the shapefile? _____

What is Metadata?
Metadata is information about information. It is extremely useful as it allows users to understand what data they are dealing with – its scale, age, etc which help determine whether they can use the data or not. You create Metadata in ArcCatalog. ArcGIS supports two metadata standards FGDC and ISO. These standards define a minimum set of properties that must be described when creating geographic data. Metadata is not mandatory but you should complete metadata for data that you create.

We have finished with ArcCatalog, so close the application. You will now explore ArcMap.

Step 2: Start ArcMap and explore a map document

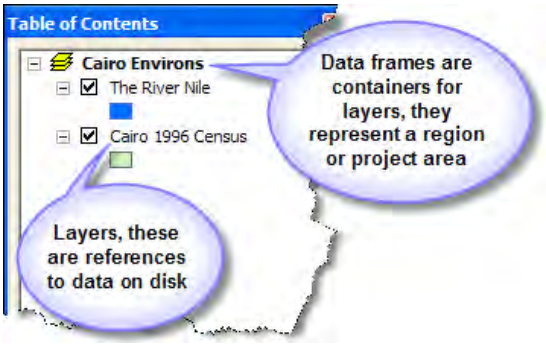
- ❑ Start ArcMap.
- ❑ When prompted choose to Start using ArcMap with 'An existing map' and double-click 'Browse for maps…':



- ❑ Navigate to the C:\TRAINING\DATA\MAP DOCUMENTS folder and open the map document 'Introduction.mxd'.

What is a Map Document?
A map document organizes your work. Map documents have the file extension MXD. Whenever you save a map document you save the current state of your work. Map documents contain data frames (containers for spatial data) and layers (references to spatial data on disk).

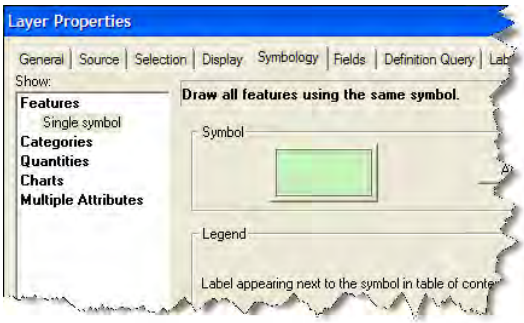
When the map document opens you will see it contains 2 layers – The River Nile and Cairo 1996 Census within a single data frame called Cairo Environs:



First you will change the symbology of the Census layer:

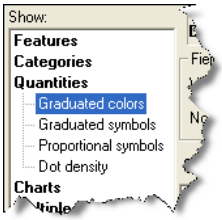
- ❑ Right click on the Cairo 1996 Census layer and choose Properties… in the context menu.

- ❑ In the Layer Properties dialog box click on the Symbology tab:

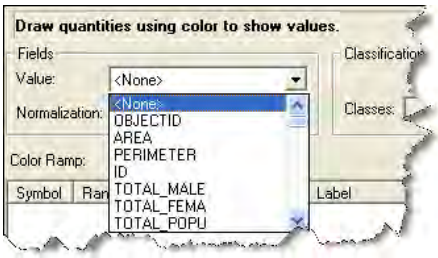


You will use a numeric legend to depict census data:

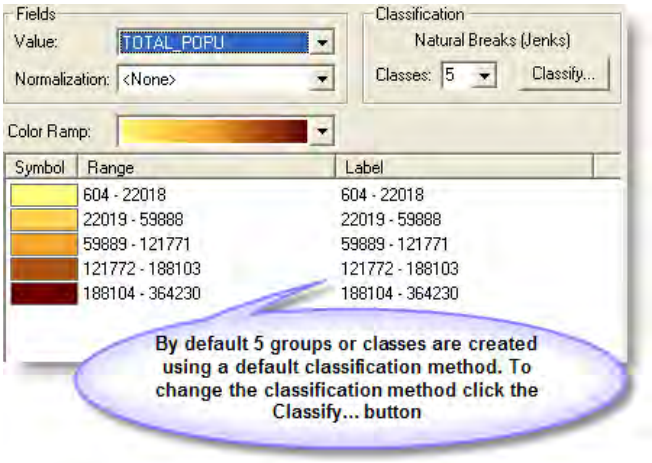
- ❑ In the Show column click 'Quantities' and accept the default numeric legend type 'Graduated Colors':



- ❑ From the Value drop-down list select the field 'TOTAL_POPU' field:



- ❑ A numeric legend based on a predefined color ramp will be create automatically:



- ❑ In the Layer properties dialog box click the OK button to apply the changes you have made and dismiss the dialog box.

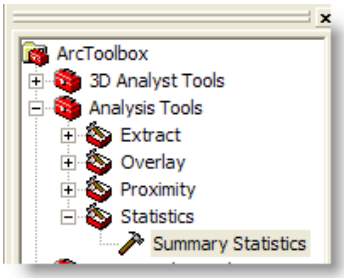
The layer will be drawn with the legend selected.

Step 3: Show ArcToolBox window and run a tool

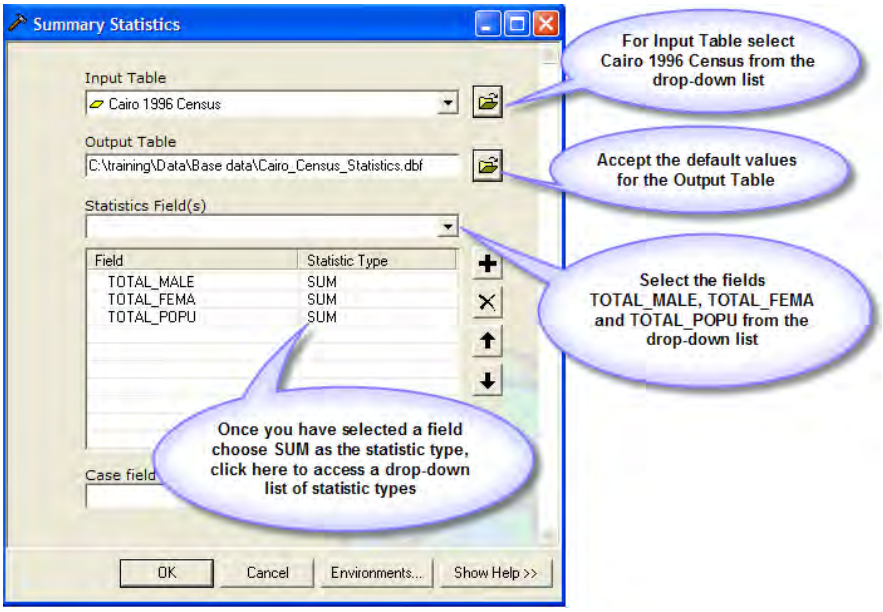
- ❑ Click the Show/Hide ArcToolBox tool to show the ArcToolBox window.

- ❑ Navigate to Analysis Tools > Statistics

- ❑ Double click on the Summary Statistics tool, this tool will create a database file that contains statistics for selected census information (e.g. the total population for Cairo):



- ❑ Complete the Summary Statistics dialog box as follows:



- ❑ Click OK to create the statistics table.

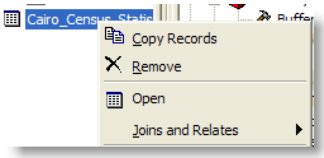
- ❑ Dismiss the Progress dialog box by clicking the Close button.

Now add the table to the map document.

- ❑ Click on the Add Data tool

- ❑ Navigate to the C:\TRAINING\DATA\BASE DATA and add the table Cairo_Census_Statistics.dbf

- ❑ Right click on the table and choose Open from the context menu:



- ❑ Examine the table, you will see that the column headings read SUM_TOTAL_ (total male), SUM_TOTAL1 (total female), SUM_TOTAL2 (total population), this corresponds to the sequence of fields in the Summary Statistics dialog box. What you have created are total figures for census data.

- ❑ Close the table and hide the ArcToolBox window by clicking the Show/Hide ArcToolBox Window.

- ❑ Close ArcMap choosing not to save your changes when prompted.

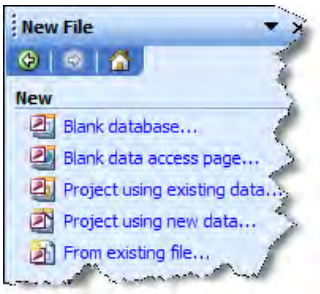
This exercise provided a brief overview of ArcMap, ArcCatalog and ArcToolBox. The subsequent exercises show you how to use ArcGIS to support out the cadastral operations methodology.

EXERCISE 2: INDEXING MUTATION FORMS

In this exercise you will learn how to create a database in MS Access to hold mutation form details recorded on the first 3 pages of a mutation form. This information relates to the property, subsequent transactions and the initial transaction. You will be required to index (record) all mutation forms for the Mokattam area (approximately 2,600 for parcels and 1,900 for apartments)

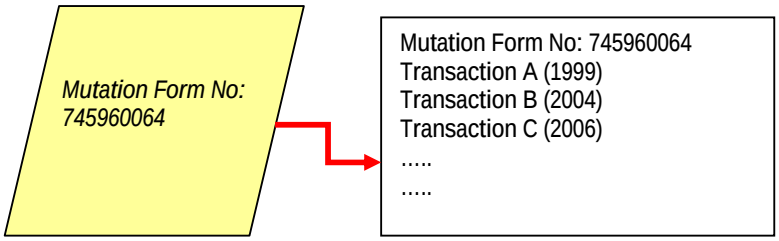
Step 1: Start MS Access, create a database and tables

- ☐ Start MS Access.
- ☐ From the File menu choose New…
- ☐ From the New File window click 'Blank Database':



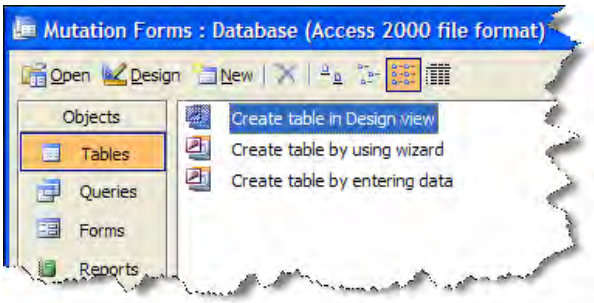
- ☐ Navigate to the C:\TRAINING\DATA\INDEXING folder and create a database called 'Mutation Forms.mdb'

You will create two tables that each shares the field 'Mutation Form Number'. One table represents the building/parcel and its initial creation as a result of a transaction (e.g. a sale). The other table represents subsequent transactions against the building/parcel. This is described as a 1: M (one to many) relationship type in other words *one property: many transactions*:



Key fields, cardinality and understanding relationships
In a relational database management system (RDBMS) tables which store information are linked by use of primary key fields (i.e. fields common to both that contain unique values and are not null). The number of matching rows in linked tables is known as cardinality. For example Table A may have a single row that matches many rows in Table B (hence 1: M). Examples of cardinality are 1:1, M: 1, 1: M and M: M. The type of relationship is important as it determines what command is used in ArcGIS when linking tables together, more later.

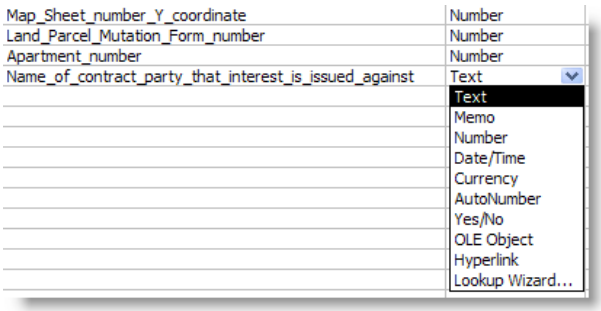
- ☐ In the 'Mutation forms: Database…' window double-click 'Create table in Design view':



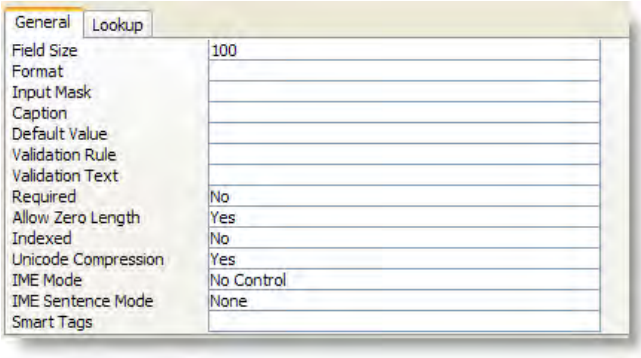
- ☐ In Design View, add the following fields (*Note:* the Type and Size columns list the properties to be set for each field you add). You must use underscores between words as no spaces are allowed in ArcGIS:

Name	Type	Size
Mutation_form_number	Long Integer	4
Governorate	Text	100
Town_City	Text	100
District	Text	100
Block_Name	Text	100
Block_Number	Long Integer	4
Street_Name	Text	100
Land_Parcel_number	Long Integer	4
Building_number	Long Integer	4
Map_Sheet_number_X_coordinate	Double	8
Map_Sheet_number_Y_coordinate	Double	8
Land_Parcel_Mutation_Form_number	Long Integer	4
Apartment_number	Long Integer	4
Name_of_contract_party_that_interest_is_issued_against	Text	200
Name_of_contract_party_that_interest_is_issued_to	Text	200
Third_party_to_contract	Text	200
Type_of_transaction	Text	200
Transaction_Application_number	Long Integer	4
Transaction_Application_Year	Text	50

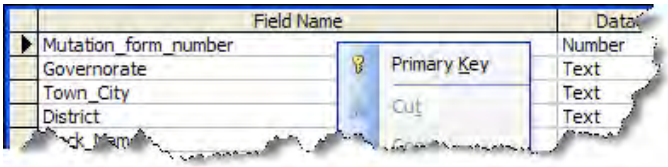
- ☐ To add a field simply type in the name as shown above, and set a data type from the drop down list:



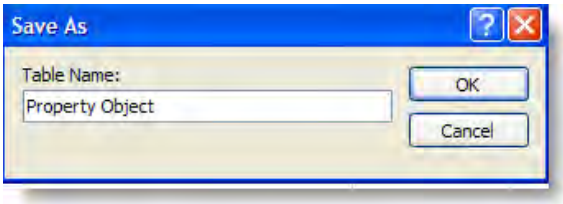
- ☐ Next set the properties for the field at the bottom of the table properties window:



- ☐ Once you have added the fields, set the Mutation_form_number field as the Primary Key by right clicking on the 'Mutation_form_number' field and choosing 'Primary Key' from the context menu:



- ☐ Next save the table. From the File menu choose Save and type in 'Property Object' as the table name:



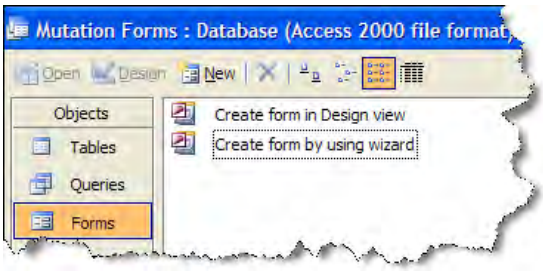
- ☐ Create another table and add fields as follows (the Type and Size columns list the properties for each field). Notice the table also contains the field Mutation_form_number, but this should *not* be set as the Primary Key as it will not be unique i.e. there will be many records with the same mutation form number. Instead set the Transaction_ID field (an *AutoNumber* data type) as the Primary key:

Name	Type	Size
Transaction_ID	Long Integer	4
Mutation_form_number	Long Integer	4
Contract_Registration_number	Long Integer	4
Date_of_Contract_Registration	Date/Time	8
Grantor	Text	200
Grantee	Text	200
Third_party_to_contract	Text	200
Type_of_transaction	Text	200
Transaction_Application_number	Long Integer	4
Transaction_Application_Year	Text	50

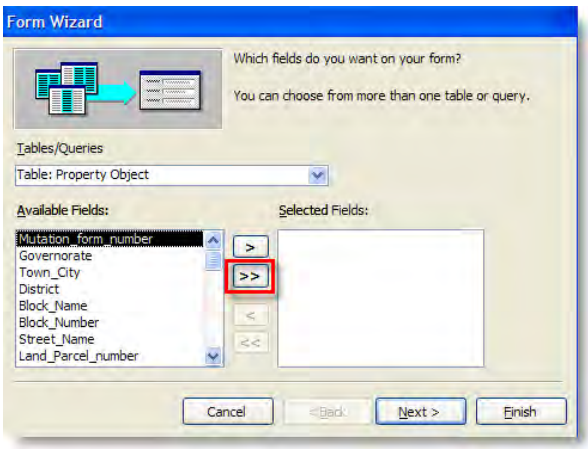
☐ Save this table as ‘Subsequent Transactions’.

To facilitate data entry you will create two forms using the two tables you have just created:

☐ In the ‘Mutation Forms: Database….’ window click on ‘Forms’ and double-click ‘Create form by using wizard’:

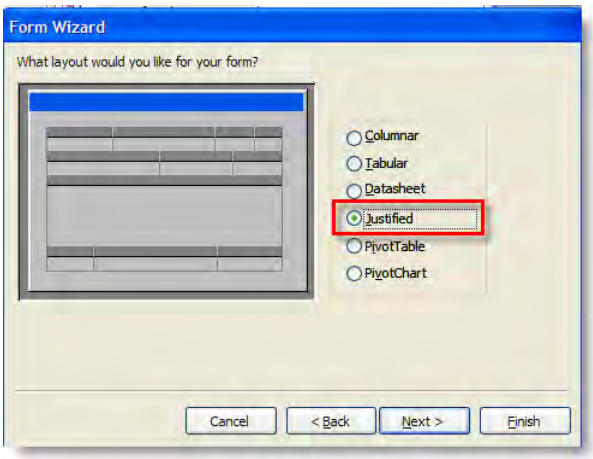


☐ In the first dialog box, select the Table: Property Object and choose to include all fields in the form by clicking the **>>** button:



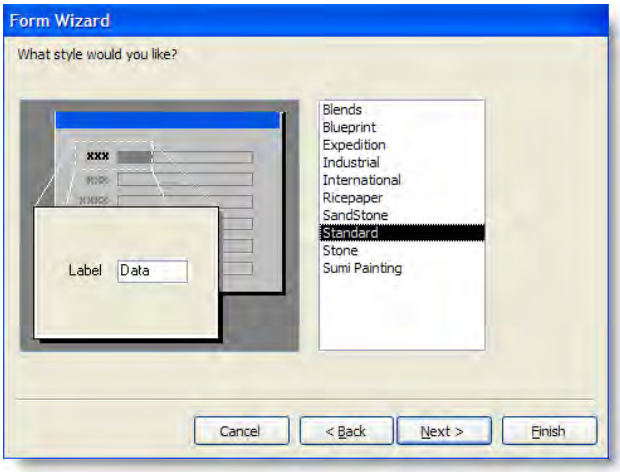
☐ Click Next > to continue.

☐ For the Layout choose ‘Justified’:



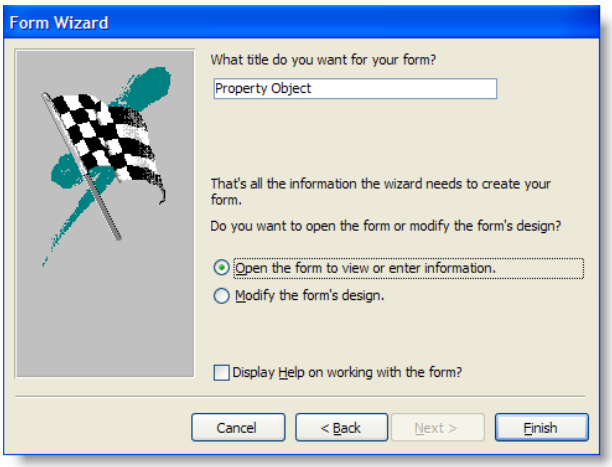
☐ Click Next > to continue.

☐ For style accept the default ‘Standard’:



☐ Click Next > to continue.

☐ Accept the default name for the form ‘Property Object’:



☐ Click Finish to create the form.

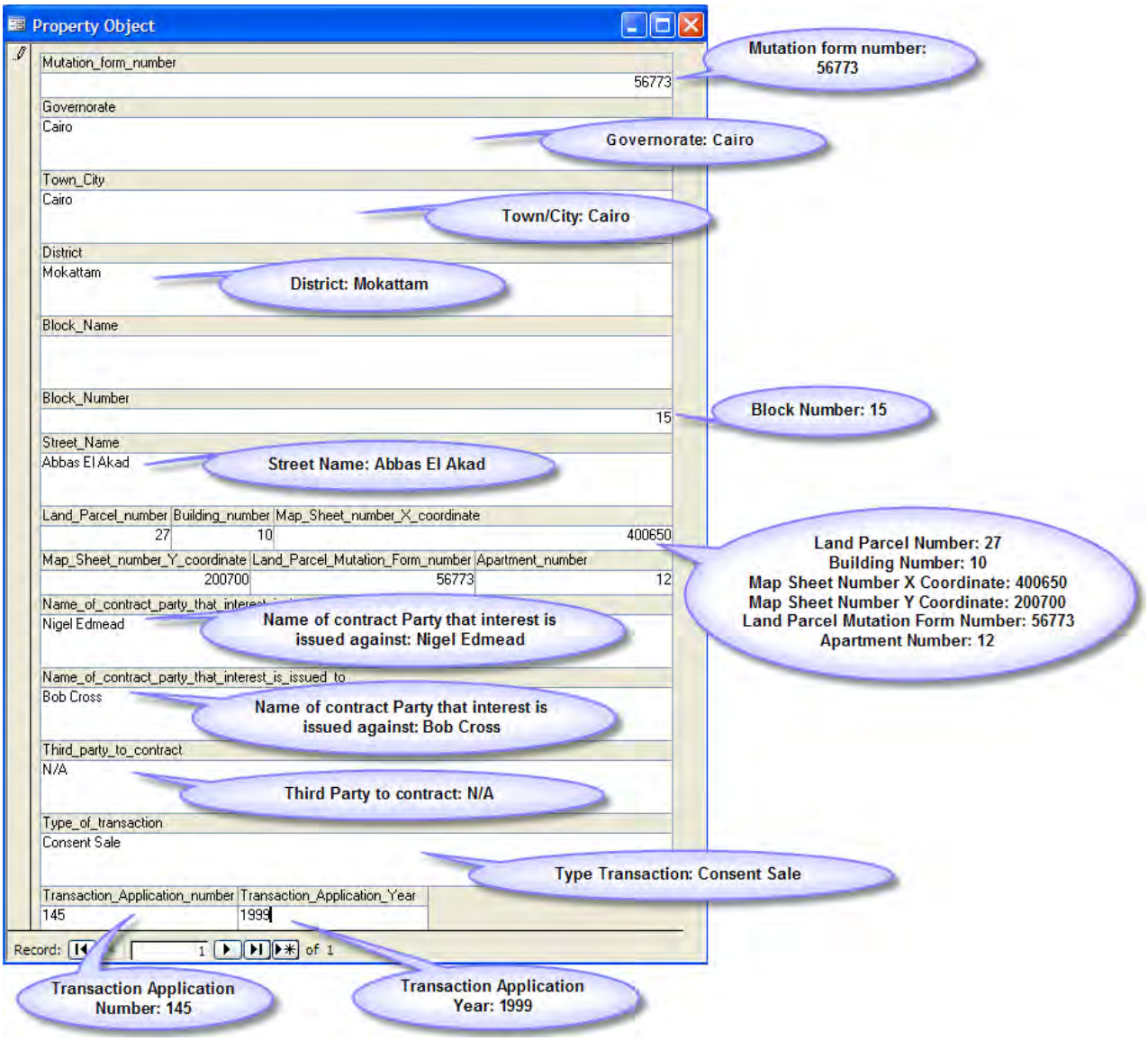
☐ Close the form and repeat the step for the ‘Table: Subsequent Transactions’ using the same settings for the Property Object form.

