Chapter 4

ILWIS objects

Note: This chapter is written as an enhancement to Chapter 4: ILWIS Objects in the ILWIS 2.1 Reference Guide. It does *not* completely replace the mentioned chapter: instead you are invited to use both as one.

Introduction

This chapter only contains those ILWIS objects for which the documentation has changed. Descriptions are included for the following objects:
- Data objects:
  - Raster maps
  - Polygon maps
  - Segment maps
  - Point maps
  - Map lists
- Service objects:
  - Representation
  - Georeferences
  - Coordinate systems
- Annotation:
  - Annotation Text
  - Simple annotation

For ILWIS objects **not** described here, refer to the ILWIS 2.1 Reference Guide. These ILWIS objects are:
- Data objects:
  - Tables
  - Columns
- Service objects:
  - Domains
- Special objects:
  - Map views
  - Histograms
  - Sample sets
  - Two-dimensional tables
  - Matrices
  - Filters
  - Functions
  - Scripts

4.1   Data objects

4.1.1   Raster maps ⊞

A raster map is a data object used to store spatial geographic information and remote sensing data as pixels (picture elements) of a certain size, e.g. 20×20 m. These pixels are either codified by IDs, class names, values or colors; this is determined by the domain of the map. The relation between pixels in a raster map and the position on earth is defined by the georeference that the raster map is using.

Raster maps can be displayed in a map window, and can be edited with the pixel editor. You can calculate with raster maps (MapCalc) and you can perform many other raster and image processing operations on them such as: Filter, Cross, Distance calculation, etc. In ILWIS, most spatial operations are performed on raster maps.

A raster map can be obtained:
- by importing an existing raster map from ILWIS version 1.41,
- by rasterizing an existing point, segment, or polygon map,
- by creating a new raster map and editing its pixels with the pixel editor,
- by using a satellite image which is already a raster map,
- by scanning a map or photograph and importing it into ILWIS.

As mentioned above, the output of spatial operations is usually another raster map.

When working with the multi-spectral bands of a satellite image or with multiple raster map of a time series, you can combine these bands or maps into a map list.

Contents of a raster map and location of pixels
The contents of a raster map are defined by the domain that the raster map is using. A raster map may store for example:
- rasterized individual point, segment or polygon features codified by IDs for instance cadastral plot IDs; the map uses an ID domain,
- rasterized classes of point, segment, or polygon features codified by class names, for example land use classes; the map uses a class domain,
- rasterized point, segment or polygon values for example height values; the map uses a value domain,
- reflection values in case of satellite images; the maps use the Image domain, the NOAA domain, or the Radar domain,
- true or false pixels; the map uses the Bit domain,
- true, false or undefined pixels; the map uses a Bool domain,
- colors in case of a scanned picture that was imported into ILWIS; the map uses a Picture domain, or the Color domain,
- output values after a map calculation (any domain),
- output values (any domain) after performing an operation, e.g. classes after the Classify operation (image classification), or values after a Distance calculation, or colors after creating a Color Composite,
- attribute values (any domain) when an attribute map was created from an attribute table,

- classified values, when a value map was classified (a group domain) with the Slicing operation.

For more information on domains, refer to Basic concepts : working with domains.

The spatial location of the pixels in a raster map is defined by the georeference that the raster map is using.

For maps using a class or ID domain, you can create an attribute table which stores additional information on the classes or IDs in the map. Use the same class or ID domain for the attribute table as you used for the map. Then, add the attribute columns to the table. To create an attribute table, refer to How to create an attribute table.

The manner in which raster maps are displayed is specified in a Display Options Raster Map dialog box.

- When a raster map uses a *class domain*, you can use or create a representation class. In a representation class, every class has its own color. You can edit the colors of a representation class in the Representation Class editor, or directly in a map window by using the Double-click action.
- When a raster map uses a *value domain*, you can use or create a representation value or a representation gradual.
- Raster maps that are satellite images and use the *Image domain*, are usually displayed with system representation Gray; the default stretch range is the `1%` interval.
- When a raster map uses an *ID domain*, you can display the map in one single color or in multiple system colors. However, an ID raster map will usually have an attribute table and you can then choose to display the map by one of its attribute columns. For class columns, you can select or create a domain class; for value columns, you can select or create a representation value or a representation gradual, etc.
- When a raster map uses a *Bool domain*, you can specify colors for True and False pixels.

☞ To store the display setting of one or more maps displayed in a map window, save the map window as a map view; open the File menu in a map window and choose the Save View or the Save View As command.

Names of raster maps
Any raster map name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a raster map
Usually, you have to rasterize a point, segment or polygon map with the Points to Raster, Segments to Raster or Polygons to Raster operation. In the Rasterize process, you have to specify the dimensions of the raster map's pixels in the georeference of the raster map.

To display a raster map

The easiest way to display a raster map is to double-click the map in the Catalog. The map will be displayed in a new map window.

In the Display Options Raster Map dialog box, you can specify how the map should be displayed.

To edit a raster map

You can edit a raster map by clicking it with the right mouse button in the Catalog and subsequently choose Edit from the context-sensitive menu. When a raster map is already displayed in a map window, you can also choose the Edit Layer command from the Edit menu in the map window. For other methods, see How to edit point, segment, polygon and raster maps.