You are now ready to start entering values.

NOTE: Once these forms and tables have been created you do not have to repeat these steps; you can simply add record values by opening the required form.

Step 2: Add records using forms

☐ Complete the 'Property Object' form as follows:



- ☐ Add two records to the ‘Subsequent Sales’ form as follows:

Mutation form number	Contract Registration number	Date of Contract Registration	Grantor	Grantee	Third party to contract	Type of transaction	Transaction Application number	Transaction Application Year
56773	156	09/09/2004	Bob Cross	Fatma Kader	Nigel Edmead	Consent Scale	156	2004
56773	199	01/01/2006	Fatma Kader	Ali Abd Salam	Bob Cross	Consent Sale	201	2006

You have now completed indexing a sample mutation form and will see in a later exercise how to link this information to features in ArcMap.

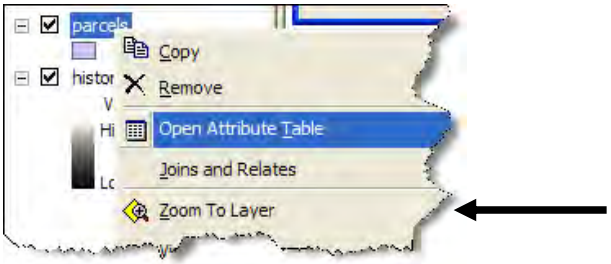
EXERCISE 3: GEOREFERENCING RASTER DATA

In this exercise you will learn how to georeference an unregistered image in ArcGIS.

- ☐ Start ArcMap and choose to open a new map document.
- ☐ Click on the Add Data tool in the application GUI.

Step 1: Load the data files

- ☐ Navigate to C:\TRAINING\DATA\GEOREFERENCING and add the following files: parcels.shp, streets.shp and historic.tif.
- ☐ If you receive a message about missing spatial information, you can ignore this message and continue by clicking OK.
- ☐ Select the Parcels layer and clicking on the right hand button of the mouse, choose Zoom to Layer from the context menu:

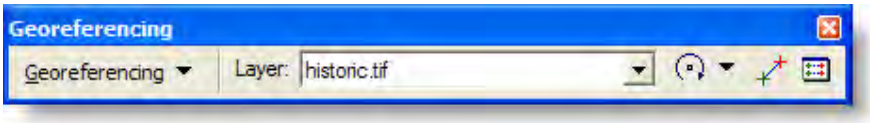


Notice the image does not sit beneath the parcels. Since the parcels layer *does* have a spatial reference defined you will use it to register the image.

- ☐ In the Tools toolbar click on the Full Extent tool , while you can't see anything very clearly the image is located in the bottom left of the display, the parcels in the top right.
- ☐ Select the image layer (historic.tif) and clicking on the right hand button of the mouse, choose Zoom To Layer.

Now you can see the image.

- ☐ From the View menu choose Toolbars and select Georeferencing to enable the Georeferencing toolbar:

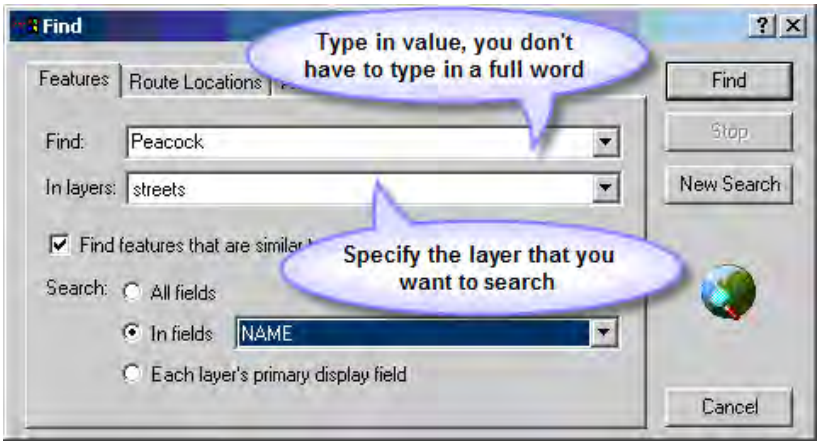


- ☐ From the Window menu choose Overview. The overview window displays whatever currently appears in the map display. You may want to move the Layers Overview window out of the way so you can see the image clearly.

Notice that placed on the image are 4 registration points, identified numerically as 601, 602, 610 and 473. These are found at street intersections.

- ☐ From the Edit menu choose Find…

- ☐ In the Find Box type ‘Peacock’.
- ☐ Under ‘In Layers’ choose the Streets layer from the drop-down list.
- ☐ Under Search click ‘In fields’ and choose NAME from the drop-down list:



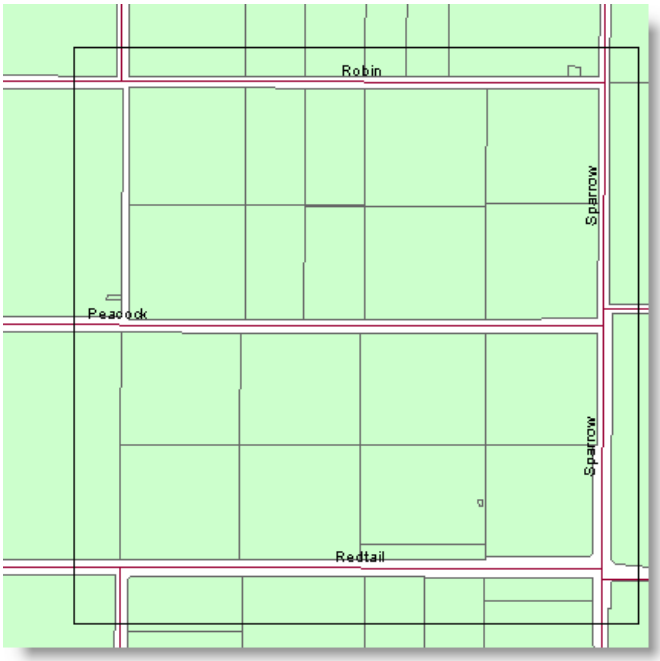
- ☐ Click the Find button. A single street is found. Right-clicking on the street, choose Zoom to feature(s). Dismiss the Find dialogue box.

Since you can’t really see which street is Peacock Street you will label the layer.

- ☐ Select the Streets layer and clicking on the right hand button of the mouse choose Label from the context menu.

You can now see which street is Peacock Street.

- ☐ Zoom into the area that corresponds to the 4 street intersections on the image:



- ☐ Turn off the Parcels layer

Step 2: Georeference the image

You are now ready to register the image.

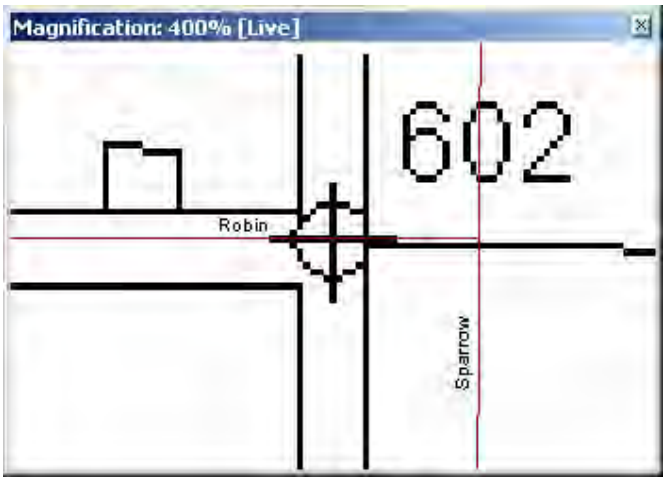
- ☐ In the Georeferencing toolbar make sure the Layer is set to Historic.tif:

- ☐ Click the Georeferencing dropdown arrow and choose 'Fit to display'.

ArcMap scales the image to fit the current window. You will notice that even though the image has been scaled the registration points do correspond exactly with the street intersections in the streets layer.

- ☐ Close the Overview window and from the Window menu choose Magnifier.

- ☐ Move the Magnification window over registration point 602, you will see the street intersection and registration point are offset:



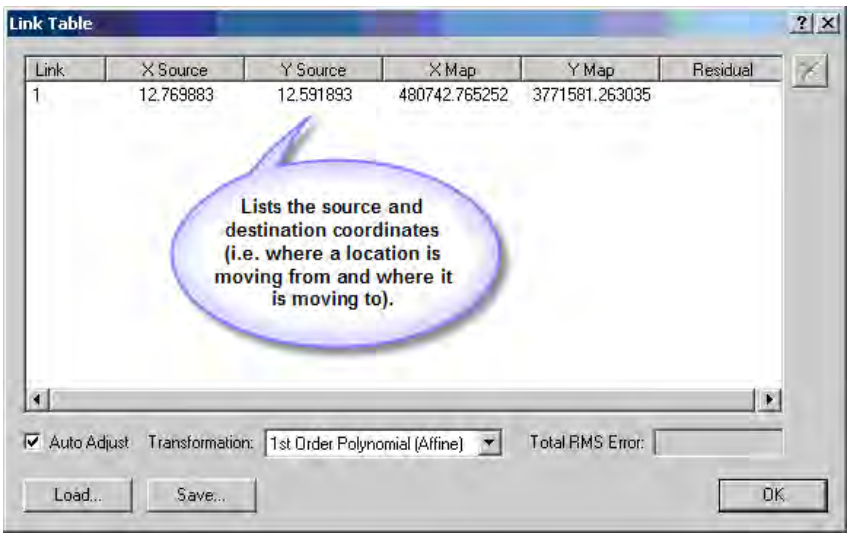
- ☐ From the Georeferencing toolbar click the Add Control Points tool:

- ☐ In the Magnification window, centre the Add Control Points tool's cursor over the registration point on the image and then click and drag a link to the street intersection in the streets layer. The link will be shown by a green line. Remember click on the image registration point first, then the street intersection.

You will notice that the image is scaled.

- ☐ You can examine the control point you have just added. From the Georeferencing toolbar click the View Link Table tool:

The Link Table window shows the image coordinates and corresponding map coordinates:



- ☐ Now continue with the other three registration points in the same manner described above. *Note* you will have to move the Magnification window over each registration point in turn and tie it to the appropriate intersection. Each time you do this the image will be scaled.

When you have completed the 3 other points you are now ready to register the image.

- ❑ From the Georeferencing drop-down menu choose Update Georeferencing to save the new registration. An AUX file is written to the directory where the image file is stored which now contains spatial reference information.

You don't need the control points anymore.

- ☐ From the Georeferencing drop-down menu choose Delete Control Points.

- ☐ Since you have finished save the map document in your C:\TEMP directory as **ExGeoferencing.mxd**.

EXERCISE 4: SPATIAL ADJUSTMENT

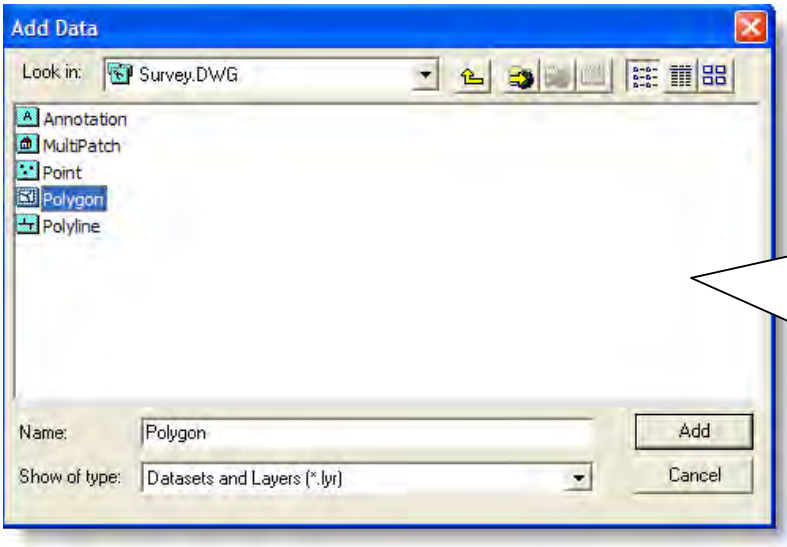
In this exercise you will learn how to convert CAD data into an editable ArcGIS format and adjust the data from local coordinates to coordinates of the Egyptian Transverse Mercator (ETM) projection.

☐ Start ArcMap and choose to open a new map document.

Step 1: Load a CAD feature dataset

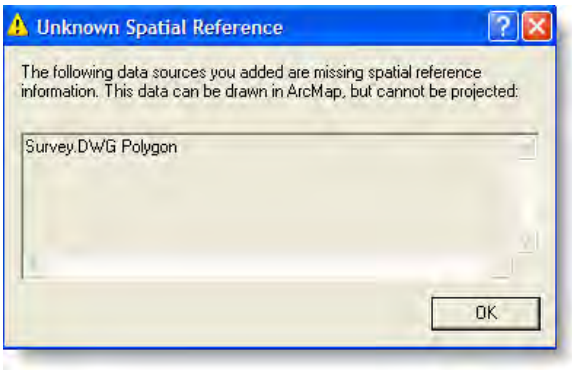
☐ Click on the Add Data tool in the application GUI

☐ Navigate to C:\TRAINING\DATA\CAD directory and add the 'Polygon' Feature Class from the *CAD feature dataset* Survey.DWG:



CAD Feature Dataset vs. CAD Drawing File, what's the difference? A CAD Feature Dataset represents entities converted to ArcGIS feature classes. A CAD Drawing is equivalent to an image; it cannot be symbolized, queried or exported.

☐ You will get a warning message that the layer lacks a spatial reference, do not worry at this point and click OK to continue:



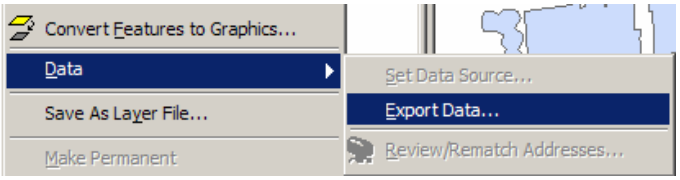
The CAD polygon feature class will be added to the map document.

You are looking at parcel outlines generated in AutoCAD. As you move the cursor over the map you will notice the coordinates do not reflect the coordinates of the Egyptian national grid (and may be reported as decimal degrees). This is because the data has been captured using local coordinate system:

You will correct the coordinate problem by applying a transformation but because you need to be editing the source data to do this and you cannot edit CAD directly data within ArcGIS you will first convert the CAD file to a shapefile.

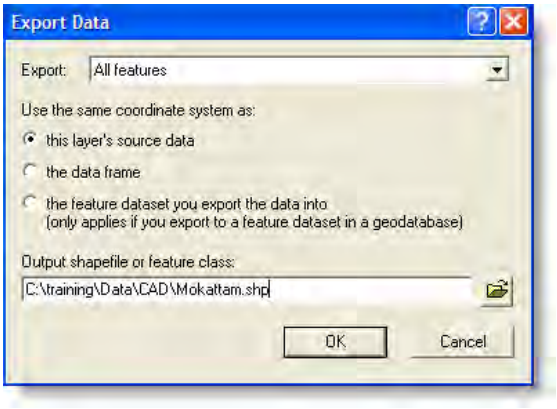
Step 2: Convert the CAD layer to a Shapefile

- ☐ Right click on the Survey.dwg Polygon layer in the table of contents and choose Data > Export Data… from the context menu:

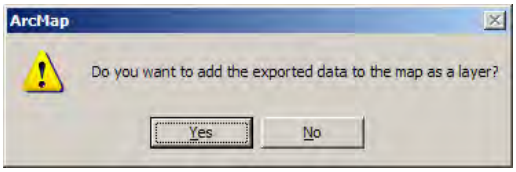


- ☐ In the Export Data dialog box, accept the default setting for 'Use the same coordinate system as: this layer's source data'.

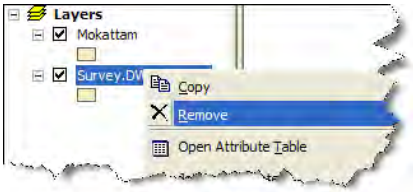
- ☐ For the 'Output shapefile or feature class' create a new shapefile called 'Mokattam.shp' in the C:\TRAINING\DATA\CAD folder, you can either use the browse button or type in the directory path yourself:



- ☐ Click OK to continue.
- ☐ After the conversion process is complete and when prompted, choose to add the shapefile to the map document:



- ☐ Since you no longer need to the drawing file, right click on the Survey Polygon.DWG layer and choose Remove from the context menu:

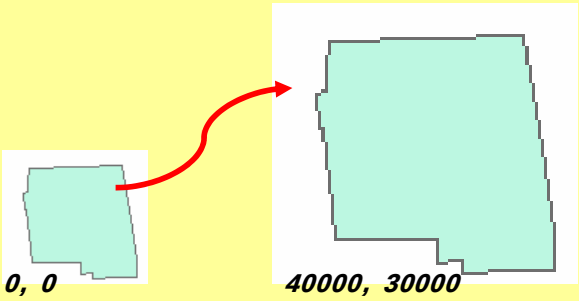


You have successfully converted the CAD file to a shapefile; you could have done this in ArcToolBox and ArcCatalog as well. This data can now be edited which means in can be adjusted.

Step 2: Perform spatial adjustment

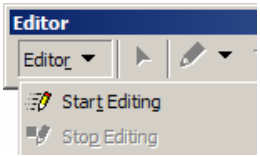
You can correct the coordinate information of vector data in ArcMap by applying a transformation, but this has to be done within an edit session.

What's a transformation?
A geometric transformation that scales rotates, skews, and/or translates images or coordinates between any two Euclidean spaces. It is commonly used in GIS to transform maps between coordinate systems for example between a local CAD coordinate system and a real world coordinate system such as the Egyptian Transverse Mercator:



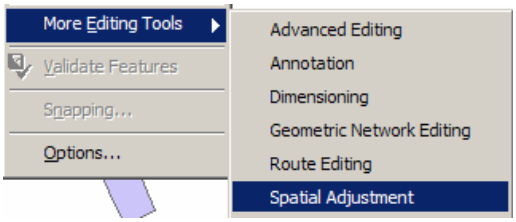
- ☐ Click the Editor Toolbar tool to enable the Editor Toolbar (if not visible already).

- ☐ From the Editor drop-down menu in the Editor toolbar choose Start Editing:

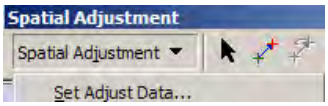


- ☐ If displayed ignore the warning message relating to different coordinate systems, clicking Start Editing to continue.

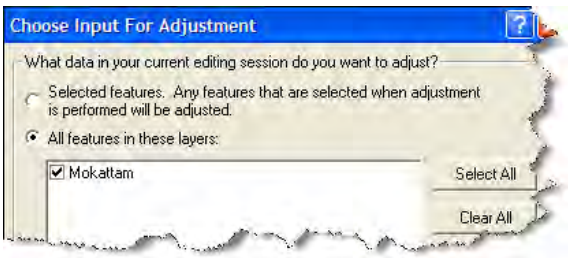
- ☐ From the Editor tool bar choose More Editing Tools > Spatial Adjustment to enable the Spatial Adjustment toolbar (if it is not visible already):



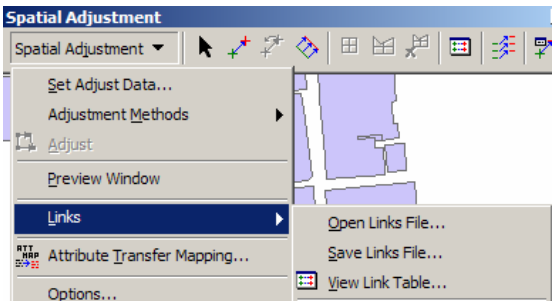
- ☐ From the Spatial Adjustment drop-down menu choose Set Adjust Data…:



- In the Choose Input for Adjustment dialog box check on the option 'All Features in these layers' for Mokattam.shp. Click OK to dismiss the dialog box:



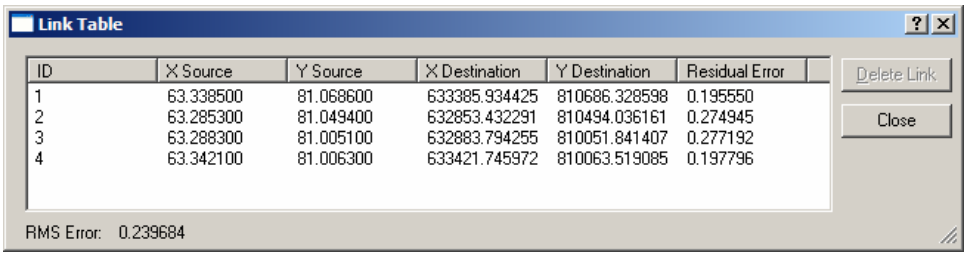
- From the Spatial Adjustment drop-down menu choose Links > Open Links File…:



- Browse to the directory C:\TRAINING\DATA\CAD and open the file 'Mokattam_Transformation.txt'. This contains a set of source and destination coordinates, allowing you to transform the data from local coordinates of the CAD drawing to the coordinates of the Egyptian Transverse Mercator.

How can you add displacement links?
There are three ways of adding displacement links, i.e. source and destination coordinates: (i) Manually, you locate both source and destination points interactively (ii) Using a Control Points file which contains destination coordinates these are known locations, you add the source coordinates interactively (iii) Using a Links File in which both source and destination coordinates are known. This method is shown in this exercise

- From the Spatial Adjustment drop-down menu choose Links > View Links Table... to view these coordinates and the residual errors for each point and an average for all 4 points:



ID	X Source	Y Source	X Destination	Y Destination	Residual Error
1	63.338500	81.068600	633385.934425	810686.328598	0.195550
2	63.285300	81.049400	632853.432291	810494.036161	0.274945
3	63.288300	81.005100	632883.794255	810051.841407	0.277192
4	63.342100	81.006300	633421.745972	810063.519085	0.197796

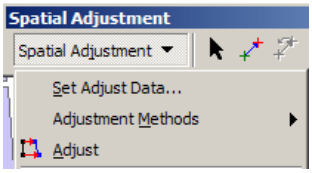
- ☐ Question: What is the overall RMS? _____ meters (the coordinates of the ETM coordinate system)

What does RMS mean and what's an acceptable value?
RMS stands for Root Mean Square. It is a measure of the difference between locations that are known and locations that have been interpolated or digitized. RMS error is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result. (Source: GIS Dictionary, ESRI). For the purposes of the project an acceptable RMS = (source scale * 0.02) e.g.:

Scale	*RMS (in meters)*[1, 2]
1:1,000	0.2 – 0.4
1:10,000	2 - 4
1:50,000	10 - 15
1:100,000	20 - 50

Notes:
1: The RMS will always be in metres as these are the units of the Egyptian Transverse Mercator coordinate system
2: The higher RMS figure is for less accurate data (e.g. CAD drawings acquired from New Communities of unknown history) for which low RMS readings may be impossible to attain

- ☐ From the Spatial Adjustment drop-down menu choose Adjust:



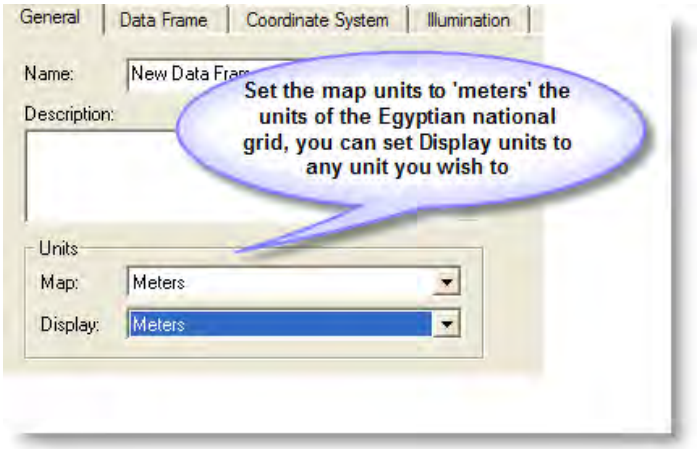
Immediately the features will be shifted to a different location and will no longer be visible in the display.

- ❑ Before zooming the layer's new location, choose Stop Editing from the Editor drop-down menu. Save your edits when prompted.
- ❑ Right click on the 'Mokattam' layer and choose Zoom to Layer from the context menu.

While the coordinate values are now correct (i.e. in meters), they may still appear to be reported as decimal degrees, to correct this problem change the units of the data frame.

- ☐ Right-click on the Layers data frame in the table of contents and choose Properties… from the context menu.

- ☐ Under the General tab, change the Map and Display Units to 'Meters':



- ☐ Click OK to apply the changes and dismiss the dialog box. The readings in the status bar will now be correct.

- ☐ Since you have finished save the map document in your C:\TEMP directory as **ExAdjustment.mxd**.

EXERCISE 5: RUBBERSHEETING

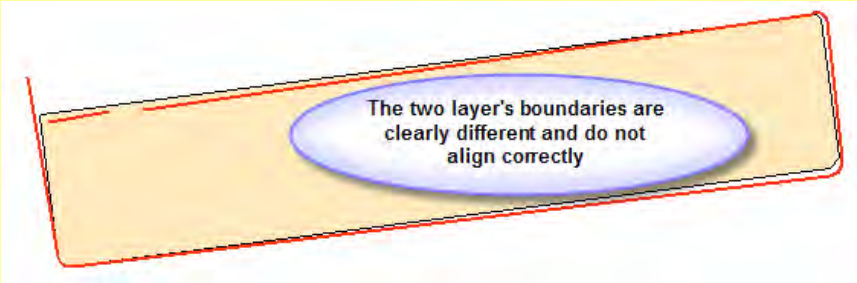
In this exercise you will learn how perform rubbersheeting using the Spatial Adjustment toolbar in ArcMap.

☐ Start ArcMap.

Step 1: Open a map document and examine problem areas

☐ First open an existing map document. Navigate to C:\TRAINING\DATA\MAP DOCUMENTS and open the map document Rubbersheeting.mxd.

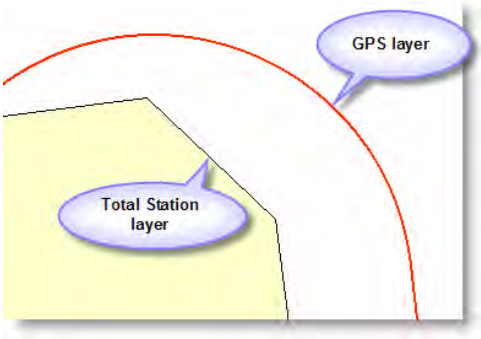
Mis-matching features and rubbersheeting
This map document shows some of the common problems you will encounter when combining data together (be it old and new data or data collected using different collection methods). In this example a block boundary has been surveyed using GPS and Total Station. You will notice there is clearly a discrepancy between the two boundaries. A decision has to be made as to which one is more accurate. Generally the answer would be Total Station. In this exercise you will move the features in the GPS layer to the features in the Total Station layer by means of rubbersheeting.



In this exercise you will use a control points file to perform the adjustment. A control points file has been saved for you. This lists destination coordinates (these are taken from the Total Station data). You will have to identify the source coordinates in the GPS layer and add displacement links interactively so as to adjust the GPS layer to the more accurate Total Station layer.

First use a saved bookmark to examine a problem area.

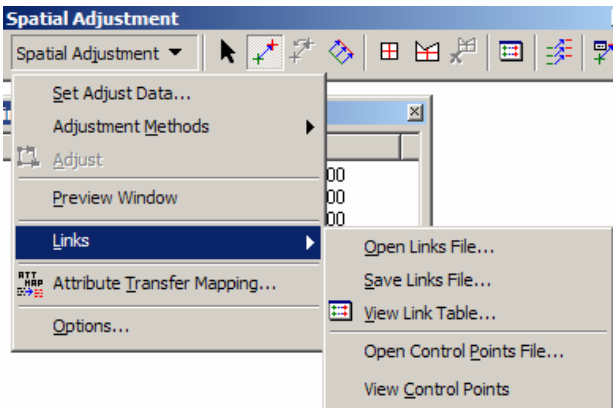
☐ From the View menu choose Bookmarks > Error 1, you will see that neither boundary aligns correctly:



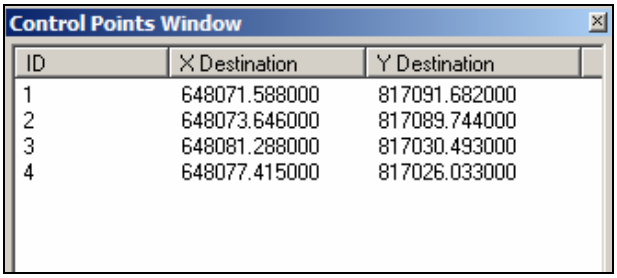
Step 2: Load a control points file

To perform rubbersheeting you must be editing:

- ☐ Enable the Editor toolbar (if it is not already visible).
- ☐ From the Editor menu choose Start Editing.
- ☐ From the Editor menu choose More Editing Tools > Spatial Adjustment to enable the Spatial Adjustment toolbar (if it is not visible already).
- ☐ From the Spatial Adjustment menu choose Links > Open Control Points File….:



- ☐ Navigate to the folder C:\TRAINING\DATA\RUBBERSHEETING and open the text file Block Coordinates.txt
- ☐ The file will open in a window in the map document:



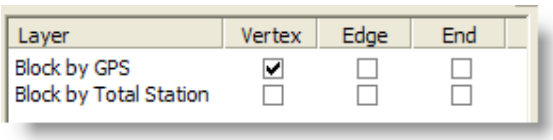
Control Points Window

ID	X Destination	Y Destination
1	648071.588000	817091.682000
2	648073.646000	817089.744000
3	648081.288000	817030.493000
4	648077.415000	817026.033000

This file list the destination coordinates for the displacement links you are about to add interactively. These coordinates are taken from the more accurate Total Station Layer.

Displacement links adhere to the current snapping environment, so before proceeding set the snap environment so that displacement links snap to the GPS layer:

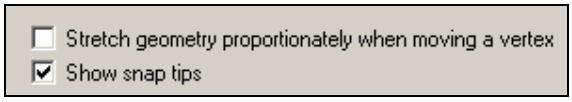
- ☐ From the Editor menu choose Snapping…
- ☐ Check on the layer snapping option Block by GPS > Vertex



- ☐ Close the Snapping Environment window

To see when you have snapped to the correct location in the GPS layer turn on Snap tips:

- ☐ From the Editor menu choose Options…
- ☐ Check on the option 'Show snap tips':

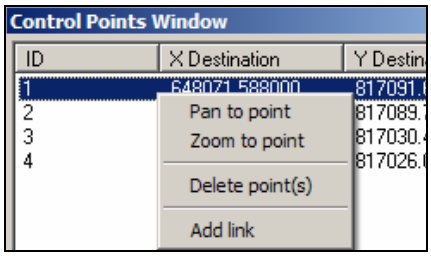


You are now ready to add displacement links.

Step 3: Add displacement links

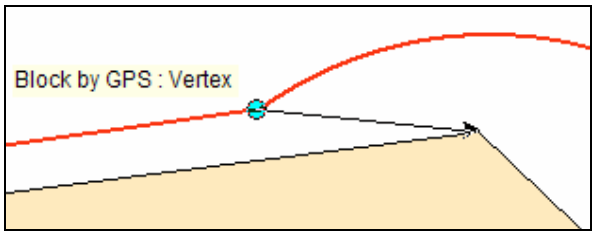
To add displacement links right click on a coordinate in the Control Points Window and choose Add Link then place a source coordinate interactively. You will place a source coordinate on the GPS layer.

- ☐ Right click on the control point ID 1 and choose Add Link from the context menu:

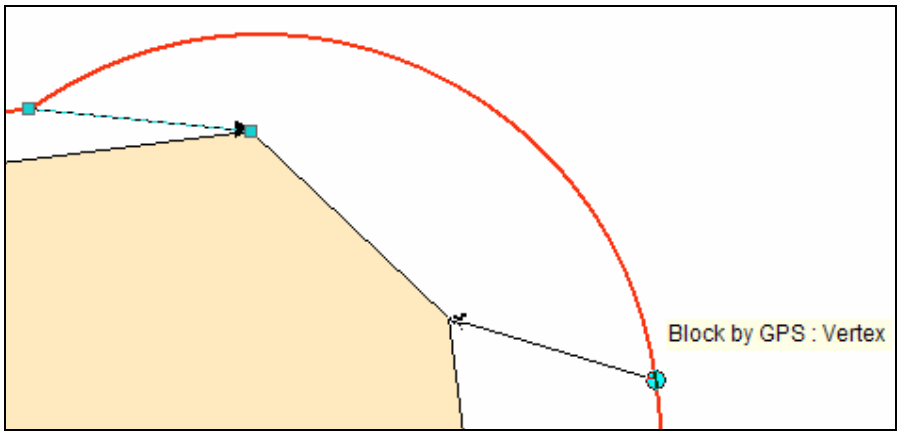


- ☐ You will see a displacement link appear in the display which points to the Total Station layer i.e. this is where a source coordinate will move to.

- ☐ Move the cursor away from the Total Station layer towards to the GPS layer until the snap tip reports 'Block by GPS: Vertex':



- ☐ Click the left hand button of the mouse to place the displacement link.
- ☐ Repeat the step for the control point 'ID 2' as shown below:

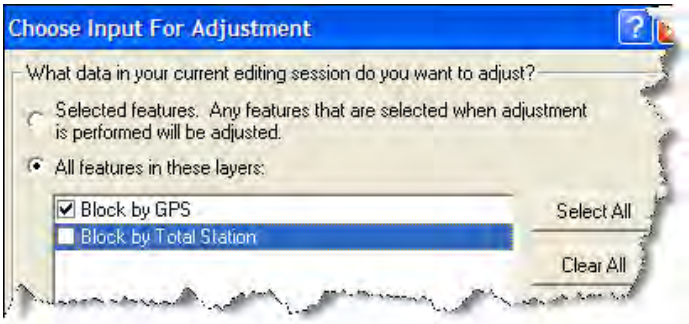


Now you have added the displacement links you can perform rubbersheeting.

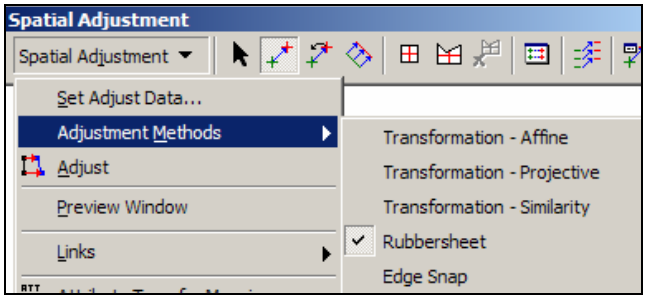
Step 4: Perform rubbersheeting

First set the spatial adjustment options:

- ☐ From the Spatial Adjustment menu choose Set Adjust Data…
- ☐ Check the option All features in these layers > Block by GPS:

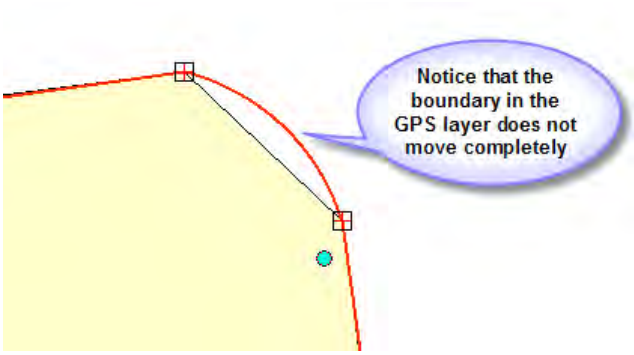


☐ From the Spatial Adjustment menu choose Adjustment Methods > Rubbersheet:



Now perform the adjustment.

☐ From the Spatial Adjustment menu choose Adjust. The GPS layer will align partially to the Total Station layer:



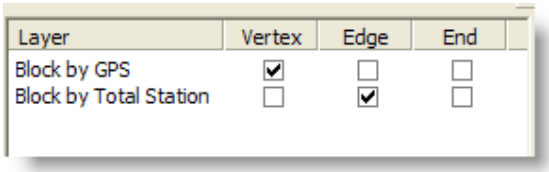
Since the alignment is partial, some more editing is required.

Step 5: Reshape the GPS Layer

You will use the Reshape task to alter the GPS layer so that the boundary matches the Total Station layer.

☐ From the Editor menu choose Snapping…

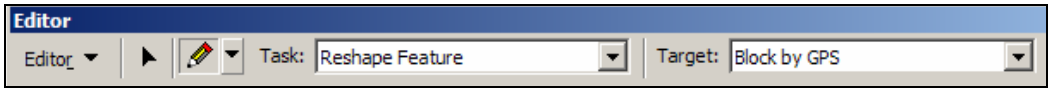
☐ Check on the option Block by Total Station > Edge:



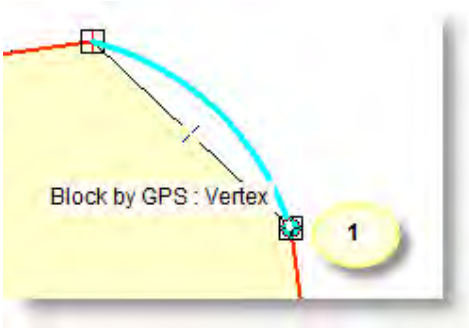
Layer	Vertex	Edge	End
Block by GPS	☑	☐	☐
Block by Total Station	☐	☑	☐

- ☐ Use the Edit tool in the Editor toolbar to select the GPS layer feature that is still not aligned with the Total Station layer:

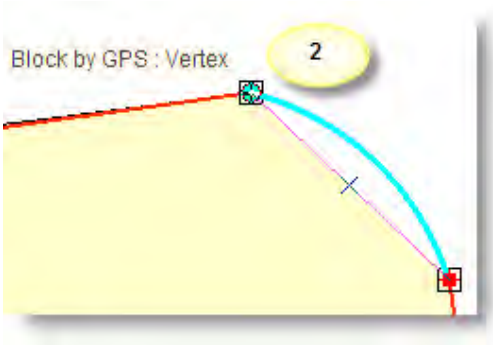
- ☐ In the Editor toolbar set the Task to 'Reshape Feature' and ensure the Layer is set to 'Block by GPS':



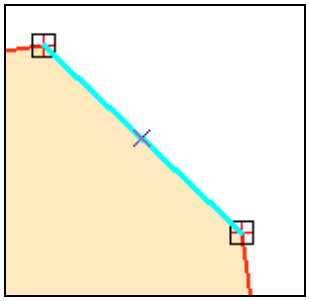
- ☐ Click on the Sketch tool and move over Identity link 1 as shown below, click once to start drawing a reshape line:



- ☐ Follow along the Total Station layer edge (you will snap to it) and when you reach the Identity link 2 as shown below, double click to finish:



The GPS boundary will be reshaped and now match the Total Station boundary:



You have successfully adjusted the boundary of the GPS layer to match the Total Station layer.

- ☐ From the Editor menu choose Stop Editing, when prompted choose to save your edits.
- ☐ Close ArcMap choosing to save your changes when prompted.

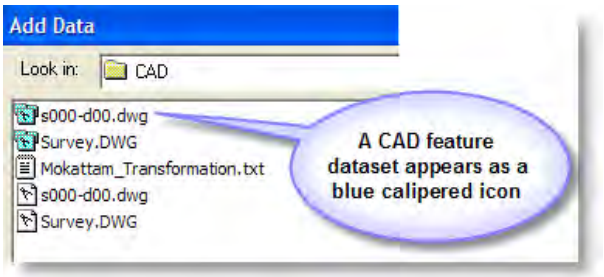
EXERCISE 6: CREATING PARCELS FROM CAD POLYLINES

In this exercise you will trace CAD polylines to create shapefile polygons. You will use the tools described here to process both existing CAD data as well as new data created from field surveying.

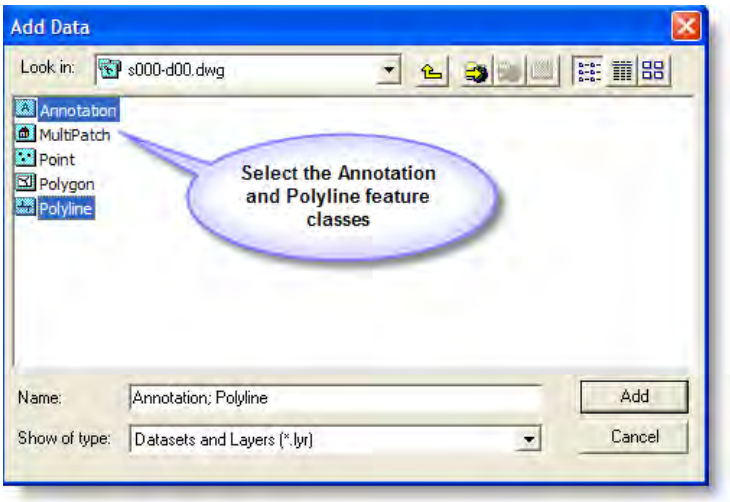
- ☐ Start ArcMap and choose to open a new map document.
- ☐ Click on the Add Data tool in the application GUI.

Step 1: Load CAD entities and create a new shapefile

- ☐ Navigate to C:\TRAINING\DATA\CAD directory and open the CAD feature dataset s000-d00.dwg:



- ☐ Using the SHIFT key select the 'Polyline' and 'Annotation' feature classes and click Add:

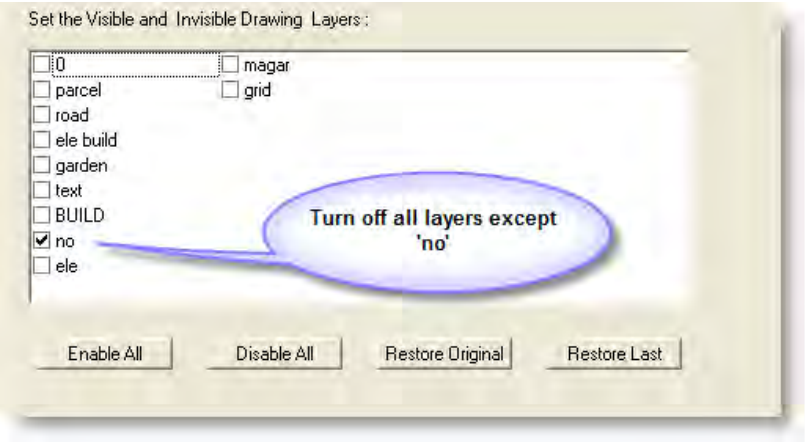


- ☐ Zoom into the lower right hand corner of the CAD drawing:

Here you'll find a number of parcels that will be digitized using the Trace tool. However, before digitizing turn off some of the annotation as the Arabic text is not being displayed correctly.

- ☐ Right click on the s000-d00.dwg Annotation layer and choose Properties… from the context menu.

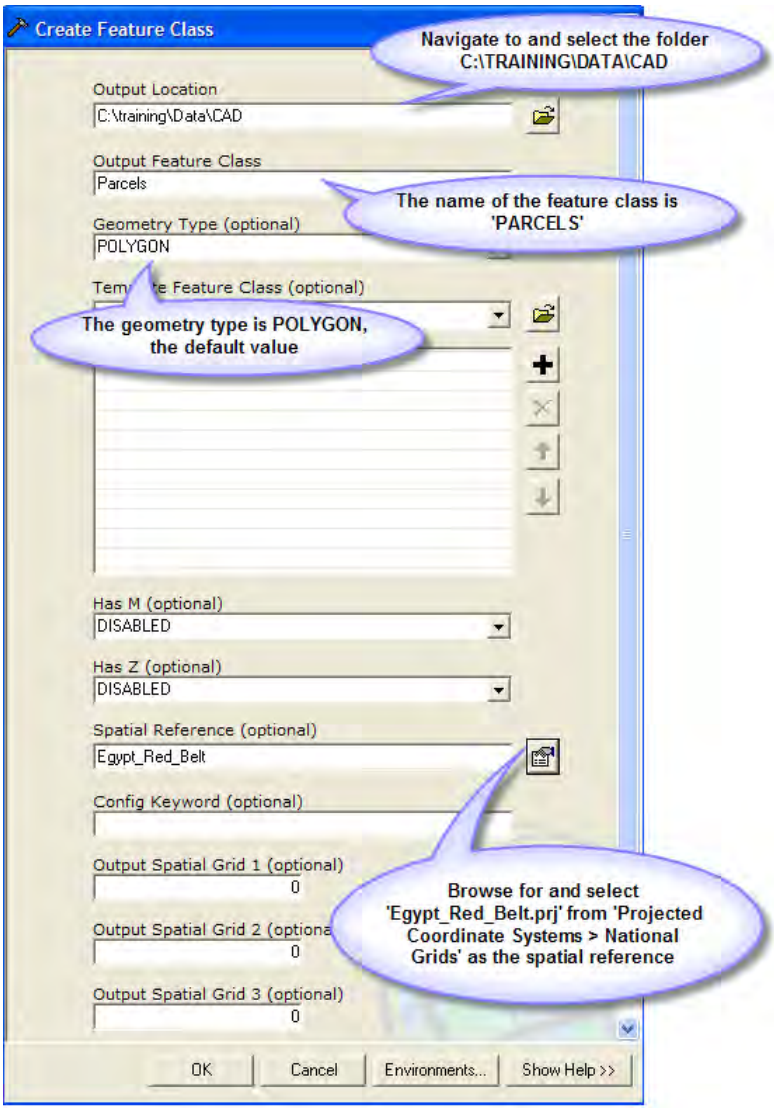
- ☐ Click in the 'Drawing Layers' tab and turn off all layers except 'no', which is the parcel identifier layer and click the OK button in the Layer Properties dialog box:



- ☐ Enable the ArcToolBox window by clicking the Show/Hide ArcToolBox tool (if it is not enabled already).