Raster maps are edited with the Pixel editor; you can edit the class names, IDs, or values of the pixels in the raster map. Dependent raster maps and read-only raster maps cannot be edited.

Operations on raster maps

You can calculate with raster maps by typing a Map Calculation formula on the command line of the Main window or in the Map Calculation dialog box. When the definition symbol = is used in a calculation, the output map is dependent.

You can also perform other operations on a raster map by selecting an operation from the Operation-list or from the Operations menu (for other methods, see How to start operations). Subsequently, fill out the appearing dialog box of that operation and click the OK button; this generates an ILWIS expression on the command line. Output objects that are obtained through an operation's dialog box are always dependent.

Advanced users can type the complete ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions. For more information, see Appendices: ILWIS expressions.

When the output map of a calculation or another operation uses a value domain, you can usually define a value range and precision for the output map, see below. Operations on raster maps are for instance Filter, Cross and Distance calculation. For more information on operations, refer to ILWIS operations.

Technical information

A raster map consists of an ASCII object definition file (.MPR) and a binary data file (.MP#). The object definition file contains further references to the domain and the georeference that the raster map is using; these are properties of a raster map.

By viewing the properties of a raster map, you can see whether the map is dependent or not, which other objects the map is using, etc. In the properties dialog box of a value raster map, you can select the Interpolation option to obtain interpolated values on sub-pixel level. For dependent maps, you can manage dependencies: break

dependencies, make dependent maps up-to-date, delete the dependent map's data file, etc.

The IDs, class names or values of pixels are stored line by line, starting from the first pixel (left) on the first line in the map (up), to the last pixel in the last line. Raster maps are stored as bit, byte, 2-byte, 4-byte or 8-byte maps. The store type of a raster map is primarily defined by the domain that the map is using. For value maps this is determined by the value range and precision that you specify for the output map during a calculation or operation. Usually, ILWIS will come up with defaults, but you can adjust these values. Choosing a wide value range and a very small precision results in a large data file on disk as more bytes are needed to store each pixel value in the map, also the speed of display and the speed of calculations may decrease.

For value maps that use 1 or 2 bytes per pixel, the map's histogram is automatically calculated when you open the map and a histogram is not available yet. For value maps that are stored using 4 or 8 bytes per pixel, you need to use the Histogram operation to obtain the map's histogram.

Limitations
The maximum number of lines in a raster map is 2 billion. The maximum number of columns is 32000 for bit, byte and 2-byte maps, 16000 for 4-byte maps and 8000 for 8-byte maps.

4.1.2   Polygon maps

A polygon map is a data object used to store spatial geographic information that consists of polygons, i.e. closed areas including the boundaries making up the areas. The areas are either codified by IDs, class names or values; this is determined by the domain of the map. The relation between polygons in a polygon map and the position on earth is defined by the coordinate system that the map is using.

Maps containing uniquely codified areas such as cadastral plots, or mapping units such as geological formations, land use classes, or soil units, can all be stored as polygon maps. Polygon maps are usually used as a stepping stone to raster maps. Polygon maps can be displayed in map windows, and edited with the polygon editor.

A polygon map can be obtained:
- by importing an existing polygon map from ILWIS version 1.41,
- by creating a segment map and editing it with the segment editor (with or without digitizer); then polygonize the segment map either in the segment editor or with the Segments to Polygons operation,
- by performing ILWIS operations that return a polygon map as output, for instance the Attribute map of polygon map operation.

Like in ILWIS 1.4, you first have to digitize segments and then polygonize these segments to obtain a polygon map.

Contents of a polygon map and location of polygons

The contents of a polygon map are defined by the domain that the polygon map is using. A polygon map may store for example:

- individual area features with or without attributes; each polygon has its own mostly unique ID, for instance cadastral plot IDs; the map uses an ID domain,
- classes of area features with or without attributes; polygons may occur in several places in the map, for instance land use classes or soil classes; the map uses a class domain,
- area features representing measurable values; polygon values representing for instance population densities or concentration levels of air pollution; the map uses a value domain,
- true, false or undefined polygons; the map uses a Bool domain,
- output values (any domain) after performing an operation, e.g. IDs after the Unique ID operation,
- attribute values (any domain) when an attribute map was created from an attribute table with the Attribute map of polygon map operation.

For more information on domains, refer to Basic concepts : working with domains.

The spatial location of polygons in a polygon map is defined by the coordinate system that the polygon map is using.

For maps using a class or ID domain, you can create an attribute table which stores additional information on the classes or IDs in the map. Use the same class or ID domain for the attribute table as you used for the map. Then, add the attribute columns to the table. When you have for example a map with building blocks (coded by IDs), you can add an attribute table with the predominant landuse per building block and the number of residents per building block. Or, when you have a soil map (coded by classes), you can add an attribute table with pH, soil texture, etc. for each soil unit.

To create an attribute table, refer to How to create an attribute table.

The manner in which polygon maps are displayed is specified in the Display Options Polygon Map dialog box.