☐ Navigate to Data Management > Feature Class toolset:

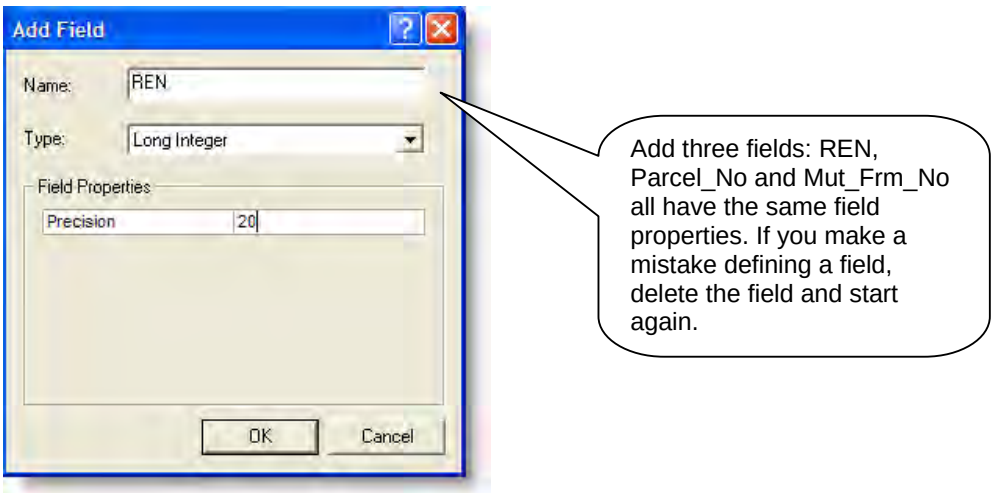
☐ Double click on the Create Feature Class tool and complete the Create Feature dialog box as follows:



- ☐ Click OK to create the new feature class and click the Close button to dismiss the Progress dialog box.

Next add a parcel identifier field:

- ☐ Right click on the Parcels layer in the map document's table of contents and choose 'Open Attribute Table' from the context menu.
- ☐ With the attribute table open click on the Options ▾ button and choose 'Add Field…' from the pop-up menu.
- ☐ Now add three (3) fields: *REN* (Type: Long Integer, Precision: 20), *Parcel_No* (Type: Long Integer, Precision: 20) and *Mut_Frm_No* (Type: Long Integer, Precision: 20):

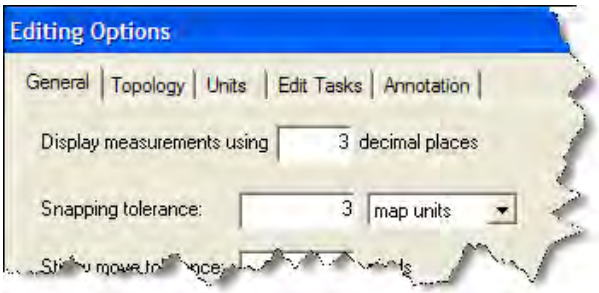


- ☐ Close the attribute table once the field has been added.

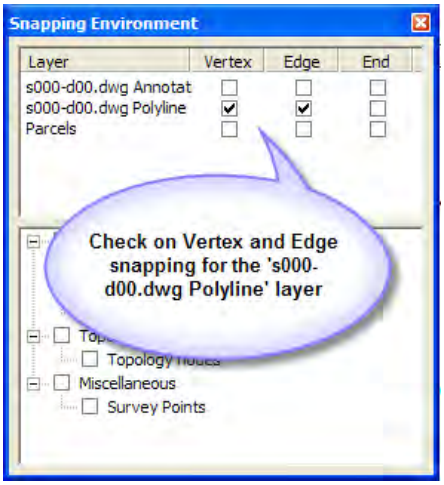
Step 2: Trace CAD polylines

You are now ready to begin tracing polylines to create parcels.

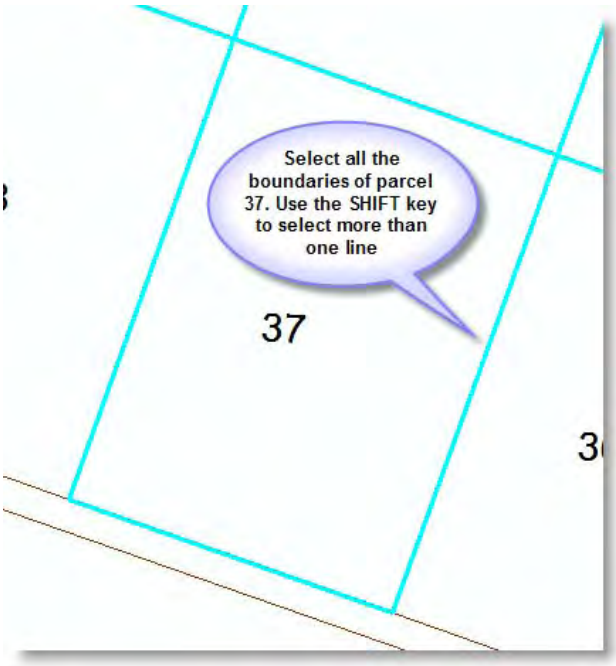
- ☐ In the application GUI click on the Editor toolbar tool to enable the Editor toolbar (if it is not enabled already).
- ☐ From the Editor drop-down menu choose Start Editing.
- ☐ Ignore the warning about editing in a different coordinate system by clicking the Start Editing button.
- ☐ From Editor drop-down menu choose Options…
- ☐ Under the General tab set the 'Snap tolerance' to '3' 'map units':



- ☐ Click the OK button to set the snap tolerance and dismiss the dialog box.
- ☐ From the Editor drop-down menu choose Snapping.
- ☐ In the Snapping Environment window check on the options shown below:

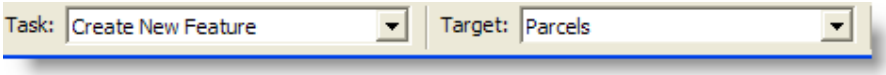


- ☐ Close the Snapping Environment window.
- ☐ In the Editor toolbar click the Edit tool
- ☐ Using the Shift key select the 4 edges of parcel 37:



☐ In the Editor toolbar click the drop-down next to the Sketch tool and select the Trace tool:

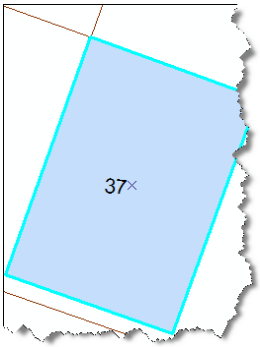
☐ Accept the default values for the Task and Target layers:



- ☐ With the trace tool selected click on the lower left corner of parcel 37.
- ☐ Then move easterly along the edge of boundary 1, move up boundary 2, along boundary 3 and down boundary 4, tracing the selected lines.

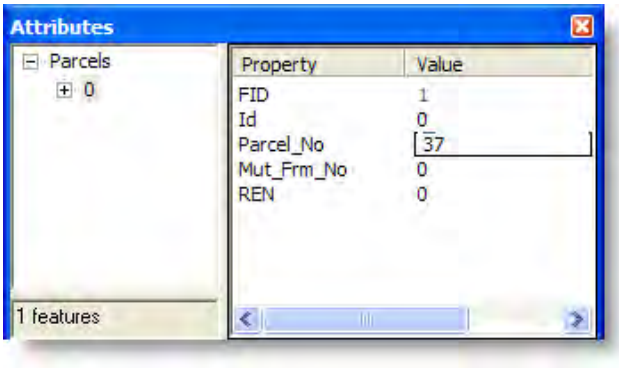
You will see a thin black line move along the selected lines which represents the trace line; do not worry if it appears to go haywire:

- ☐ When you have returned to the start point double-click the left hand button of the mouse to create a new parcel:



Next assign a parcel identifier to the feature.

- ☐ In the Editor toolbar click on the Attributes tool .
- ☐ In the Attributes dialog box type in '37' as the *Parcel_No*:

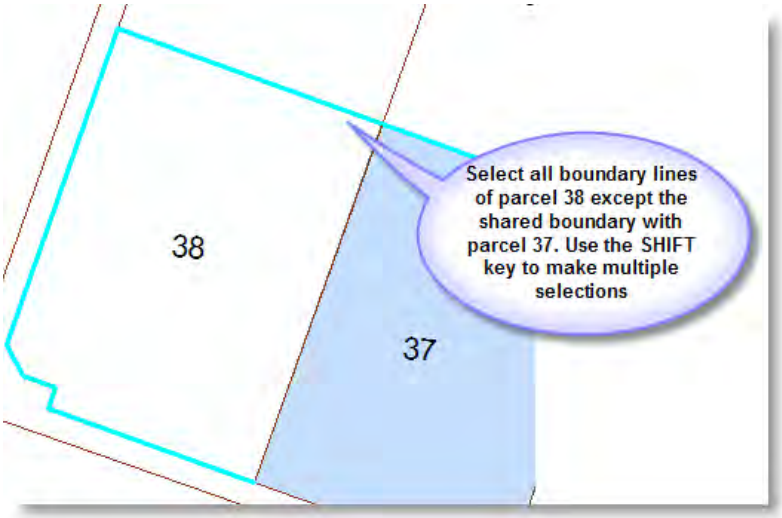


- ☐ Press the Enter key on the keyboard to update the parcel's identifier.
- ☐ Close the Attributes dialog box.

Step 3: Digitize an adjacent polygon

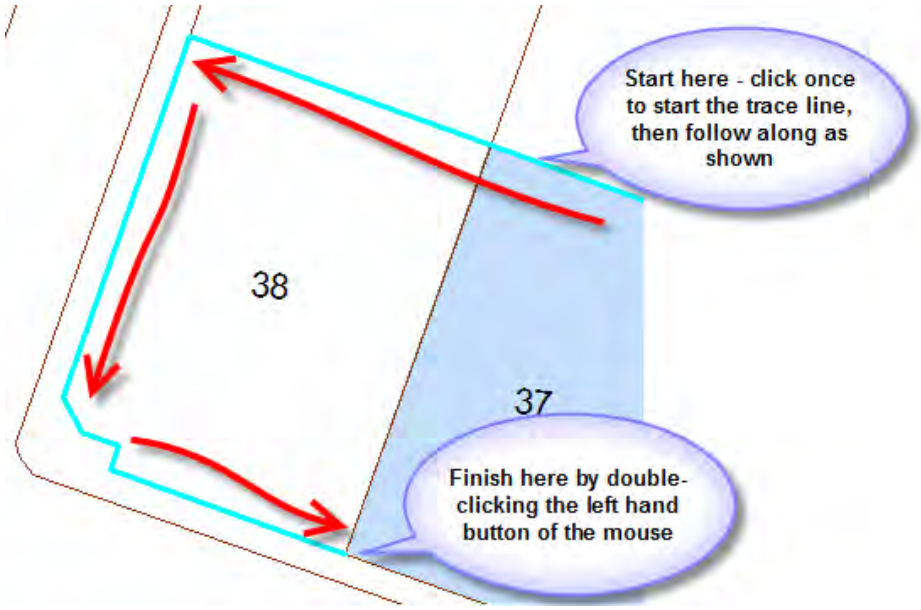
Now that you have digitized parcel 37, you will now digitize parcel 38 using the Auto-Complete polygon task:

- ☐ Select all the boundaries of parcel 38 identified below using the Select tool in the Editor toolbar *except* is shared boundary with parcel 37:



- ☐ In the Editor toolbar set the Task to Auto-Complete Polygon.
- ☐ From the Sketch tools drop-down list select the Trace tool.

- ☐ Trace the boundary lines of parcel 38 as shown in the graphic below:



- ☐ When you have reached the boundary of parcel 37 double click the left hand button of the mouse.

- ☐ Using the Attributes tool assign a parcel number of 38 to the new polygon.

Step 3: Calculate area and perimeter values

Finally add an area and perimeter field to the parcels' attribute table and use VBA code to calculate the geometry figures.

- ☐ From the Editor drop-down menu choose 'Stop Editing'. When prompted choose to save your edits.

- ☐ Right click on the Parcels layer in the map document's table of contents and choose Open Attribute table.

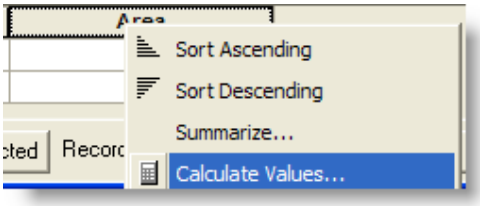
- ☐ In the Attribute table window click the Options ▾ button and choose Add Field… from the pop-up menu.

- ☐ Add an Area field as follows:

- ☐ Repeat the process adding a field called Length with the same properties.

You are now ready to update geometry values.

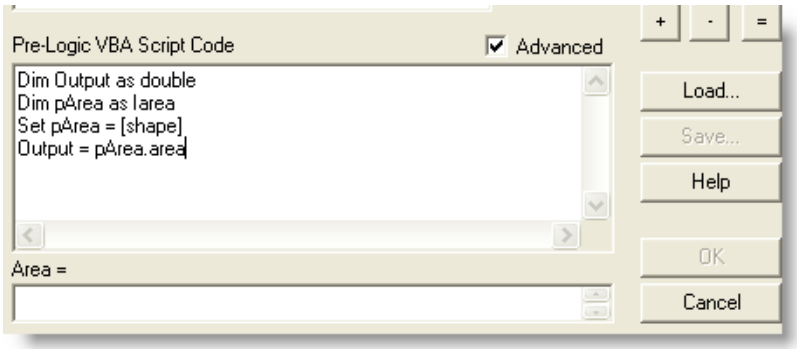
- ☐ Right click on the Area field just added and choose ‘Calculate Values’ from the context menu:



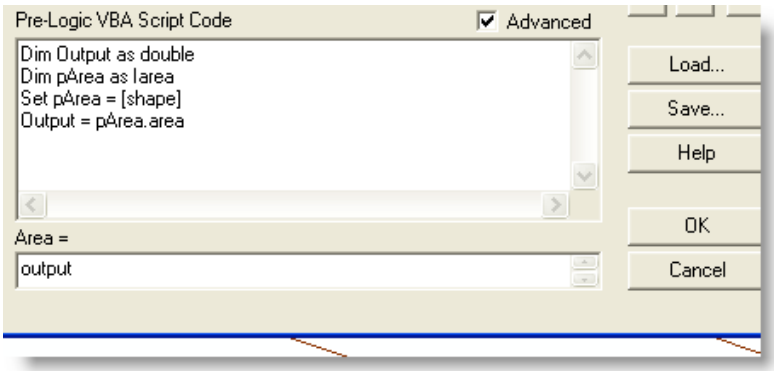
- ☐ Ignore the warning about being outside an edit session by clicking Yes.
- ☐ In the Field Calculator dialog box check the ‘Advanced’ option.
- ☐ Click the Help button and scroll down through the help until you find ‘How to use Visual Basic code to calculate fields based on area, length, perimeter, etc.’
- ☐ Copy the code beneath ‘To calculate area:’:

```
Dim Output as double
Dim pArea as Iarea
Set pArea = [shape]
Output = pArea.area
```

- ☐ Paste the code into the Field Calculator as shown below:



- ☐ Beneath ‘Area =’ type `output` and click the OK button:



The area figure will be updated.

CHALLENGE STEP

Now that you have added an Area field, repeat the step adding a Perimeter field and then calculate the perimeter values. Can you do this? If in doubt please ask you instructor, meantime here are a few helpful tips:

1. *Add field called 'Perimeter' the attribute table, defining its properties*
2. *Use the Field Calculator to update the perimeter values using VBA code – do you remember where to find this code?*

EXERCISE 7: HEADS UP DIGITIZING

In this exercise you will learn how to perform heads-up digitizing to capture vector data from IKONOS imagery. The same principles described here can be applied to scanned images, plans or maps.

What is Heads up digitizing?
Heads up digitizing is described as 'Manual digitization by tracing a mouse over features displayed on a computer monitor, used as a method of vectorizing raster data' (Source: GIS Glossary, ESRI)

☐ Start ArcMap.

Step 1: Open a map document and create a new feature class

☐ From the File menu choose Open and navigate to the C:\TRAINING\DATA\MAP DOCUMENTS folder and open the map document 'Heads Up Digitizing.mxd':

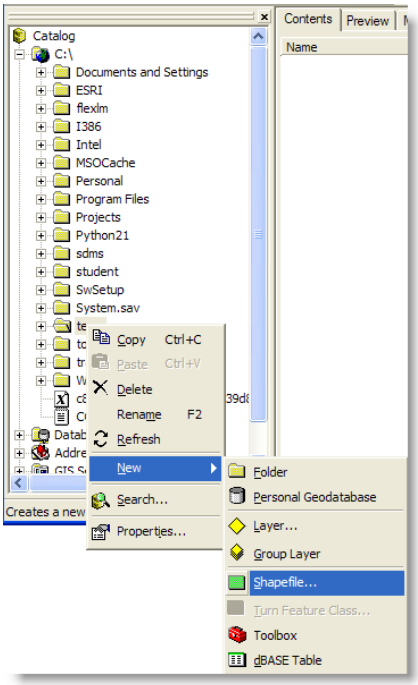
You will digitize these two factory/warehouse outlines, not the buildings themselves as these are industrial sites but the skills introduced here can be applied to building and parcel outlines.

The map document contains a subset of IKONOS data for south east Cairo. Using the imagery you will capture (digitize) the extents (outlines) of the two industrial parcels in the centre of the display.

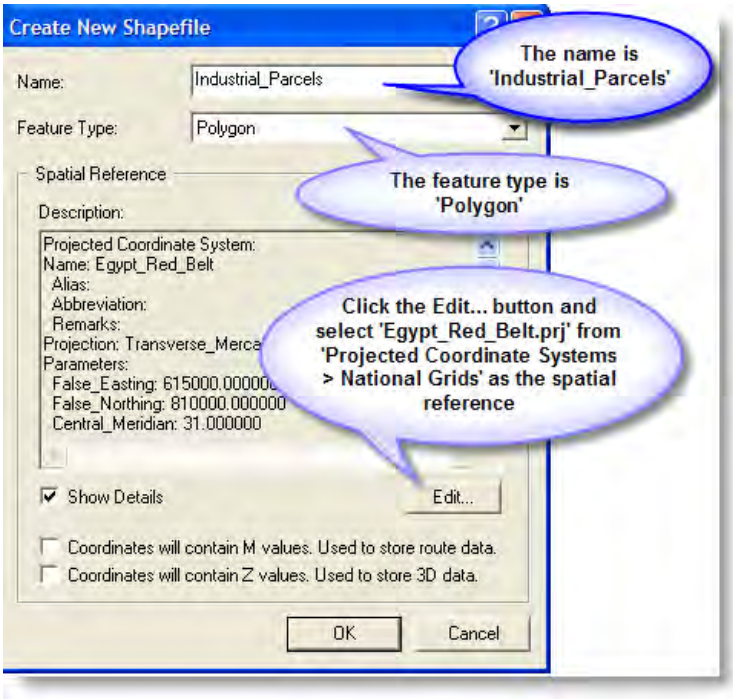
☐ Open ArcCatalog by clicking the ArcCatalog tool

☐ In the Catalog tree navigate to the C:\TEMP folder

☐ Right click on the folder and choose New > Shapefile… from the context menu:



☐ Complete the New Shapefile dialog box as follows:



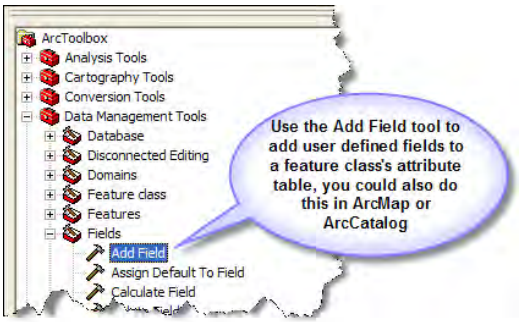
☐ Click OK to create the new shapefile.

☐ Close ArcCatalog.

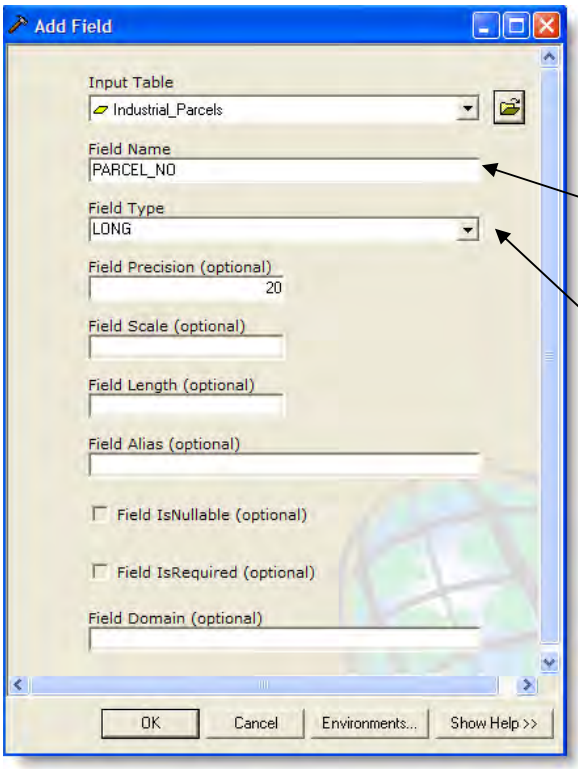
Step 2: Add the shapefile to ArcMap and add a parcel identifier field

Now that you have created a new empty feature class you need to add a parcel identifier field, first add the shapefile to the map document:

- ☐ Click the Add Data tool in the application GUI.
- ☐ Navigate to the C:\TEMP folder and add the shapefile 'Industrial_Parcels'
- ☐ Enable the ArcToolBox window by clicking the Show/Hide ArcToolBox tool (if it is not enabled already).
- ☐ In ArcToolBox navigate to the Data Management > Fields toolset and double click on the Add Field tool:



- ☐ Complete the Add Field dialog as shown:



Field Name: type in PARCEL_NO for the new field name

Field Type: accept the default setting LONG – this means long integer, in other words a whole number (no digits after the decimal place).

The Field Precision (optional) should be set to 20.

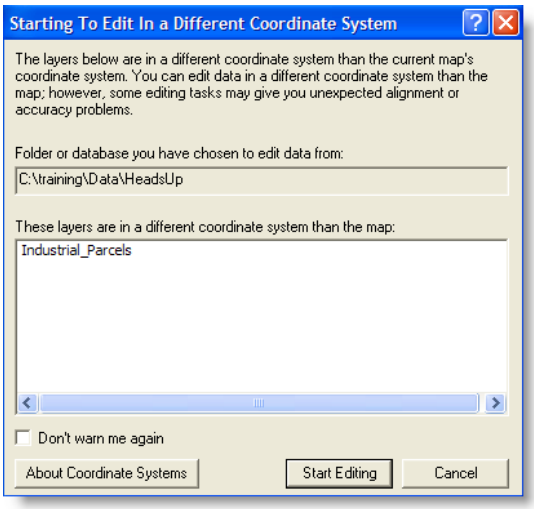
Leave all other fields as they are.

- ☐ Click OK to continue.

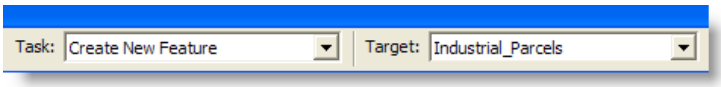
- ☐ Close the Progress dialog box by clicking the Close button.

Step 3: Digitize two parcel outlines

- ☐ Click the Editor Toolbar tool in the Standard toolbar to enable to Editor toolbar (ignore this step if the toolbar is already enabled).
- ☐ From the Editor drop-down menu choose Start Editing.
- ☐ Ignore the warning about editing in a different coordinate system by clicking the Start Editing button:



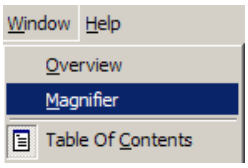
- ☐ In the Editor toolbar ensure the *Task* is set to 'Create New Feature' and the *Layer* is set to 'Industrial_Parcels':



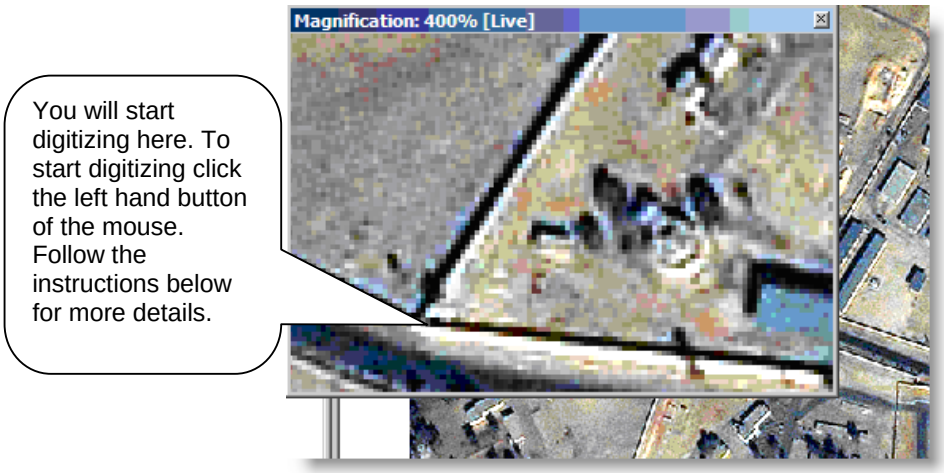
- ☐ Click on the Sketch tool

To help you digitize you will open the Magnifier window; this enlarges areas of the display without the need for zooming in. All editing functionality works within the Magnifier window.

- ☐ From the Window menu choose Magnifier.



- ☐ Move the Magnifier window over the bottom left hand corner of westerly warehouse/factory:



- ☐ Click once on the fence/wall with the left hand button of the mouse and continue clicking the left hand button of the mouse moving in a northerly direction to place vertices (**green** boxes) along the fence/wall.

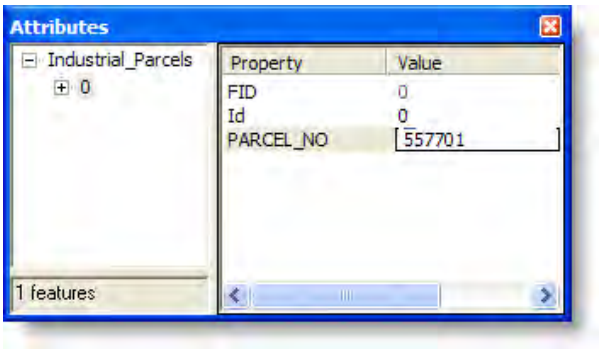
- ☐ Continue around factory/warehouse moving the Magnifier window as needed and clicking the left hand button of the mouse. *NOTE:* If you make a mistake press the **CTRL + Z** keys on the keyboard.

- ☐ When you return to the start point, double click the left hand button of the mouse. Your parcel should look like the one shown below, if in doubt please ask your instructor. It will be selected (highlighted in **cyan**):

Now enter an identifier for the parcel:

- ☐ In the Editor toolbar click on the Attributes tool

☐ Type in a parcel ID of **557701**:



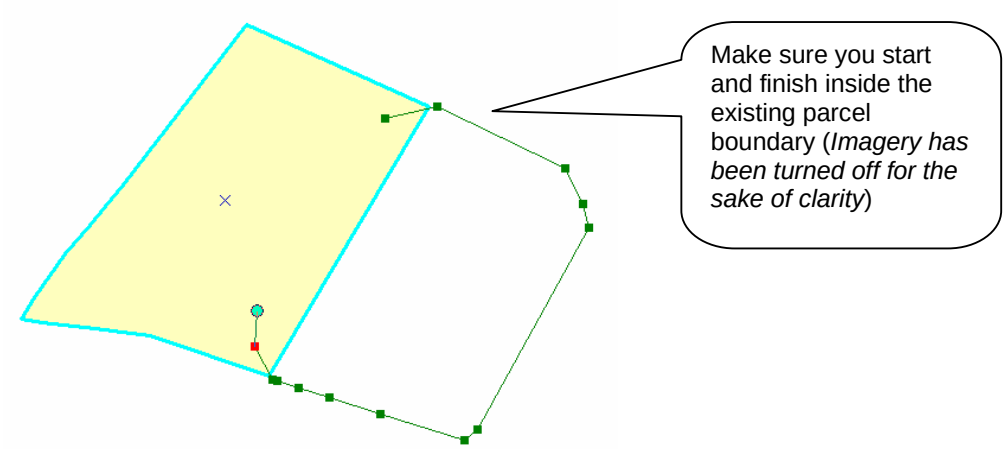
❑ Press the Enter key on the keyboard to dismiss the Attributes dialog box.

Now digitize the easterly parcel.

☐ Close the Magnifier Window.

☐ In the Editor toolbar change the *Task* to 'Auto-Complete Polygon':

☐ Start digitizing the easterly parcel boundary by clicking the left hand button of the mouse inside the parcel you have just digitized. Continue around the easterly parcel's boundary finishing the boundary line by double clicking the left hand button of the mouse inside the parcel you have just digitized:



☐ Update the attributes for the second parcel, assigning it a parcel number of **557702**

You have now completed the required edits.

☐ From the Editor menu choose Stop Editing and when prompted save you edits.

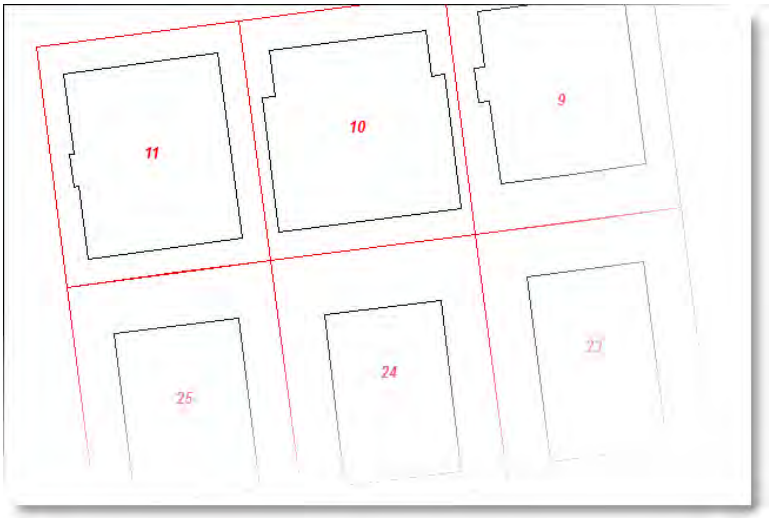
☐ When you have finished exit ArcMap and choose to save the map document when prompted.

EXERCISE 8: CAPTURE APARTMENTS

In this exercise you will digitize apartments and attribute these as described in the lecture notes. A map document containing buildings and parcels has been saved for you. First open an existing map document:

- ☐ Start ArcMap and choose to open an existing map document.
- ☐ Navigate to the C:\TRAINING\DATA\MAP DOCUMENTS folder and open the map document 'Apartments.mxd'

This map document contains two layers buildings and parcels. The Parcels layer is labeled by parcel number:



First you will add additional fields to the building layer. If you remember these fields (as described in the lecture notes) are: Real Estate Number (REN), Mutation Form Number (Mut_Frm_No), Building Number (Build_No), Apartment Number (Apt_No), Parcel Number (Parcel_No), Street Name (Str_Name), District, City and Status, with the actual field names in brackets because of the shapefile's 10 character limit on field names.

Use ArcToolBox to add these fields:

- ☐ Enable the ArcToolBox window by clicking the Show/Hide ArcToolBox tool (if it is not enabled already).
- ☐ In ArcToolBox navigate to the Data Management > Fields toolset and double click on the Add Field tool.

- ☐ Use the Add Field tool to add the fields as shown in the table below. *Note:* You will have to add these fields one at a time:

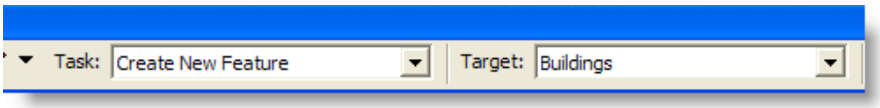
Field Name	***Data Type***	***Precision***
REN	Long_Integer	20
Mut_Frm_No	Long Integer	20
Build_No	Long Integer	20
Build_Name	Text	100
Apt_No	Long Integer	20
Parcel_No	Long Integer	20
Str_Name	Text	100
District	Text	100
City	Text	100
Status	Text	50

Once you have added the fields you can start editing.

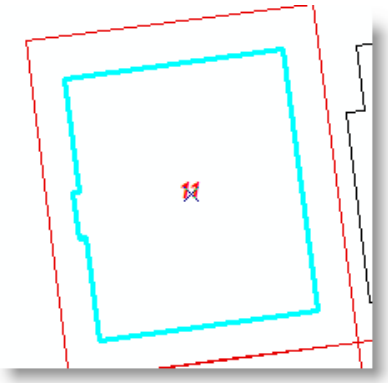
- ☐ Click the Editor Toolbar tool in the Standard toolbar to enable to Editor toolbar (ignore this step if the toolbar is already enabled).

- ☐ From the Editor drop-down menu choose Start Editing.

- ☐ In the Editor toolbar make sure the Task is set to 'Create new feature' and the Target is 'Buildings':



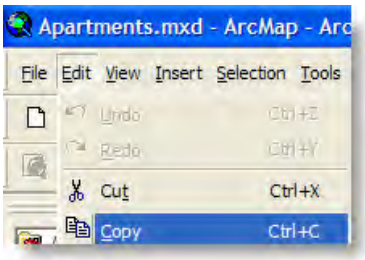
- ☐ Use the Edit tool to select the Building inside Parcel Number 11.



You will now copy and paste the building footprint 5 times as you have been informed there are 5 apartments at this location.

- ☐ From the Target drop-down list select the Buildings layer once again to activate the layer.

- ☐ From the Edit menu choose Copy:

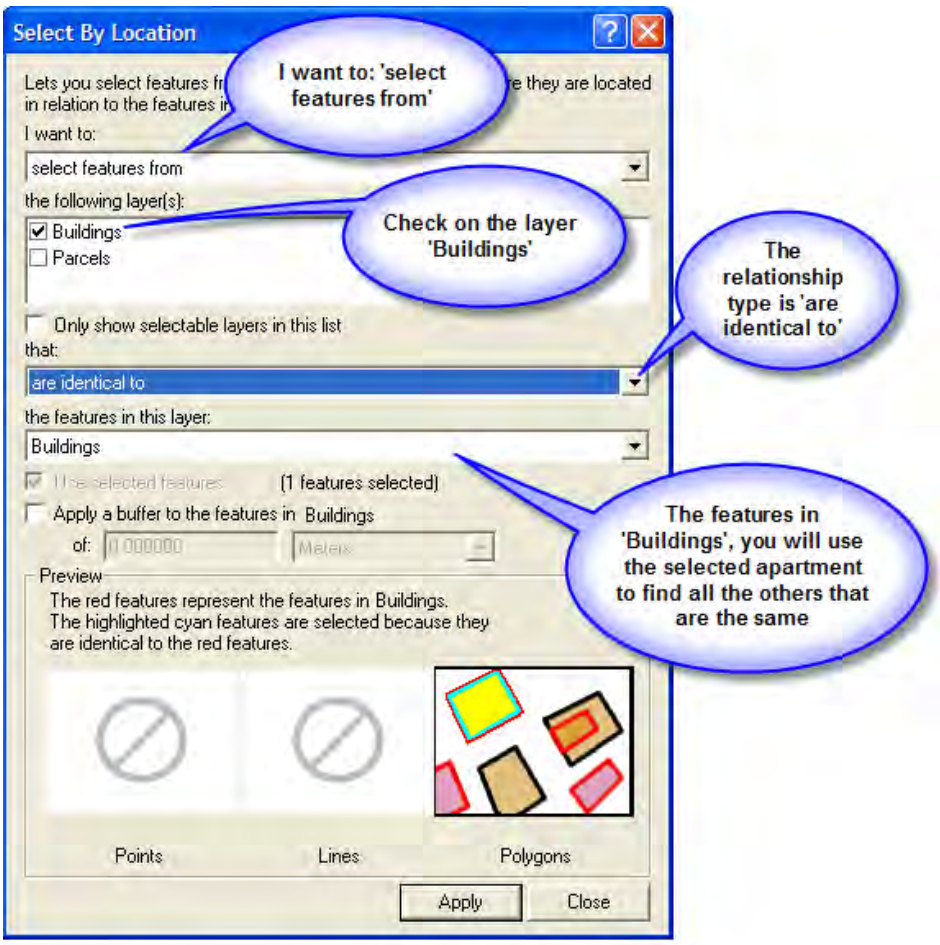


- ☐ From the Edit menu now choose Paste *5* times, pasting 5 copies of the selected building. In other words for each apartment you are adding a polygon (which is indicative of ownership). Remember the polygon is not meant to represent the exact internal dimensions of the apartment just that there is an apartment in the building.

Now select all of the apartments so that you can attribute them. To select the 5 apartments you have just added to the following:

- ☐ From the Selection menu choose 'Select by Location…'

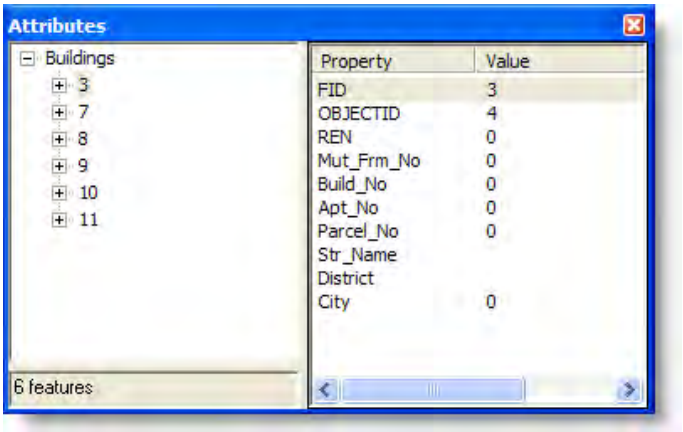
- ☐ Complete the Selection by Location dialog box as shown:



- ☐ Click the Apply button.

- ☐ In the Editor tool bar click the Attributes tool .

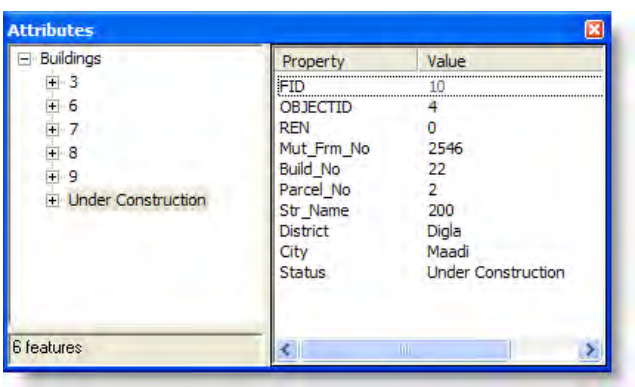
- ☐ In the Attributes dialog box you will see that 6 features are selected, as in addition to the 5 apartments you have just added you also selected the building footprint which represents the common area of the building:



- ☐ Clicking on each building identifier in the left hand side of the Attributes dialog box, complete apartment details as shown in the table below (there is no building name):

FID	REN	Mut_Frm_No	Build_No	Apt_No	Parcel_No	Str_Name	District	City	Status
3	0	555	22	-99	11	200	Digla	Maadi	Communal
6	0	768	22	101	11	200	Digla	Maadi	Occupied
7	0	898	22	102	11	200	Digla	Maadi	Occupied
8	0	909	22	103	11	200	Digla	Maadi	Unoccupied
9	0	1020	22	201	11	200	Digla	Maadi	Occupied
10	0	2546	22	202	11	200	Digla	Maadi	Under Construction

- ☐ You will notice *-99* is used for the communal area, this is because it has no apartment number. You could have also used 0, but -99 clearly indicates that this is not an apartment:



- ☐ Once you have added all the values choose to Stop Editing from the Editor drop-down menu choosing to save your edits when prompted.

- ☐ Quit ArcMap choosing the save the changes to the map document when prompted.

EXERCISE 9: EDGEMATCHING

In this exercise you will learn how perform edge matching using the Spatial Adjustment toolbar in ArcMap.

- ☐ Start ArcMap and when prompted choose to open an existing map document.

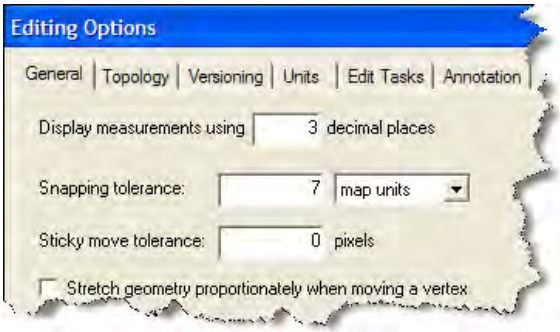
Step 1: Open a map document and start editing

- ☐ Navigate to the C:\TRAINING\DATA\MAP DOCUMENTS directory and open the map document Edgematching.mxd

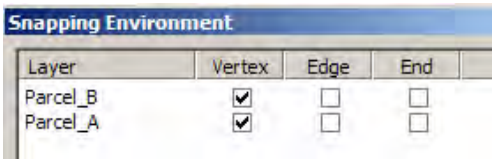
The map document contains two layers: Parcel_A and Parcel_B clearly misaligned from one another, as you realize there shouldn't be a gap between the parcels in the different layers. You have also been told that the layer Parcel_A is more accurate than Parcel B.

In order to perform edge snapping you must be editing.

- ☐ Enable the Editor toolbar (if it is not visible already).
- ☐ Enable the Spatial Adjustment toolbar (if it is not visible already).
- ☐ From the Editor drop-down menu choose Start Editing.
- ☐ From the Editor drop down menu choose Options…
- ☐ In the Editing Options dialog box set the Snapping Tolerance to 7 map units (meters) and click OK to continue:



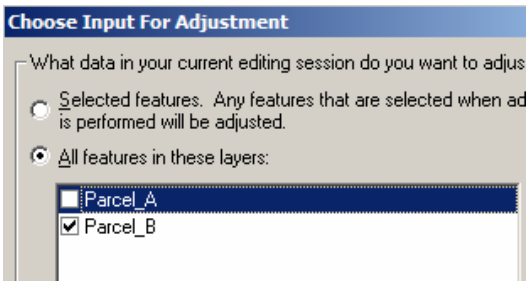
- ☐ From the Editor drop-down menu choose Snapping and set the snap environment to Vertex for both layers:



- ☐ Close the Snapping Environment window.

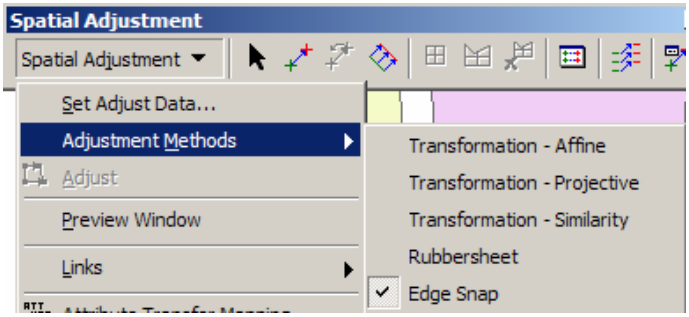
Step 2: Set adjustment options and perform edge matching

- ☐ From the Spatial Adjustment drop-down menu choose Set Adjust Data… and check the option 'All features in these layers' checking on Parcel_B as you know Parcel_B is less accurate than Parcel_A and features can move in this layer:



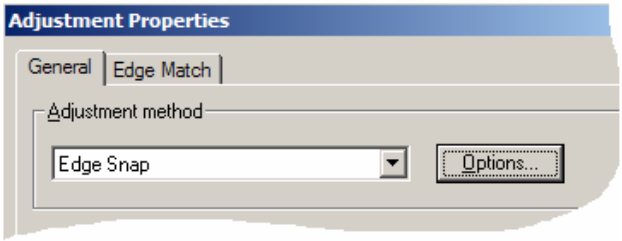
- ☐ Click OK to dismiss the Choose Input for Adjustment dialog box.