- When a polygon map uses a *class domain*, you can display polygons in a single color, or by using or creating a representation class. In a representation class, every class can have its own color, and optionally you can use hatchings or patterns.
- When a polygon map uses a *value domain*, you can display polygons in a single color or you can use or create a representation value or a representation gradual.
- When a polygon map uses an *ID domain*, you can display polygons in a single color or in multiple system colors. However, an ID polygon map will usually have an attribute table and you can then choose to display the map by one of its attribute columns. For class columns, you can select or create a domain class; for value columns, you can select or create a representation value or a representation gradual, etc. For more information, see How to display a map by one of its attributes.

- When a polygon map uses a *Bool domain*, you have to specify colors each time you display the map.

☞   To store the display setting of one or more maps displayed in a map window, save the map window as a map view; open the File menu in a map window and choose the Save View or the Save View As command.

Names of polygon maps
Any polygon map name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a polygon map
To create a polygon map, you first have to create a segment map in which you can digitize polygon boundaries. Furthermore, you can create a point map in which you can digitize the polygon names or IDs as label points. When you display both the segment and point map in one map window, you can easily see whether the areas enclosed by segments have a label point. Then, polygonize the segments from within the segment editor. For more information, refer to How to create polygon maps or to Segment editor. To check after polygonization whether all polygons obtained a class name, ID or value, you can use the Polygons to Points operation.

To display a polygon map
The easiest way to display a polygon map is to double-click the map in the Catalog. The polygon map will be displayed in a new map window. You can also drag a polygon map from the Catalog to an existing map window, in order to show that polygon map on top of other information shown in the map window.

In the Display Options Polygon Map dialog box, you can specify how the map should be displayed.

To edit a polygon map
Class names, IDs, or values of selected polygons can be edited in the polygon editor. To change the shape of polygons, or to delete or undelete polygon boundaries you need to use the segment editor; then re-polygonize the segment map.

To open the polygon editor, you can click a polygon map with the right mouse button in the Catalog and subsequently choose Edit from the context-sensitive menu. When a polygon map is already displayed in a map window, you can also choose the Edit Layer command from the Edit menu in the map window. For other methods, see How to edit point, segment, polygon and raster maps. In the polygon editor, you can use a digitizer but you can also use the mouse pointer. Dependent polygon maps and read-only polygon maps cannot be edited.

Operations on polygon maps
The most frequently used operation on polygon maps is probably the Polygons to Raster operation, which rasterizes a polygon map. During this operation, you have to select or create a georeference for the raster map to define the size of the pixels in

the raster map. Another operation on polygon maps is for instance Attribute map of polygon map.

You can perform operations on a polygon map by selecting an operation from the Operation-list or from the Operations menu (for other methods, see How to start operations). Subsequently, fill out the appearing dialog box of that operation and click the OK button; this generates an ILWIS expression on the command line. Output objects that are obtained through an operation's dialog box are always dependent. Advanced users can type the complete ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions.

For more information on operations, refer to Chapter 7: Operations.

Technical information
A polygon map consists of an ASCII object definition file (.MPA) and a number of binary data files (.PC#, .PD#, .PL#, .PS#, .TP#). The object definition file contains further references to the domain and the coordinate system that the polygon map is using; these are properties of a polygon map.

By viewing the properties of a polygon map, you can see whether the map is dependent or not, which other objects the map is using, etc. For dependent maps, you can also manage dependencies: break dependencies, make dependent maps up-to-date, delete the dependent maps's data files, etc.

A polygon map stores one or more polygons. A polygon is nothing more than a list of XY-coordinate pairs (the polygon boundaries) which form the boundaries of a polygon. The first and last coordinate pair of a boundary is called a node, so all individual polygon boundaries are connected to each other by nodes. Each polygon boundary is used both for the polygon on the left and right of this boundary; this is called a topological structure. Polygons are identified by IDs, class names or values.

Coordinate pairs are stored as pairs of 2-byte fixed point reals. This means that a paper map with a size of 3 by 3 meter can be stored with a resolution of 0.1 millimeter on paper. For all practical purposes, this should be enough. Paper maps smaller than 3 by 3 meters can thus be stored with an even finer resolution. When you create a map and specify the coordinate boundaries of the map, you should take care that the boundaries do not exceed this size of 3 by 3 meter on paper.

Limitations
The maximum number of polygons in one polygon map is 32000. The maximum number of polygon boundaries is 32000. The maximum number of coordinate pairs in one polygon boundary is 1000 (taken care of by the system).

4.1.3   Segment maps

A segment map is a data object used to store spatial geographic information that consists of lines, for example roads, rivers or contour lines. Segments are either codified by IDs, class names or values (height map); this is determined by the

domain of the map. The relation between segments in a segment map and the position on earth is defined by the coordinate system that the map is using. Segment maps can be displayed in map windows, and edited with the segment editor.

A segment map can be obtained:
- by importing an existing segment map from ILWIS version 1.41,
- by creating a new segment map and editing it with the segment editor with or without using a digitizer, or
- by performing ILWIS operations that return a segment map as output, for instance the Mask Segments operation.