- ☐ From the Spatial Adjustment drop-down menu choose Adjustment Method > Edge Snapping:



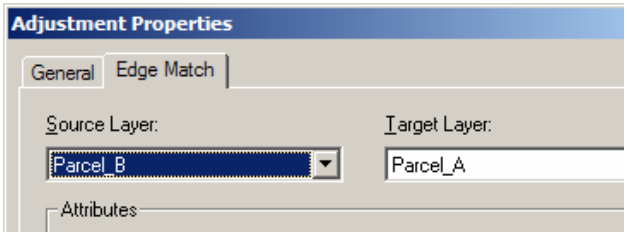
- ☐ From the Spatial Adjustment drop-down menu choose Options…

- ☐ Under the General tab click the Options… button:



- ☐ Set the Method to 'Line' and click OK to continue

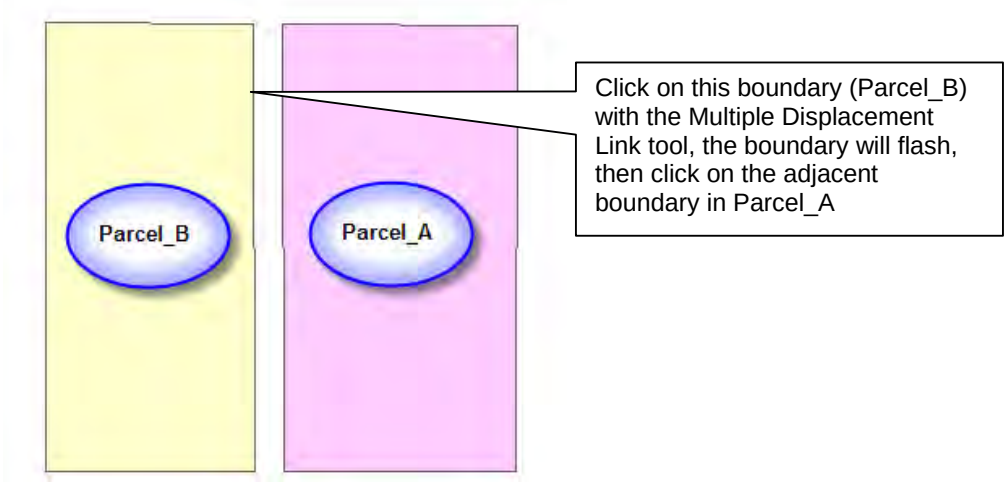
- ☐ Click on the Edge Match tab and ensure the source is Parcel_B and the target Parcel_A, again this confirms features in the less accurate layer will move to those of the more accurate layer:



- ☐ Click OK to continue.

- ☐ In the Spatial Adjustment toolbar click on the Multiple Displacement Links tool

- ☐ Click on the eastern edge of the top parcel in the Parcel B layer:

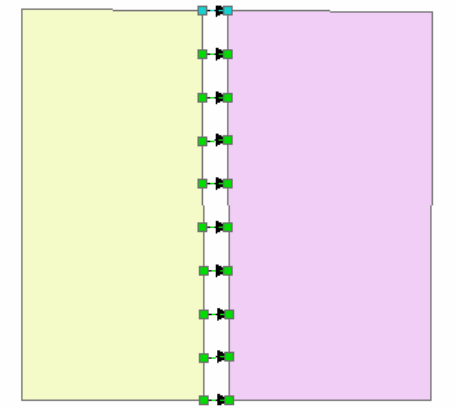


- ☐ The boundary will flash. Next click on the adjacent boundary in Parcel_A, it too will flash.

- ☐ When asked how many links to add accept the default number (10):

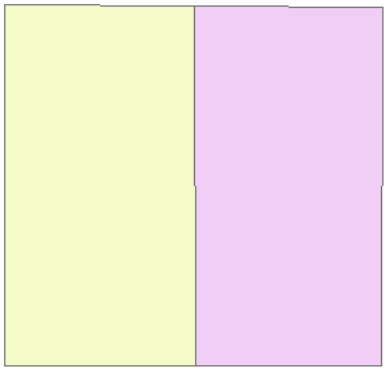
- ☐ Press the Enter key on the keyboard.

You will see 10 displacement links added automatically:



You are now ready to perform the adjustment.

- ☐ From the Spatial Adjustment drop-down menu choose Adjust, the edge of Parcel_B will be adjusted to match Parcel_A:



You will notice the edge of Parcel_B has been extended to meet Parcel_A and the parcel will have become bigger as a consequence. If you think this was wrong then the solution would be apply a transformation (see the exercise Spatial Adjustment). However, having successfully matched the parcels you can save your work and exit ArcMap.

- ☐ Exit ArcMap choosing to save your edits and the map document when prompted.

EXERCISE 10: MERGING DATA

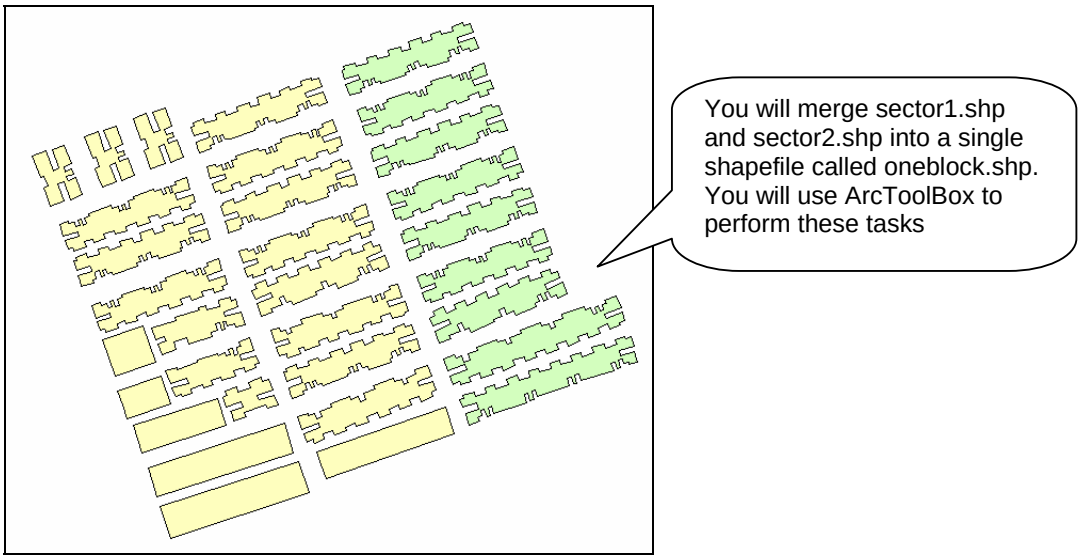
In this exercise you will learn how to merge (append) data using ArcToolBox.

☐ Start ArcMap and choose to open a new map document.

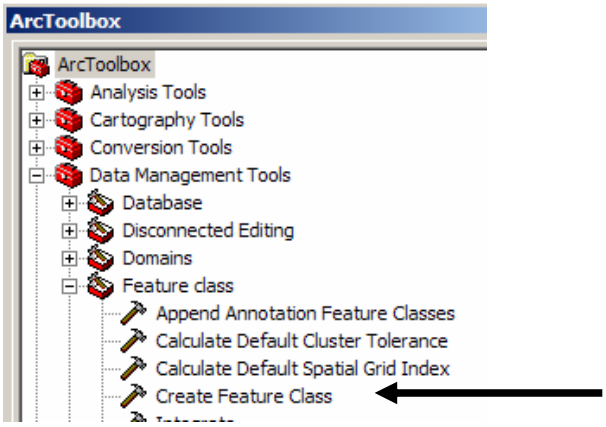
Step 1: Load shapefiles to be merged

☐ Click on the Add Data tool in the application GUI.

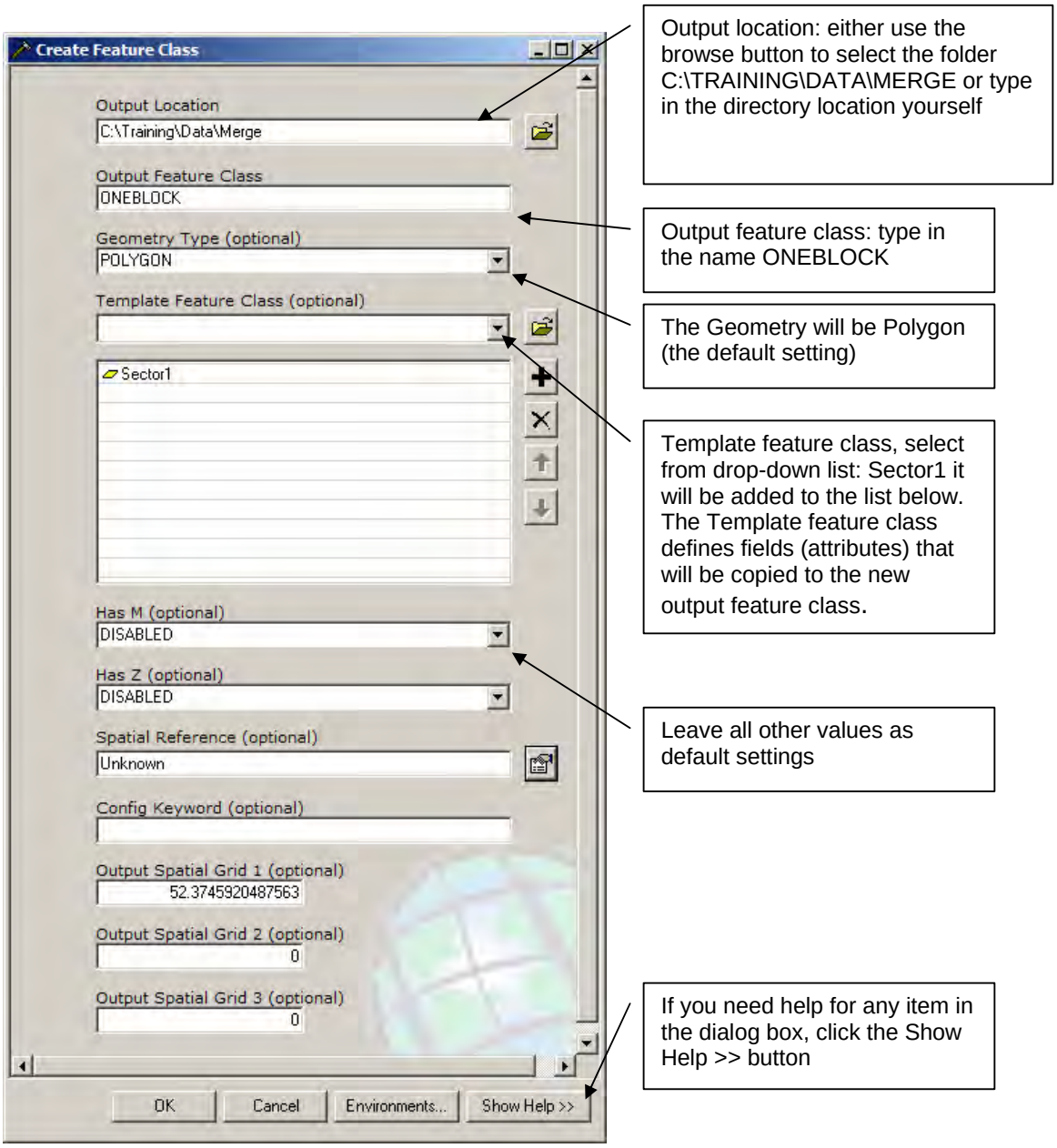
☐ Navigate to the C:\TRAINING\DATA\MERGE and add the two shapefiles: sector1.shp and sector2.shp, representing to adjacent blocks of apartments. One block has been acquired from the New Communities agency and the other from field survey work. These two shapefiles must be merged together to create a seamless dataset, however, before doing that you must first create a new, empty feature class (this is a requirement in ArcGIS 9.0, in ArcGIS 9.1 you do not have do this):



☐ Enable ArcToolBox, by clicking the Show/Hide ArcToolBox tool and navigate to the ArcTool > Data Management Tools > Feature Class toolset and double click on the Create Feature Class tool:



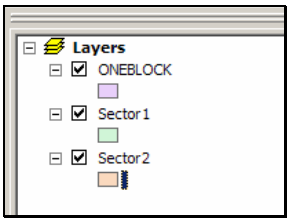
☐ Complete the Create Feature Class dialog box as follows:



☐ Click OK to continue.

☐ Dismiss the Progress dialog box by clicking the Close button.

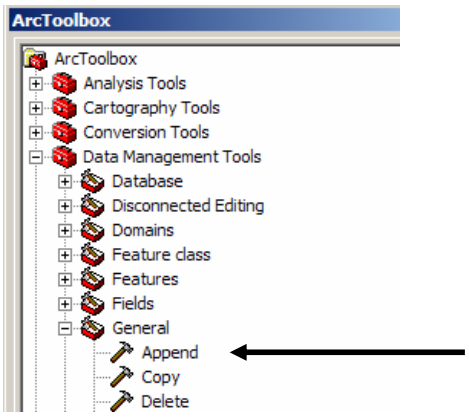
☐ The new shapefile will be added to the table of contents:



Note: If there are any errors running the tool they will appear in red. The most common mistake is caused by mistyping a directory or folder name.

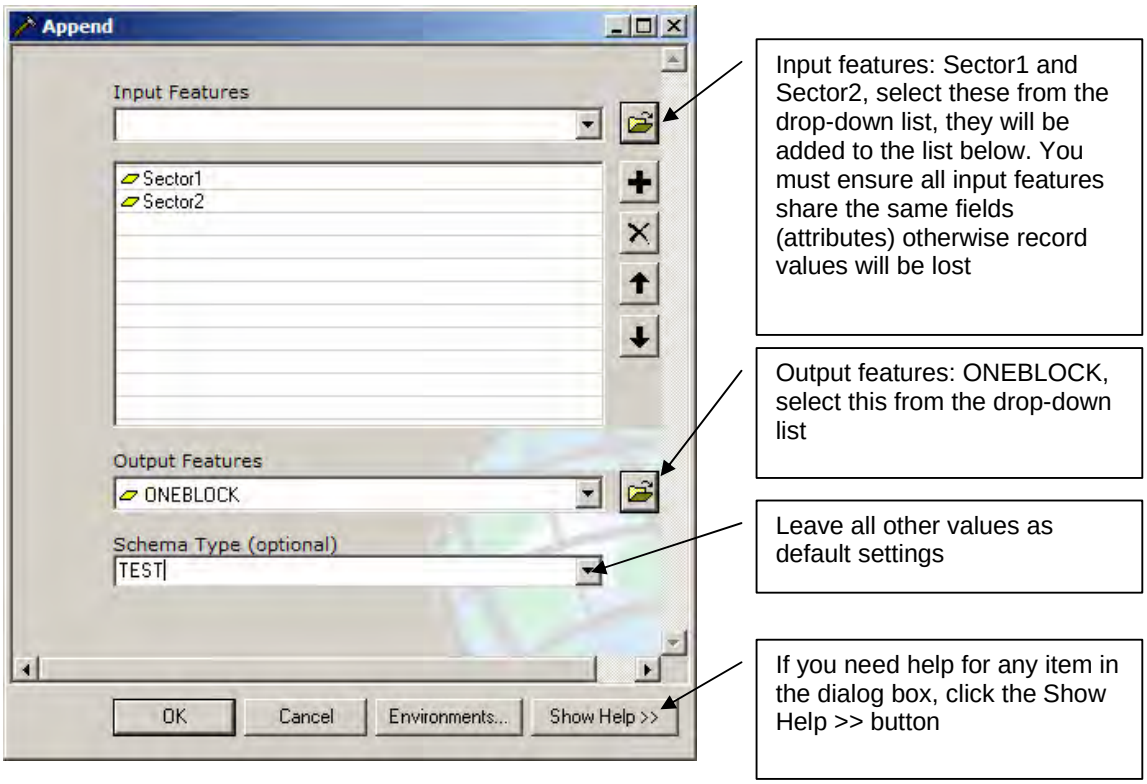
Step 2: Append shapefiles together

- ☐ In ArcToolBox and navigate to the ArcTool > Data Management Tools > General toolset and double click on the Append tool:



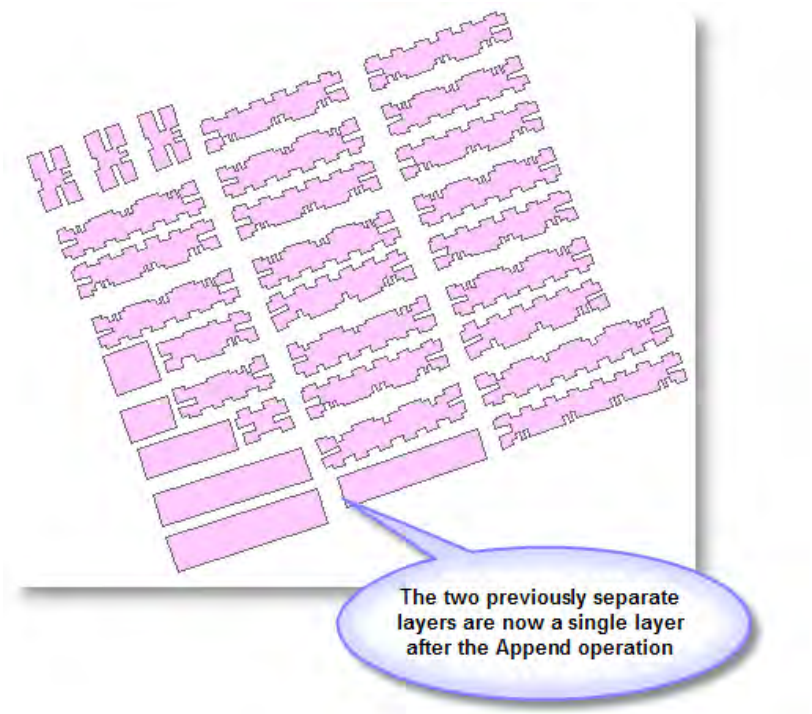
The Append tool allows you to merge separate tiles or layers of data together into a single seamless dataset, having created an empty feature class called oneblock.shp you will now merge sector1.shp and sector2.shp into it:

- ☐ Complete the Append dialog box as follows:



☐ Click OK to continue. Dismiss the progress dialog box by clicking the Close button.

The result is a single seamless block:



☐ When you have finished save the map document in your C:\TEMP directory as **ExMerge.mxd**.

EXERCISE 11: ESTABLISHING HYPERLINKS

In this exercise you will set up hyperlinks to link mutation forms in one of two ways – *dynamically* using the Identify tool and *permanently* by entering values in an attribute table. If you set up dynamic hyperlinks you must share the map document with other users, if you enter values into the attribute table you need only share the source data or layer file.

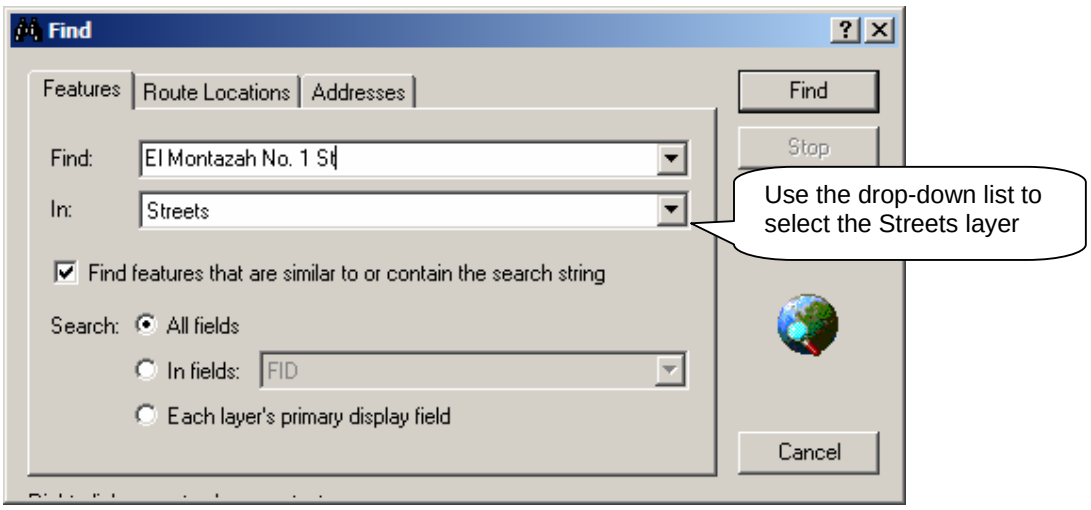
- ☐ Start ArcMap and choose to open a new map document.

- ☐ Click on the Add Data tool in the application GUI and navigating to the C:\TRAINING\DATA\HYPERLINKS directory add the shape files: Streets.shp and Buildings.shp.

Step 1: Setting dynamic hyperlinks

- ☐ Click on the Find tool in the Tools toolbar

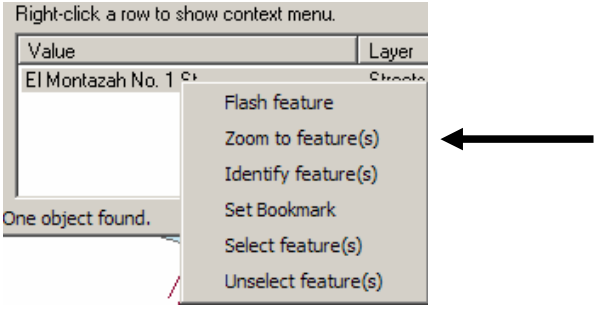
- ☐ In the Find dialogue box, for 'Find' type in 'El Montazah No. 1 St', set 'In:' to 'Streets':



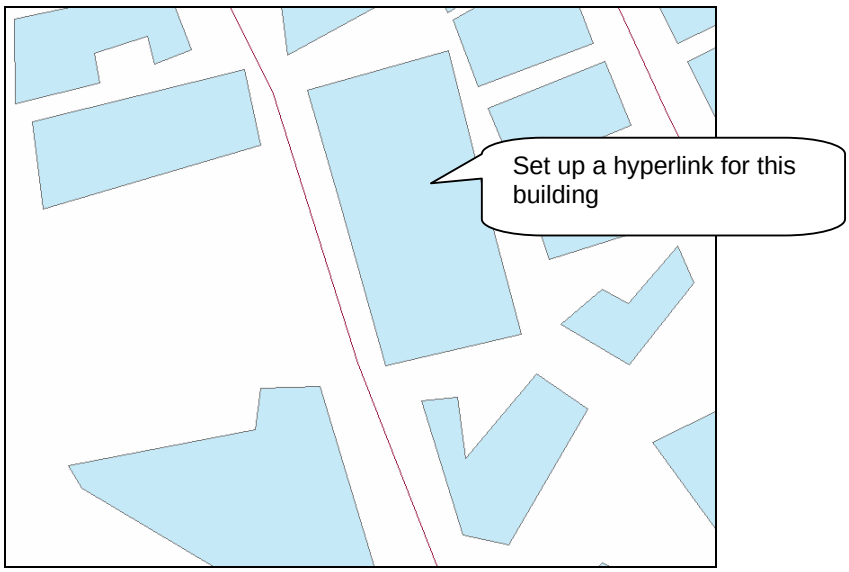
- ☐ Click the Find button to search for matching record values.

Only one record will be returned.

☐ Select the record and right clicking on the mouse choose Zoom to Feature(s):



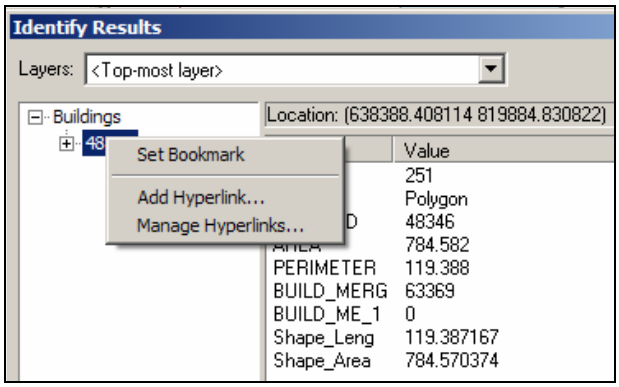
The display will centre on 'El Montazah No. 1 St' street. In the middle of the display is a large rectangular building. You will you associate a mutation form with this building.



☐ Close the Find dialog box.

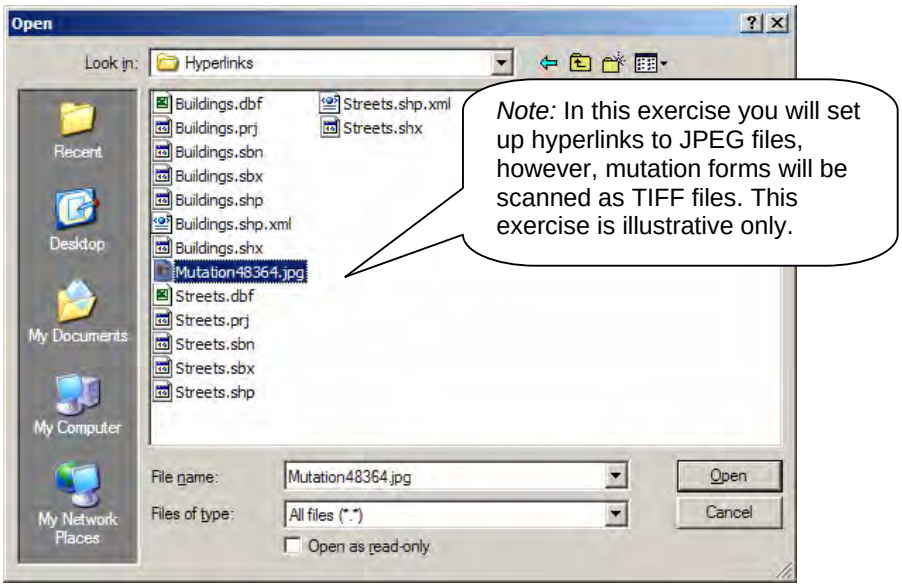
☐ In the Tools toolbar select the Identify tool and click on the parcel shown above.

- ☐ In the Identify Results dialogue box right click on building identifier (48364) and choose Add Hyperlink… from the context menu:

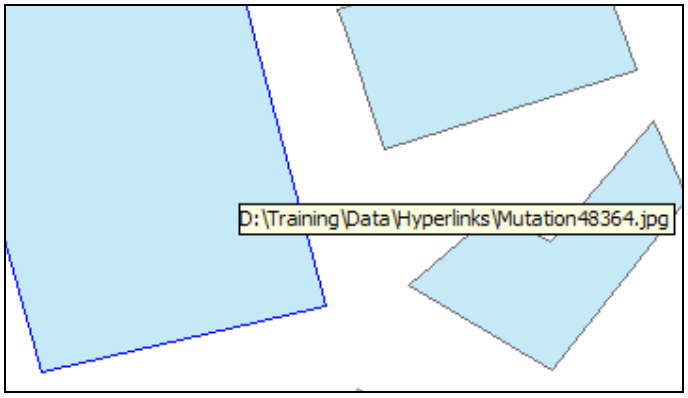


- ☐ Accept the setting 'Link to a Document' and click the Browse button :

- ☐ Navigate to the folder C:\TRAINING\DATA\HYPERLINKS. Select the JPEG file 'Mutation48364.jpg' and click Open:



- ☐ Click OK to dismiss the Add Hyperlink dialog box and close the Identify Results window.
- ☐ In the Tools toolbar select the Hyperlink tool and click on the building now identified with a blue outline:

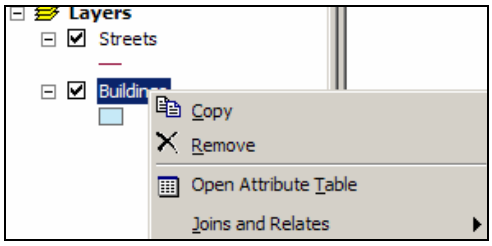


- ☐ The mutation form will open. Once you have examined it, close the image viewing application it opened in (e.g. Windows Fax and Image View).

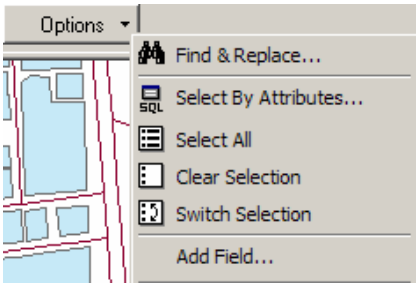
This is a dynamic way of storing hyperlinks. Note however this is only valid for the map document you are working with. To permanently associate a hyperlink you would add records to the attribute table, you will see how to do this in the next step.

Step 2: Setting permanent hyperlinks

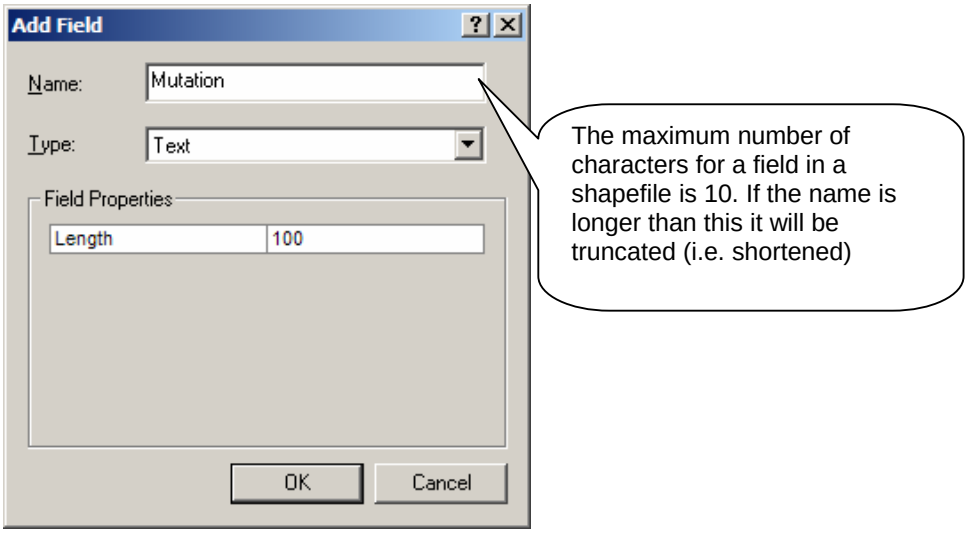
- ☐ In the Tools toolbar click on the Full Extent tool
- ☐ In the table of contents, right click on the Buildings layer and choose Open Attribute Table in the context menu:



☐ In the table window click the Options ▾ button and choose Add Field…:



☐ In the Add Field dialog box, name the new field 'Mutation'; set it's type 'Text' and length to '100':



☐ Click OK to continue.

Next you will build two queries to select the buildings with identifiers 46994 and 48403 and then update the record values for the Mutation field. Below are the mutation forms for the each building. You will notice that they share the same directory base (up to \HYPERLINK). It means you don't actually have to add everything to the Mutation field just that which appears after \HYPERLINK\ as you can set a hyperlink base as a property of the map document:

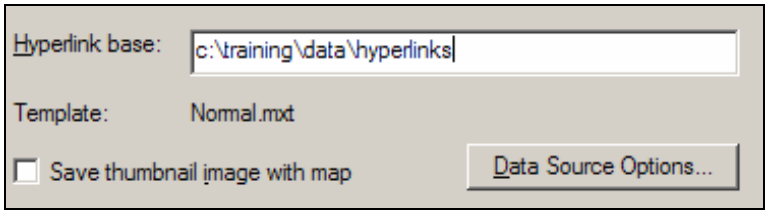
Building 46994: C:\TRAINING\DATA\HYPERLINKS\MUTATION46994.JPG

Building 48403: C:\TRAINING\DATA\HYPERLINKS\MUTATION48403.JPG

Using Building 46994 as the example:

- ☐ In the table click on the Options ▾ button and choose Select By Attributes…
- ☐ Build the expression "OBJECTID" = 46994 and click the Apply button:

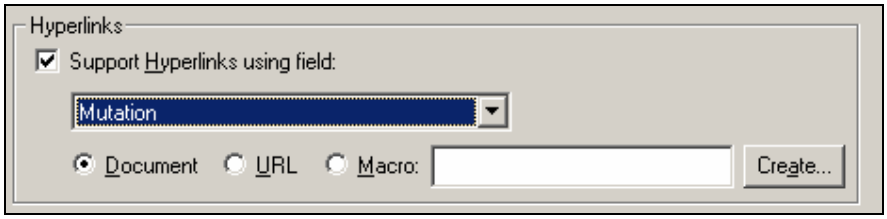
- ☐ Close the Select by Attributes dialogue box.
- ☐ In the table window click the Selected button to display the single selected record.
- ☐ Scroll to the right until you can see the 'Mutation' field.
- ☐ From the Editor toolbar choose Start Editing.
- ☐ Click in the record for 'Mutation' field and enter: **Mutation46994.jpg**
- ☐ Now repeat the step for building 48403.
- ☐ When finished choose Stop Editing from the Editor toolbar. Choose to save the edits you have made, and then close the attribute table.
- ☐ From the File menu choose Map Properties… and in the Hyperlink base field enter: C:\TRAINING\DATA\HYPERLINKS and click OK. This base value will be applied to all field values:



- ☐ Next select the Buildings layer in the table of contents and clicking on the right hand button of the mouse choose Properties… from the context menu.

- ☐ In the Layer Properties dialog box click on the Display tab.

- ☐ Check on the option the ‘Support Hyperlinks using field’ and select the ‘Mutation’ field from the drop-down list:



- ☐ In the Tools toolbar click on the Hyperlink tool. The two buildings will be identified with blue outlines, click on either one of them to see the associated mutation form.

- ☐ When you have finished save the map document in your C:\TEMP directory as **ExHyperlinks.mxd**.

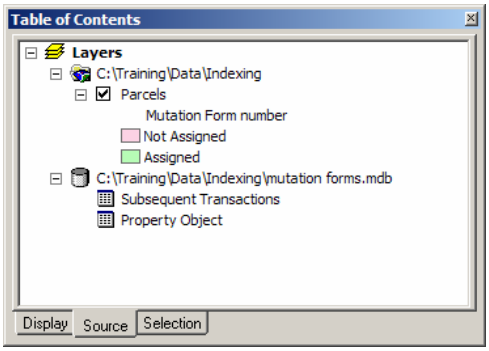
EXERCISE 12: ASSOCIATING MUTATION FORMS

In this exercise you will learn how to use the ArcMap Join and Relate commands to associate mutation form details held in a MS Access database using the 'Mutation Form Number' as the common field.

- ☐ Start ArcMap open the map document Indexing.mxd the C:\TRAINING\DATA\MAP DOCUMENTS folder. The map document contains a parcels layer symbolized according to whether a mutation form number has been assigned or not.

Step 1: Add the tables to the map document

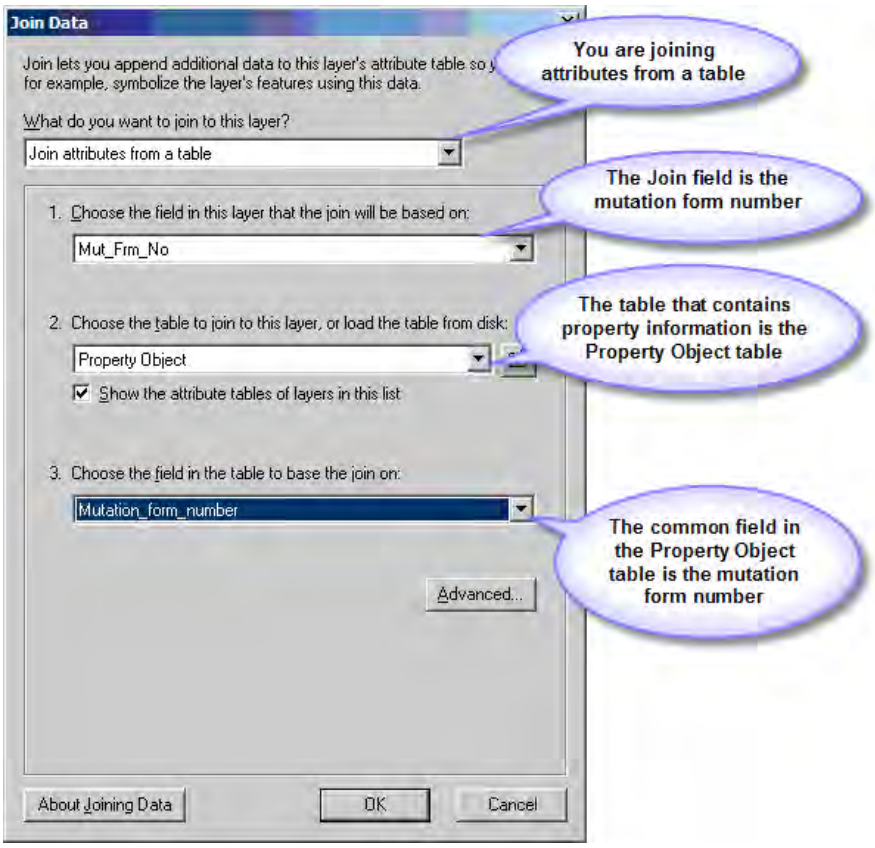
- ☐ In the Standard toolbar click the Add Data tool
- ☐ Navigate to the C:\TRAINING\DATA\INDEXING folder and double click the Mutation Forms.mdb database to open it.
- ☐ Add the two personal geodatabase tables: 'Property Object' and 'Subsequent Transactions':



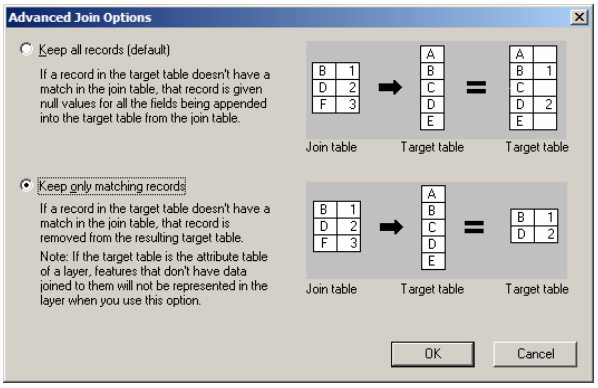
Since the tables contain information regarding the property you will now use the Join and Relate commands to build an association.

Step 2: Join the Property Object table to the Parcels layer

- ☐ Right click on the Parcels layer and choose Joins and Relates > Join… and complete the Join Data dialog box as follows:



- ☐ Click the Advanced… button and check the option 'Keep only matching records':

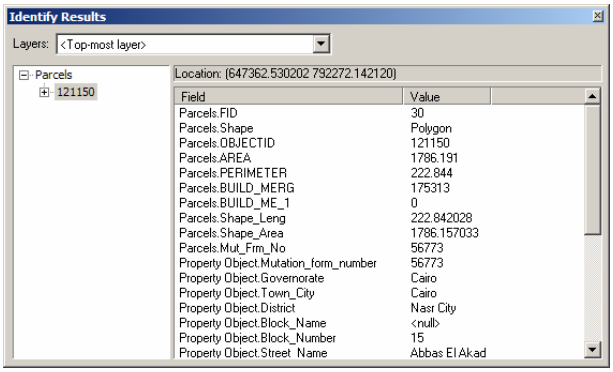


- ☐ Click OK to continue and OK to dismiss the Join Data dialog box. Only a single parcel will remain in the display.

- ☐ Right click on the Parcels layer and scroll through the table to see the additional fields that have been added. You will notice that the field name is preceded by the table which it has come from.

- ☐ Close the Parcel layer's attribute table.

- ☐ In Tools toolbar click on the Identify tool and click in the centre of the single parcel in the display examining the attributes that describe it – namely information relating to the first transaction for which the mutation form was created:

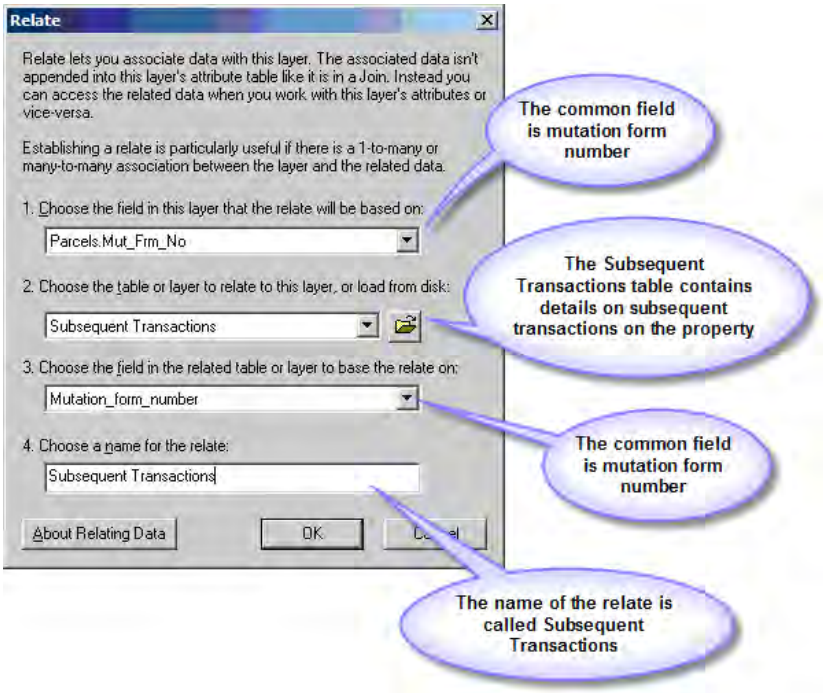


Here you have used the Join command to append fields from the Property Object table to the Parcels layer; you have been able to do this because this is a one to one relationship type. However, since there are many subsequent transactions in order to associate the Subsequent Transactions table with the parcel layer you will have to use the Relate command.

Step 3: Relate the Subsequent Transactions table to the Parcels Layer

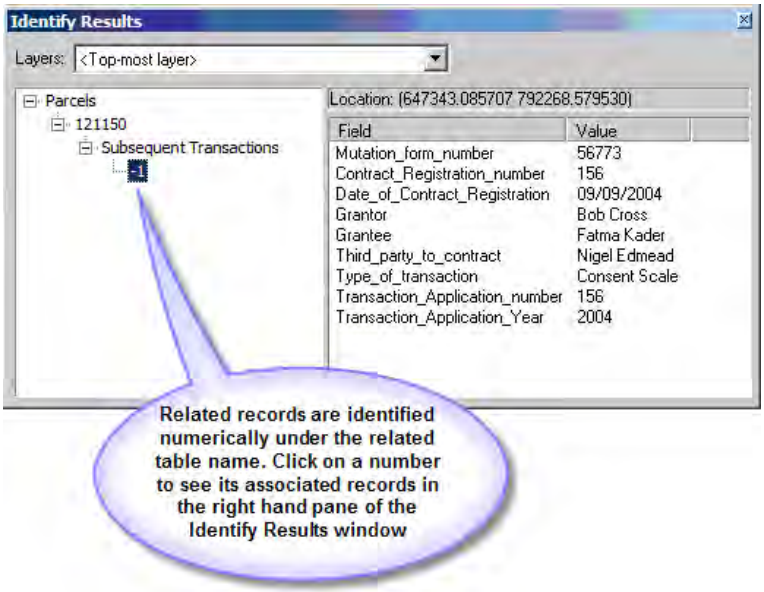
- ☐ Right click on the Parcels layer and choose Joins and Relates > Relate… from the context menu.

- ☐ Complete the Relate dialog box as follows:



- ☐ Click OK to continue
- ☐ Use the Identify tool to click on the parcel
- ☐ In the left hand pane of the Identify Results dialogue box, click the plus (+) button to the left of the parcel number, then the click the plus (+) sign next to the table 'Subsequent Transactions'.

You will see the two records you added to the Subsequent Transactions table identified numerically:



- ☐ Click on each one to see the details of these transactions in the Identify Results window.
- ☐ Close the Identify Results window.
- ☐ Since you have finished save the map document in your C:\TEMP directory as **ExJoin.mxd**.

EXERCISE 13: MAP PRODUCTION

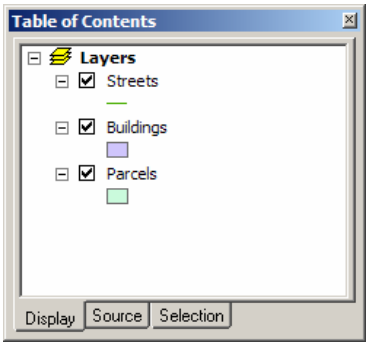
In this exercise you will learn how to prepare a cadastral index map in ArcMap.

☐ Start ArcMap and choose to open an existing map document.

Step 1: Open a map document

☐ Navigate to the C:\TRAINING\DATA\MAP DOCUMENTS directory and open the map document Map Production.mxd.

The map document contains three layers: Buildings, Parcels and Streets:

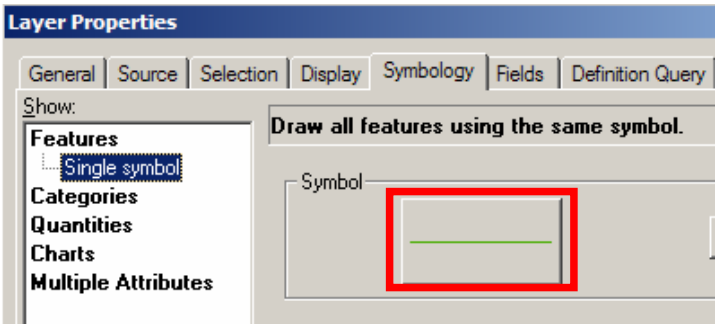


You will notice the symbology of the layers is not correct (i.e. it does not follow ESA guidelines as symbols are assigned randomly). Using tools in ArcMap you will first assign the correct symbols to all three layers and label the streets.

Step 2: Set symbology and labeling for layers

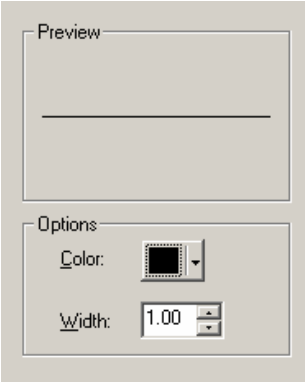
☐ Right click on the Streets layer and choose Properties… from the context menu.