Contents of a segment map and location of segments
The contents of a segment map are defined by the domain that the segment map is using. A segment map may store for example:
- individual line features: each segment is codified by its own ID for instance when each pipe line or river section has its own unique ID; the map uses an ID domain,
- classes of line features: segments may occur in several places in the map for instance primary roads, secondary roads, etc.; the map uses a class domain,
- line features representing measurable values, for instance a contour map with height information; the map uses a value domain,
- true, false or undefined segments; the map uses a Bool domain,
- output values (any domain) after performing an operation, e.g. IDs after the Unique ID operation,
- attribute values (any domain) when an attribute map was created from an attribute table with the Attribute map of segment map operation.

For more information on domains, refer to Basic concepts: working with domains.

The spatial location of segments in a segment map is defined by the coordinate system that the segment map is using.

For maps using a class or ID domain, you can create an attribute table which stores additional information on the classes or IDs in the map. Use the same class or ID domain for the attribute table as you used for the map. Then, add the attribute columns to the table. To create an attribute table, refer to How to create an attribute table.

The manner in which segments are displayed is specified in the Display Options Segment Map dialog box.
- When a segment map uses a *class domain*, you can display segments in a single color, or by using or creating a representation class. In a representation class, every class can have its own line type, line width, color, etc. You can also represent a line by equally spaced symbols. For more information, see Representation Class editor and the Edit Repr Class item (segment) dialog box.
- When a segment map uses a *value domain*, you can display segments in a single color, in multiple system colors or by using or creating a representation value or a representation gradual.

        ■ When a segment map uses an *ID domain* or a *Bool domain*, you have to specify colors each time you display the map.

☞   To store the display setting of one or more maps displayed in a map window, save the map window as a map view; open the File menu in a map window and choose the Save View or the Save View As command.

Names of segment maps
Any segment map name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a segment map
Open the File menu of the Main window and select the Create Segment Map command, or double-click the New SegMap item in the Operation-list. In the appearing Create Segment Map dialog box, enter a name and description for the segment map, select or create a coordinate system, enter boundary values for the map and select or create a domain. For other create methods, see How to create a map.

To display a segment map
The easiest way to display a segment map is to double-click the map in the Catalog. The map will be displayed in a new map window. You can also drag a segment map from the Catalog to an existing map window, in order to show that segment map on top of other information shown in the map window. For other methods, see How to display maps and tables.

In the Display Options Segment Map dialog box, you can specify how the map should be displayed.

To edit a segment map
You can edit a segment map by clicking it with the right mouse button in the Catalog and subsequently choose Edit from the context-sensitive menu. When a segment map is already displayed in a map window, you can also choose the Edit Layer command from the Edit menu in the map window. For other methods, see How to edit point, segment, polygon and raster maps.

Segment maps are edited with the Segment editor: you can insert new segments and delete and undelete existing ones, edit the class names, IDs, or values of segments, change the shape of segments, split and merge segments, and pack, check and polygonize segments. You can use a digitizer but you can also use the mouse pointer. Dependent segment maps and read-only segment maps cannot be edited.

Operations on segment maps
Frequently used operations on segment maps are for instance the Segments to Polygons operation to polygonize a segment map and the Segments to Raster operation, which rasterizes a segment map. During the rasterize operation, you have to select or create a georeference for the raster map to define the size of the pixels in

the raster map. Another operation on a segment map is for instance Contour interpolation.

You can perform operations on a segment map by selecting an operation from the Operation-list or from the Operations menu (for other methods, see How to start operations). Subsequently, fill out the appearing dialog box of that operation and click the OK button; this generates an ILWIS expression on the command line. Output objects that are obtained through an operation's dialog box are always dependent. Advanced users can type the complete ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions.

For more information on operations, refer to Chapter 7: Operations.

Technical information
A segment map consists of an ASCII object definition file (.MPS) and three binary data files (.CD#, .SC#, .SG#). The object definition file contains further references to the domain and the coordinate system that the segment map is using; these are properties of a segment map.

By viewing the properties of a segment map, you can see whether the map is dependent or not, which other objects the map is using, etc. For dependent maps, you can also manage dependencies: break dependencies, make dependent maps up-to-date, delete the dependent maps's data files, etc.

A segment map stores one or more segments. A segment is nothing more than a list of XY-coordinate pairs. Each list of XY-coordinates represents a (part of a) linear feature. Segments are identified by IDs, class names or values. Places where two or more segments are connected are called **nodes**: a node is thus a common XY-coordinate for two or more segments. Further, the beginning and end of a segment are always nodes.

Coordinate pairs are stored as pairs of 2-byte fixed-point reals. This means that a paper map with a size of 3 by 3 meter can be stored with a resolution of 0.1 millimeter on paper. For all practical purposes, this should be enough. Paper maps smaller than 3 by 3 meters can thus be stored with an even finer resolution. When you create a map and specify the coordinate boundaries of the map, you should take care that the boundaries do not exceed this size of 3 by 3 meter on paper.

Limitations
The maximum number of segments in one segment map is 32000. The maximum number of coordinate pairs per segment is 1000 (taken care of by the system).

4.1.4   Point maps

A point map is a data object used to store spatial geographic information which consists of points, for example water wells or sample points. Points are either identified by IDs, class names or values; this is determined by the domain of the map. The relation between points in a point map and the position on earth is defined

by the coordinate system that the map is using. Point maps can be displayed in map windows, and edited with the point editor.

A point map is obtained:
- by importing an existing point map from ILWIS version 1.41,
- by creating a new point map and editing it with the point editor with or without using a digitizer,
- by converting a table which contains coordinate columns to a point map with the Table to Point map operation, or
- by performing ILWIS operations that return a point map as output, for instance the Attribute map of point map operation, or the Segments to Points operation.

Contents of a point map and location of points
The contents of a point map are defined by the domain that the point map is using. A point map may store for example:
- individual point features: each point is codified by its own ID, for instance individual sample points, individual bore holes, individual rainfall stations, etc.; the map uses an ID domain,
- classes of point features: points may occur in several places in the map for instance all water wells of a certain type; the map uses a class domain,
- point features representing measurable values, for instance height information; the map uses a value domain,
- true, false or undefined points; the map uses a Bool domain.
- output values (any domain) after performing an operation, e.g. IDs after the Unique ID operation,
- attribute values (any domain) when an attribute map was created from an attribute table with the Attribute map of point map operation.
For more information on domains, refer to Basic concepts : working with domains.

The spatial location of points in a point map is defined by the coordinate system that the point map is using.

For maps using a class or ID domain, you can create an attribute table which stores additional information on the classes or IDs in the map. Use the same class or ID domain for the attribute table as you used for the map. Then, add the attribute columns to the table. When you have for a example a point map with rainfall stations, coded with IDs, you can add an attribute table with the rainfall figures per month for each station. To create an attribute table, refer to How to create an attribute table.

Point symbols
The manner in which points are displayed is specified in the Display Options Point Map dialog box.
- When a point map uses a *class* domain, you can display point symbols as single symbols or by using or creating a representation class. In a representation class, every class can have its own symbol, size, color, etc. For more information, see Representation Class editor and the Edit Repr Class item (point) dialog box.

- When a point map uses an *ID domain* and when the point map has an *attribute table*, you can display point symbols as single symbols, as arrows, as graphs or by attributes. In this way, you can for instance obtain pie charts, bar graphs, volume cubes, etc. for every point in the map. Sizes, colors, etc. can be specified by using columns in the attribute table.
- When a point map uses a *value domain*, you can choose a symbol set and a symbol for all the points while the size of the selected symbol may depend on the value of the points.
- When a point map uses a *Bool domain*, you can specify colors for True and False points.

☞ To store the display setting of one or more maps displayed in a map window, save the map window as a map view; open the File menu in a map window and choose the Save View or the Save View As command.

Names of point maps
Any point map name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a point map
Open the File menu of the Main window and select the Create Point Map command, or double-click the New PntMap item in the Operation-list. In the appearing Create Point Map dialog box, enter a name and description for the point map, select or create a coordinate system, enter boundary values for the map and select or create a domain. For other create methods, see How to create a map.

When you have a table, which contains columns with X- and Y-coordinates, you can use the Table to Point map operation to obtain a point map from this table.

To display a point map
The easiest way to display a point map is to double-click the map in the Catalog. The map will be displayed in a new map window. You can also drag a point map from the Catalog to an existing map window, in order to show that point map on top of other information shown in the map window. For other methods, see How to display maps and tables.

In the Display Options Point Map dialog box, you can specify how the map should be displayed.

Point maps can also be opened as tables: click the point map with the right mouse button in the Catalog, and subsequently choose Open as Table from the context-sensitive menu. When you display a point map in a table window, you can edit the XY-coordinates of the points and perform calculations with the XY-coordinates of the points.

To edit a point map
You can edit a point map by clicking it with the right mouse button in the Catalog and subsequently choose Edit from the context-sensitive menu. When a point map is already displayed in a map window, you can also choose the Edit Layer command from the Edit menu in the map window. For other methods, see How to edit point, segment, polygon and raster maps.

Point maps are edited with the Point editor: you can insert new points and delete existing ones, edit the class names, IDs, or values of points, and move points to a new position. You can use a digitizer but you can also use the mouse pointer. Dependent point maps and read-only point maps cannot be edited.

Operations on point maps
Examples of operations on point maps are for instance point interpolations: moving average, trend surface, moving surface, or kriging. The point map itself may use a value domain but you can also use point maps with a class or ID domain and that have an attribute table, which contains the values, which you want to interpolate.

You can perform operations on a point map by selecting an operation from the Operation-list or from the Operations menu (for other methods, see How to start operations). Subsequently, fill out the appearing dialog box of that operation and click the OK button; this generates an ILWIS expression on the command line. Output objects that are obtained through an operation's dialog box are always dependent. Advanced users can type the complete ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions.

For more information on operations, refer to Chapter 7: Operations.

Technical information
A point map consists of an ASCII object definition file (.MPP) and a binary data file (.PN#). The object definition file contains further references to the domain and the coordinate system that the point map is using; these are properties of a point map.

By viewing the properties of a point map, you can see whether the map is dependent or not, which other objects the map is using, etc. For dependent maps, you can also manage dependencies: break dependencies, make dependent maps up-to-date, delete the dependent maps's data files, etc.

Each point is stored as a pair of XY-coordinates. The coordinates pairs are stored as pairs of 8-byte floating point reals. Points are identified by a class name, ID or a value.