☐ In the Layer properties dialog box click on the Symbology tab:

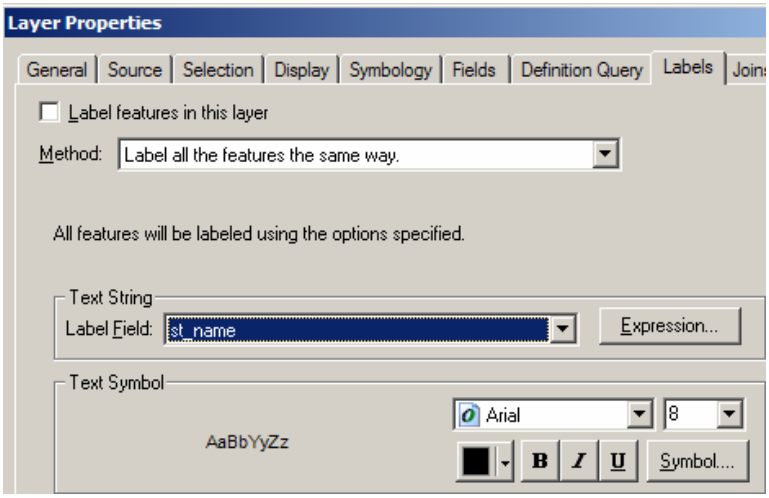


☐ Click on the current symbol for the streets layer (a thin green line).

- ☐ In the Symbol Selector dialog box click on the Color drop-down arrow and set the color of the line to black. Leave the width as 1:

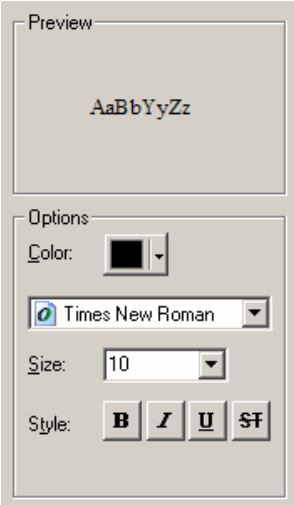


- ☐ Click OK to dismiss the Symbol Selector dialog box.
- ☐ Click the Apply button in the Layer properties dialog box to apply the changes to the layer, but keep the dialog box open.
- ☐ Next click on the Labels tab in the Layer properties dialog box:



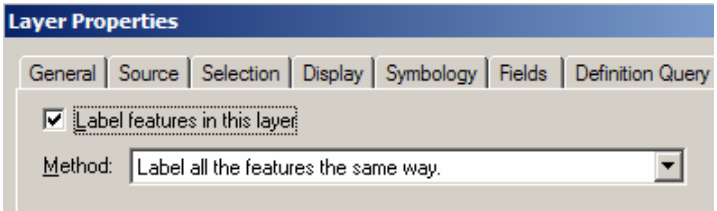
- ☐ Confirm the Label Field is ‘st_name’ – this is the first text field in the attribute table.
- ☐ Click on the Symbol… button.

- ☐ In the Symbol Selector dialog box set the Font to 'Times New Roman' and the Size to 10:

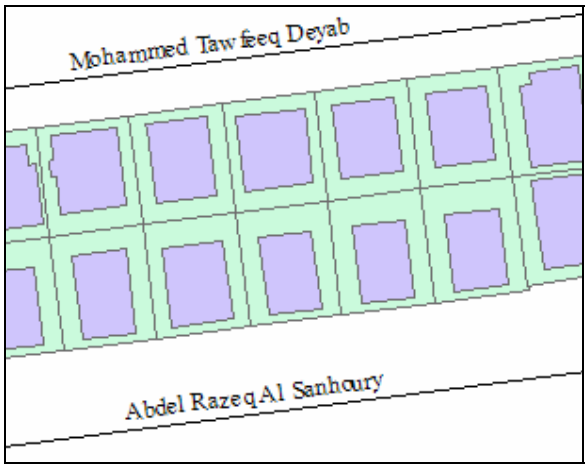


- ☐ Click OK to dismiss the Symbol Selector dialog box.

- ☐ Check the option 'Label features in this layer', then click the OK button in the Layer Properties dialog box:



The streets will be labeled by name:

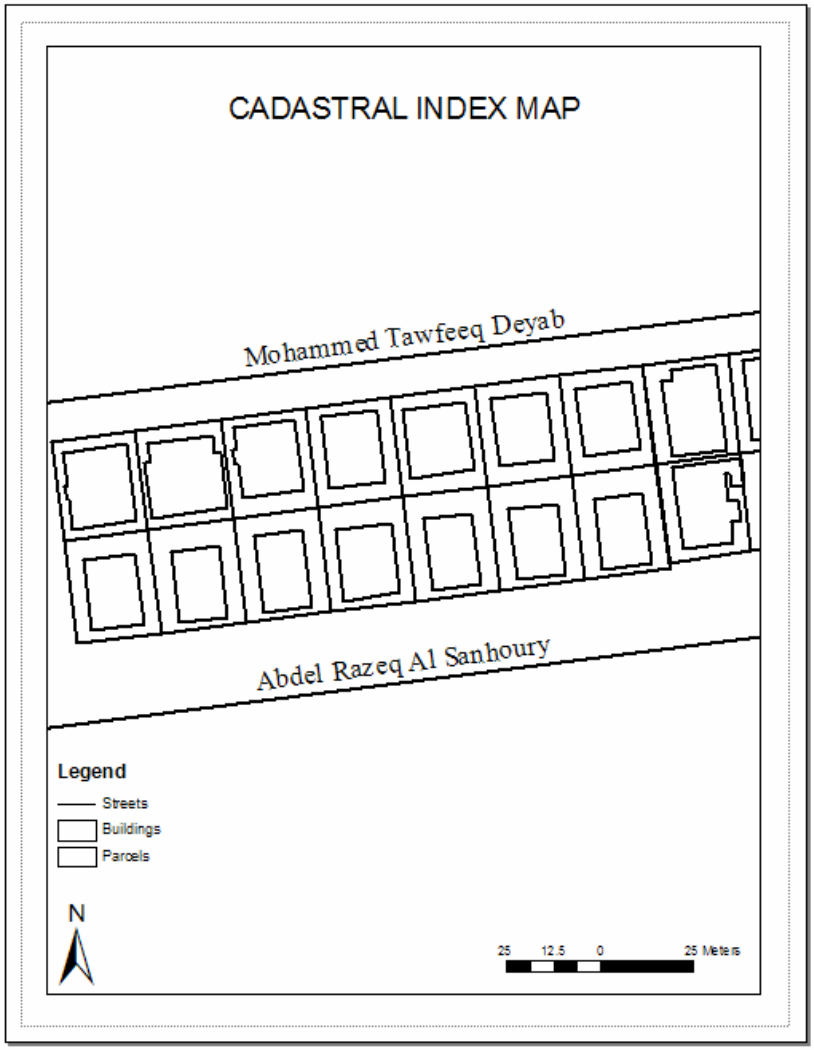


CHALLENGE STEP

Next repeat the steps described for the streets layer to symbolize the parcels and buildings layers with black outline (Width 1) and no fill (i.e. hollow). There is no need to label either the buildings or parcels as there are no major buildings in this block. Can you do this? If not please ask your instructor for guidance.

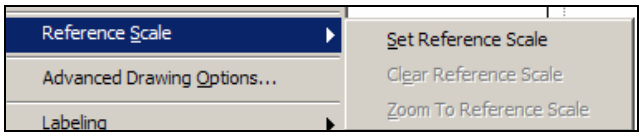
Step 3: Create a layout

In this step you will create a simple cadastral index map that looks something like this:



Do not worry if yours is not exactly the same. Follow the steps on the next page to get started.

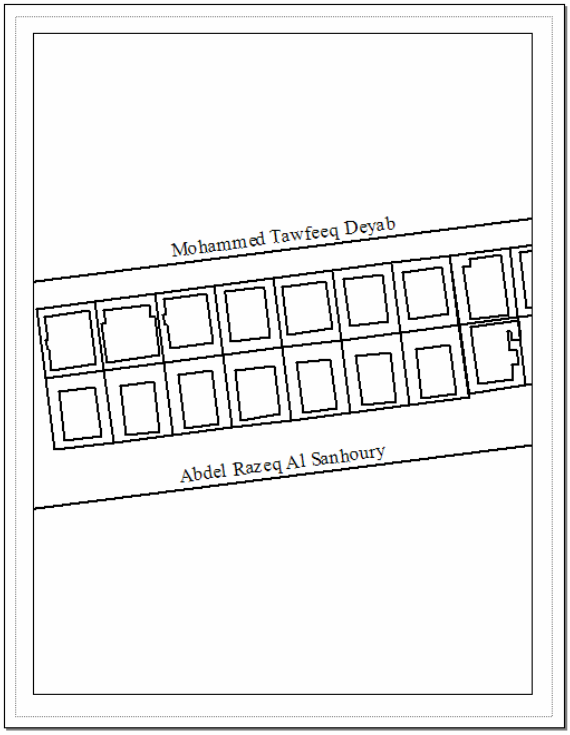
- ☐ Right click on the Layers data frame and choose Reference Scale > Set Reference Scale, by setting a reference scale when you zoom in symbols and text will get larger:



- ☐ From the View menu choose Layout View, switching to the layout view means you can begin the process of map design.

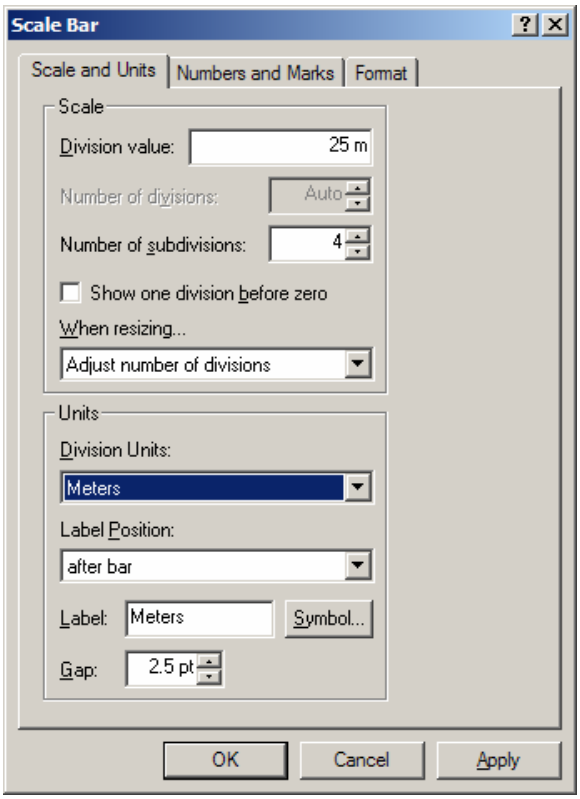
- ☐ In the Standard toolbar set the scale to 1:1000. Using the scale notation in the Standard toolbar allows you to create fixed scale maps:

You will notice both labels and outlines appear bigger in the layout, this is because you set a reference scale:



Now add a scale bar:

- ☐ From the Insert menu choose Scale Bar…
- ☐ In the Scale Bar Selector dialog box, select the 'Alternating Scale Bar 1' scale bar and click the Properties… button.
- ☐ Under the Scale and Units tab set the following options: (i) Division Value 25 m (ii) When resizing… 'Adjust number of divisions':



- ☐ Click OK to dismiss the Scale Bar dialog box.
- ☐ Click OK to dismiss the Scale Bar Selector dialog box and place the Scale Bar on the Layout.
- ☐ Use the Select Elements tool in the Drawing toolbar to drag the scale bar to an appropriate location:

Next add a north arrow:

- ☐ From the Insert menu choose North Arrow…
- ☐ In the North Arrow Selector dialog box select the 'ESRI North 3' north arrow and click OK to dismiss the North Arrow Selector dialog box and place the north arrow on the layout. Again use the Select Elements tool to place the North Arrow in an appropriate location.

Next add a title:

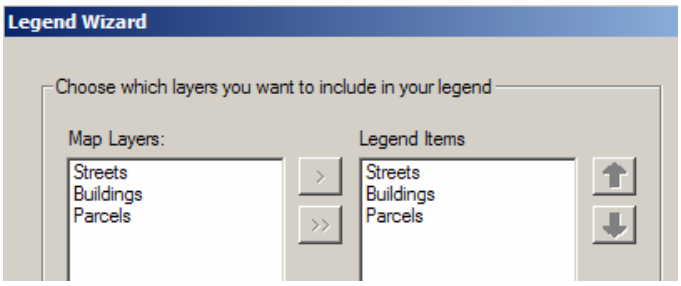
- ☐ From the Insert menu choose Title

The Title is actually the name of the map document so change this:

- ☐ Overtype the text 'Map Production' with 'CADASTRAL INDEX MAP' and press the Enter key on the keyboard.

Lastly add a legend:

- ☐ From the Insert menu choose Legend…
- ☐ In the first dialog box accept the default settings – all the layer's legends will appear in the layout. Click Next>> to continue:



- ☐ For Legend title accept the default settings and click Next>> to continue.
- ☐ For Legend frame accept the default settings and click Next>> to continue.
- ☐ For Legend symbols accept the default settings and click Next>> to continue.
- ☐ For Legend spacing accept the default settings and click Finish to place the legend on the layout. Again use the Select Elements tool to place the Legend in an appropriate location.

And that's it, obviously more can be added, but these are the principles of map design. Since you have finished save your work:

- ☐ Save the map document in your C:\TEMP directory as **ExMapProduction.mxd**.

ANNEX C:

Course evaluation form

ESA CADASTRAL OPERATIONS COURSE

Instructor:

Class Location:

Date:

Your Name:

Organisation:

Job Duties:

About You

What percentage time do you spend performing Surveying tasks?	10-20%	21-40%	41-70%	71-100%
What percentage time do you spend performing GIS tasks?	10-20%	21-40%	41-70%	71-100%
What percentage time do you spend performing GPS tasks?	10-20%	21-40%	41-70%	71-100%

What did you learn?	Not Learned	Learned	Can't say	
How to….				*Comments:*
Describe the methodology?	☐	☐	☐	
Scan and index mutation forms?	☐	☐	☐	
Transform raster and vector data?	☐	☐	☐	
Establish control points using GPS?	☐	☐	☐	
Survey a parcel boundary using Total Station?	☐	☐	☐	
Save survey data to ESRI shapefile format?	☐	☐	☐	
Perform quality control tasks?	☐	☐	☐	
Create a cadastral index map?	☐	☐	☐	

What additional course content should we include?

Course Evaluation

↖Continued on back

How were the course materials?

	Disagree		Agree	Comments:
Easy to work with?	☐	☐	☐	
Well organised?	☐	☐	☐	
Thorough?	☐	☐	☐	
Clear directions in the exercises	☐	☐	☐	
Will you use the materials after the class?	☐	☐	☐	

How might we improve the materials?

How was the instructor?

	Disagree		Agree	Comments:
Knowledgeable	☐	☐	☐	
Presented material clearly and effectively	☐	☐	☐	
Encouraged class participation	☐	☐	☐	
Answered questions clearly and completely	☐	☐	☐	
Paced the class too slow	☐	☐	☐	
Paced the class too fast	☐	☐	☐	

How might the Instructor improve the presentation?

What did you like best about this course?

Suggestions for otherwise improving this course:

ANNEX D:

Glossary of terms

GLOSSARY

Adjudication A judicial decision or formal judgment by a court or tribunal. Systematic adjudication is generally carried out during the introduction of a system of title registration to investigate and identify and adjudicate all rights, responsibilities and interests connected with individual real property objects. These are then registered against the object in the title register.

Aerial Survey A survey of an area made by taking sequential photographs from an aircraft; plans are then drawn from the aerial photographs.

Benchmark A permanent reference mark or point established for use by surveyors in measuring differences in elevation.

Boundary The line which separates property in one ownership from its neighbour(s); it is therefore the limit in all directions to which the ownership extends.

Building Footprint Building footprint data should be collected from sources, as paper or digital data, however it may be necessary to undertake field measurements to determine their actual spatial location.

Cadastral Form (*Sahiyfa akariya*) Used in the *Sigueal el-ainee* system as the form on which ownership information is recorded. Every parcel has its Cadastral Form. The Cadastral Form is akin to what is called a registration card or registration sheet in other countries. It is the document referred to in Article 58 of Law 142 of 1964 (the *Sigueal el-aine*e Law). That Law also refers to the Cadastral Form as a title deed (*sanad al mulkkaya*). The original of the Cadastral Form is kept in the central registration office. A copy of the Cadastral Form is provided only to the original parcel owner. Subsequent owners receive Certificates (*Shaheda*) pursuant to Article 59 of Law 142 of 1964.

Cadastral Information Form (CIF) (*kashf tahadeed*) The form generated by the ESA district office (EDO) describing the property that is the subject of a transaction. The EDO must provide the CIF to the local registration office (RO) before the RO will proceed with registering a transaction.

Cadastral Index Map The purposes of a cadastral index map is not to show each individual property with high spatial accuracy but rather to show properties in their correct spatial relationships to each other. Historically, cadastral index maps were often built up from surveys of individual parcels, a bottom-up approach. The bottom-up approach requires generalization of the individual parcel maps to get an overview map in which all parcels fit smoothly. In modern times, with the availability of computerized maps, aerial and satellite photography, and other top-down views, cadastral index maps are often prepared independently in parallel with the surveys of individual parcels.

Cadastral Plan (Location Plan) A plan which, for clarity of interpretation, is of a large scale (e.g. 1:1,250 or 1:2,500) to show the position of a specific property in relation to its surroundings.

Cadastral Survey A survey carried out for the determination, identification, reestablishment of adjustment of the boundaries of a property on a plan.

Cardinality The correspondence or equivalency between sets; how sets relate to each other. For example, if one row in a table is related to three rows in another table, the cardinality is one to many.

CCITT Group 4 This is a form of data compression commonly applied to images. roup 4 compression is a two dimensional algorithm that produces better compression results than Group 3, and is used by Ariel systems. CCITT stands for Comite Consultatif Internationale de Telegraphie et Telephonie. In the early 1990's the CCITT organization changed its name to ITU-T (International Telecommunications Union-Telecommunication), but the old French name lives on

Certificate of Authenticity (*Shaheda*) The certificate issued pursuant to Article 61 of the *Sigueal elainee* Law to confirm the authenticity of a copy of the Cadastral Form or Certificate issued under Article 59. Certificate of Title A statement of opinion on the status of the title to a parcel of real property based on an examination of specified public records.

Deed A document, being written evidence of a legal transaction, which has been signed, sealed and delivered to testify to the agreement of the parties concerned.

Displacement Link A displacement link is a displacement vector that represents a source location to a destination location.

DXF ***D****ata* ***Ex****change* ***F****ile*, a two-dimensional graphics file format supported by virtually all CAD and GIS products. It was created by AutoDesk for the AutoCAD system.

Easement A right to use the land of another for a specific purpose, such as for a right-of-way or utilities; an incorporeal interest in land.

Encroachment Unauthorized extension of the boundaries of a piece of land over adjoining land, via occupation, which belongs to another.

Feature class A collection of features that share the same geometry and attributes.

Geodatabase A geodatabase is the storage of geographic data implemented with a relational database. All geodatabase elements are managed in standard RDBMS tables using standard SQL data types. A personal geodatabase is a MS Access database with feature classes stored as tables in the mdb file. Personal geodatabases can only be edited by one person at a time.

Ground Control Points (GCPS) A system of points with known positions used as fixed references in geo-referencing map, plans, aerial photographs, or remotely sensed images.

Identity Link An Identity Link is a link whose source and destination coordinate are the same.

Mutation Form The document generated by the EDO when a parcel is created. It contains spatial information regarding the real property object as well as ownership information that is updated each time there is a transaction. The spatial information is generated through results of cadastral surveys performed by EDO or EPO surveyors.

Final Output The Cadastral map should include in addition to the previous a basic component of the map should be included such as map legend, north arrow and key or link to adjoining maps.

Map Scale Simply defined, scale is the relationship between distance on the map and distance on the ground. A map scale usually is given as a fraction or a ratio 1/1000 or 1:1000. These "representative fraction" scales mean that 1 unit of measurement on the map, 1 centimetre represents 1000 of the same units on the ground. "The larger the number, the smaller the scale". ESA has already produced many maps at different scales. The most important factor in choosing the scale in urban areas is to show a lot of details. The most commonly used scale for cadastral mapping purposes is 1:1000. This scale is large enough to allow most features such as parcel boundaries and building footprints to be drawn to scale.

Parcel Identifiers Each parcel should have assigned to it a unique identification number that links the specific parcel with files containing ownership data. Parcel identifiers provide a common index for all property records and may help track changes in legal descriptions in a uniform and more manageable way.

Parcel Polygon Polygon layer that can be of great value to the Registration, this polygon indicate the parcel boundary.

Plan 1) A drawing to scale of the layout and construction of a part of a building, whether existing or proposed, in horizontal section e.g. of a particular floor or set of rooms, and showing details such as windows, doors and permanent partitions. 2) A drawing of a relatively small area of land, usually drawn to a large scale and including details of boundaries, buildings, structures, service and other man-made features of a relatively permanent nature in addition to physical features. 3) A set of proposals for the performance of a task or undertaking in a controlled manner or in a series of predefined steps according to certain principles or rules. In the case of the future development of an area, it would probably embrace maps and written statements.

RDBMS ***R****elational* ***D****atabase* ***M****anagement* ***S****ystem*. A type of database in which data is organized across one or more tables. Tables are associated with each other through common fields called keys, examples include MS Access, SQL Server and ORACLE.

Registered Contract (*ad el baiya el nehaie*) A final contract, sometimes referred to as a deed, registered under the *Sigueal el-shaksi* system. The original is printed on oversized green paper and is kept in the central registration office. A blue copy on laminated legal size paper is provided to the owner.

Root Mean Square Error (RMS) A root mean square error (RMS) describes the deviation that will occur when the transformation is applied to the input and the output coordinate systems. The error is determined using the least squares regression method.

Rubbersheeting A procedure for adjusting the coordinates of all the data points in a dataset to allow a more accurate match between known locations and a few data points within the dataset. Rubber sheeting preserves the interconnectivity between points and objects through stretching, shrinking, or reorienting their interconnecting lines.

Shapefile An ArcView GIS data set used to represent a set of geographic features such as streets, buildings or parcels. Shapefiles can represent point, line, or area features. Each feature in a shapefile represents a single geographic feature and its attributes.

Sigueal el-ainee Registry of real property (all rights, responsibilities and interests are registered against real property objects).

Sigueal el-shaksi Personal registry (meaning registration of real property objects against the name of a person).

Site Plan A drawing of an area of land, on a horizontal plane, showing the boundaries and physical extent of the land included in a particular parcel. It may also show existing buildings or the proposed layout of a development.

Subdivision A tract of land divided by the owner, known as the sub divider, into blocks, building lots, and streets according to regulations.

Survey A process of investigation into some subject involving measurement and/or assessment, e.g. building survey; land survey; land use survey; pedestrian survey.

TIFF ***T****ag* ***I****mage* ***F****ile* ***F****ormat*. t is one of the most popular and flexible of the current public domain raster file formats.

Traversing A method of land surveying by measuring angles with a theodolite or total station, from each station to other stations, measuring the distance between stations and plotting the results. The stations are generally used as local geodetic control points for land surveys.