Limitations
The maximum number of points in a point map is 2 billion.

4.1.5   Map lists ⊞

A map list is a data object and stores the names of a set of raster maps, for example of the multi-spectral bands of a satellite image that you want to classify. A map list may also store the names of several raster maps of a time series which you can display as a slide show. All raster maps in a map list must have the same the same domain and georeference.

A map list is used:
- for sampling and image classification,
- for the creation of interactive color composites,
- for a principal components analysis or factor analysis,
- for the calculation of multiband statistics (variance-covariance matrix or correlation matrix),
- to present temporal changes in maps; make a time-series by combining several maps of the same theme but of for instance different years into a map list and show the map list as a slide show.

Names of map lists
Any map list name must start with a character between A and Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a map list
Open the File menu in the Main window and select the Create Map List command, or double-click the NewMapList item in the Operation-list, or start an operation which requires a map list as input and click the create button in the operation's dialog box. In the appearing Create Map List dialog box, enter a name and description for the map list, and select the raster maps that together should form the map list.

To display a map list
A map list is simply a list of raster map names. You can display the individual raster maps as usual, for instance by double-clicking a raster map in the Catalog; the map is displayed in a new map window. To open and edit the contents of a map list, see paragraph To edit a map list.

When your map lists contains raster maps, which have the Image domain or another value domain, and your graphics board is configured to use more than 256 colors, e.g. High Color 16-bit or True Color 24-bit, you can display three maps of a map list as an interactive color composite. Choose Visualization, Show Map List as Color Composite from the Operations menu and select a map list, or use the right mouse button on a map list in the Catalog and choose Visualization, as Color Composite from the context-sensitive menu. You can select the maps of the map lists, which should be used in the color composite and you can specify the stretch ranges for each of the selected maps. By changing the display options of the map list, you can change the color composite. This is very suitable for sampling and on-screen digitizing. For more information, refer to How to create a color composite.

Furthermore, all maps in a map list can be displayed one after the other in one map window, as a slide show. This is very suitable to display a time series. Choose Visualization, Show Map List as Slide Show from the Operations menu, or use the right mouse button on a map list in the Catalog and choose Visualization, as Slide Show from the context-sensitive menu. For more information on slide shows, see How to display a map list as a slide show or Map window: advanced functionality.

To edit a map list
To edit a map list, select Edit Object from the Edit menu in the Main window and select a map list, or use the right mouse button on a map list in the Catalog and choose Edit from the context-sensitive menu. In the appearing Edit Map List dialog box you can change the selection of raster maps that are included in the map list. See also How to edit a map list.

Operations on map lists
Usually, you will create a map list during sampling to obtain a sample set with which you can perform a supervised classification in a later stage. Sampling however is an interactive process and not a genuine operation.

Operations on a map list return multivariate statistical information (a matrix) on the values of the different raster maps in a map list. Only the Principal Components and Factor Analysis operations result in an output map list.

You can start an operation on a map list for instance by selecting an operation from the Operation-list or from the Operations menu. For other methods, see How to start operations. Subsequently, fill out the appearing dialog box of that operation and click the OK button; this generates an ILWIS expression on the command line. Output matrices and output raster maps that are obtained through an operation's dialog box are always dependent; however output map lists are not dependent yet. Advanced users can type the complete ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions.

Technical information
A map list consists only of an ASCII object definition file (.MPL). The object definition file contains further references to raster maps that are included in the map list.

By viewing the properties of a map list, you can see the size of the object and the time it was last changed. In case you calculated a variance-covariance matrix or a correlation matrix, the properties dialog box contains an extra button Additional Info, which shows you the Optimum Index Factor (OIF) of combinations of three bands in the map list. For more information, see How to calculate the Optimum Index Factor.

Limitations
In principle, the maximum number of raster maps that can be included in a map list is 5440. In practice however limitations will occur by memory and available disk

space. For operations that result in a matrix, a map list cannot contain more than 80 raster maps.

4.2   Service objects

4.2.1   Representations

A representation defines the manner in which classes of a map with a class domain, a group domain or a picture domain, or the values of a map with a value domain or the image domain should be represented on the screen and on a printer.

A representation stores colors or ranges of colors for the classes in a class domain, or for specific values or ranges of values for the values in a value domain. Furthermore, for polygon classes, colors, hatching and patterns can be stored; for segment classes, colors, line types and line widths, etc. can be stored; and for point classes, colors, symbols, symbol sizes, etc. can be stored.

A representation is a service object for a domain, i.e. a domain uses a certain representation.

Maps with a Bool, the `Bit`, an ID, or the Color domain do *not* have a stored representation on disk:
- For maps with a Bool domain or the `Bit` domain, you can interactively select colors in the Display Options dialog box of the map each time you display the map.
- Maps with an ID domain can be shown in 7, 15, or 31 colors to inspect the map itself. In most cases however, you will display an ID map by one of its attributes as stored in the map's attribute table; to do so, select the Attribute check box in the Display Options dialog box of the ID map and select an attribute column.
- Raster maps with the Color domain store colors in each pixel, so no representation is needed.

Furthermore, special options for point symbols available in the Display Options dialog box of a point map.

☞ You can always create a number of representations for a certain domain, for instance by clicking the create button next to the Representation list box in the Display Options dialog box of a map. Then, to display the map with a certain representation, in the map's Display Options dialog box, select the representation you want to use.

Types of representations
There are three types of representations:
- **representation class**: for the classes in a class domain, the groups a group domain, or the items in a picture domain. For each class in the domain, a representation class contains: colors for mapping units in raster maps; colors, hatching or patterns for polygons; colors, line types, line widths, etc. or equally spaced symbols for segments; colors, symbol type, symbol sizes, etc. for points.

▪ **representation gradual**: defines colors for ranges of values (as *percentages*) in a value map. Any map with a value domain can be displayed with an existing representation gradual. Maps, which use system domain `Value`, can only be displayed with a representation gradual; you can also create a representation gradual for such maps. Examples of a representation gradual are `Gray` and `Pseudo`. To change the domain of a map, which uses system domain Value to a user-defined value domain, in order to create a representation value, see How to change the domain of maps.

▪ **representation value**: defines colors for ranges of values (as *values*) in a value map. A representation value can be created for maps with the `Image` domain (interactive slicing), for maps with a *user-defined value domain* (e.g. a `Height` domain), and for maps with a system value domain except system domain `Value`. You can create various value representations for individual value domains.

General use of representations

▪ All maps which use the same class domain (e.g. `Landuse`) will by default use the same representation class: these maps will thus by default be displayed in the same colors. You can also create or select another representation class, which fits the classes in the domain.

▪ All maps which use the same value domain (e.g. `Height`) will by default use the same representation value: these maps will thus by default be displayed in the same colors. Except for maps, which use system domain `Value`, you can also create or select another representation value, which fits this domain. Furthermore, you can select a representation gradual e.g. `Pseudo`.

▪ Maps, which use the system domain `Value`, can only be shown in a representation gradual. You can select any existing representation gradual, or create your own representation gradual.

Names of representations

Any representation name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

☞ To show representations in the Catalog, refer to How to customize the Catalog.
☞ To view which representation is linked to a certain domain, check the properties of the domain.

To create a representation

1. Creating a representation class:
   When creating a new class or group domain, a representation class is automatically created with default colors; these can of course be edited.

   The easiest way to create another representation class for a map with a class, group or picture domain, is to click the create button in the Display Options dialog box of the map. Then a new representation class is created for the domain that is used by the map.
   The Representation Class editor will be opened.

In the Representation Class editor, choose whether you want to adapt the representation for the raster form, the polygon form, the segment form or the point form. Then, edit the colors, etc. of each class for instance by double-clicking individual classes. You can also select multiple classes and choose Edit Multiple Items from the Edit menu to assign one color or a smooth range of colors to the selected classes.

2. Creating a representation value:
   When creating a new value domain, a representation value is not automatically created. You can always show a map with a value domain with an existing representation gradual, e.g. Pseudo.

   The easiest way to create a representation value for a map with a value domain (except the system domain Value) is to click the create button in the Display Options dialog box of the map. Then a new *representation value* is created for the domain that is used by the map. The Representation Value/Gradual editor will be opened.

   In the Representation Value/Gradual editor, you can insert limits, i.e. *boundary values* for a representation value, you can choose or create a color for each limit, and you can indicate whether to stretch between the limits or to use the color of the upper of lower boundary.

3. Creating a representation gradual:
   When you click the create button in the Display Options dialog box of a map which uses the system domain Value, a new *representation gradual* is created with default colors. Furthermore, a representation gradual will be created when you select system domain Value in the Create Representation dialog box. The Representation Value/Gradual editor is opened.

   In the Representation Value/Gradual editor, you can insert limits, i.e. *boundary percentages* for a representation gradual, you can choose or create a color for each limit, and you can indicate whether to stretch between the limits or to use the color of the upper of lower boundary.

   When a map (e.g. Map1) is currently using system domain Value, and thus a representation gradual, and you want to use a representation value instead, you have to change the domain of the map with system domain Value to a user-defined domain:
   − Perform a simple mapcalc statement like Map2 = Map1;
   − Create a new value domain in the Raster Map Definition dialog box by clicking the create domain button;
   − Then display Map2 and in the map's Display Options dialog box, click the create representation button. You have created a representation value and you can assign colors to specific values in the map.
   For more information, see How to change the domain of a map.

4. Other ways to create representations:
   Furthermore, you can create a representation through the File menu of the Main window, by double-clicking the New Repr item in the Operation-list, or via the Properties dialog box of a domain. For more information, see How to create a representation.

To view and edit a representation
To edit an existing representation, you can for instance double-click a representation in the Catalog. When a map is displayed in a map window, you can also open the Edit menu in the map window and choose Representation. Depending on the type of representation you selected, the Representation Class editor or the Representation Value/Gradual editor is opened. For more information, see How to edit a representation or the respective editors.

Advanced users may wish to open and/or edit a representation class as a table. For more information, see How to open objects as a table. System representations and read-only representations cannot be edited.

Technical information
A representation consists of an ASCII object definition file (.RPR); in case of a representation class also a binary data file (.RP#) is available. The object definition file has no further references to other objects.

By viewing the properties of a representation, you can see for instance the type of the representation and you can find out to which domain the representation is linked. A representation is a property of a domain.

A **representation class** stores, for each class in the domain:
- a color (raster form);
- a color, hatching or pattern (polygon form);
- a color, a line type (e.g. single, double, triple, dot, dash dot, blocked), line width, optional support line, optional background color for the support line, and a symbol font and a symbol when a line should be represented by symbols (segment form);
- symbol type, symbol, size, line width, color, fill color, rotation (point form).

Advanced users may wish to open and edit a representation class as a table.

A **representation gradual** stores:
- limits, i.e. boundary values *as percentages* of the values in the domain,
- a color for each limit,
- for each range of percentages in between two limits, whether to stretch colors or to use the color of the upper of lower boundary (slice), and
- when you stretch the colors in between two limits: the number of steps to be used for stretching.

A **representation value** stores:
- limits, i.e. boundary values *as values* of the domain,

- a color for each limit,
- for each range of values in between two limits, whether to stretch colors or to use the color of the upper of lower boundary (slice), and
- when you stretch the colors in between two limits: the number of steps to be used for stretching.

System representations

The following system representations are *representations gradual*:

Blue	From black to blue in 16 stretch steps.
Clrstp6	Six times from black to a color (6 colors between blue to red), each time in 8 stretch steps.
Clrstp8	Eight times from black to a color (8 colors between blue to red), each time in 8 stretch steps.
Clrstp10	Ten times from black to a color (10 colors between blue to red), each time in 8 stretch steps.
Clrstp12	Twelve times from black to a color (12 colors between blue to red), each time in 8 stretch steps.
Cyan	From black to cyan in 16 stretch steps.
FineGray	From black to white in 60 stretch steps.
Gray	From black to white in 30 stretch steps.
Green	From black to green in 16 stretch steps.
Inverse	From white to black in 30 stretch steps.
Magenta	From black to magenta in 16 stretch steps.
Pseudo	From blue to green to red in 6 x 9 stretch steps.
Red	From black to red in 16 stretch steps.
Yellow	From black to yellow in 16 stretch steps.

There is one system *representation class* available:

ColorCmp	Designed for output raster maps of the Color Composite operation created with the Standard option; 216 colors.

4.2.2   Georeferences

A georeference defines the relation between rows and columns in a raster map and XY-coordinates. The location of pixels in a raster map is thus defined by a georeference. It is advised that raster maps of the same area use the same georeference. A georeference uses a coordinate system, which may contain projection information. Polygon, segment and point maps merely use a coordinate system. A georeference is a service object, usually for several raster maps.

Georeference types

There are five main types of georeferences:

- **georeference corners**: a North-oriented georeference to be used during rasterization of vector data or as the North-oriented georeference to which you want to resample maps;
- **georeference tiepoints**: a non-North-oriented georeference to add coordinates to a satellite image or to a scanned photograph, a scanned map, etc. without using a DTM;

- **georeference direct linear**: to add coordinates to a scanned photograph while using a DTM;
- **georeference orthophoto**: to add coordinates to a scanned aerial photograph while using a DTM and camera parameters;
- **georeference 3D**: to create a three dimensional view of maps.

☞ For a correct behaviour of a georef direct linear, and a georef orthophoto, it is essential that you have marked the 'Interpolation' check box in the Properties dialog box of your DTM raster map. For more information, refer to the Raster Map Properties dialog box.

Furthermore, system georeference None is available for raster maps that do not have coordinates.

Other types of georeferences are obtained when performing an operation on raster maps:
- georeference factor: created by the Aggregate map and the Densify operation;
- georeference mirrorrotate: created by the MirrorRotate operation;
- georeference submap: created by the Sub-map of raster map and the Glue raster maps operation.

General use of georeferences
When a raster map has a georeference, you can:
- inspect coordinates at the position of the mouse pointer in a map window, at the status line;
- retrieve information at the position of the mouse pointer in a map window from other maps, i.e. functionality of the pixel information window;
- inspect the pixel size of raster maps in meters;
- check if raster maps fit on top of each other (requirement for MapCalc and Cross);
- overlay vector data on raster maps;
- rasterize vector data to raster maps;
- resample raster data which uses a particular georeference to another georeference; create an orthophoto from a scanned aerial photograph which has a georef orthophoto by resampling it to a georef corners;
- screen digitize on satellite images or on scanned photographs which have a georef tiepoints; screen digitize on scanned photographs which have a georef direct linear; monoplot on scanned aerial photographs which have a georef orthophoto.

A map window also uses a georeference. When the map window displays a raster map, this is the georeference of the raster map. When a map window only displays vector data, an internal georeference is used that is created from the coordinate system and coordinate boundaries of the vector maps.

Names of georeferences

Any georeference name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

☞   To show georeferences in the Catalog, refer to How to customize the Catalog.
☞   To view which georeference is used by a raster map, check the properties of the raster map.

To create a georeference

A georeference can be created:

▪   during rasterization, click the create georeference button in a Rasterize dialog box; the Create Georeference Corners dialog box will appear; you can create a georef corners.
▪   when a satellite image, a scanned photograph, or a scanned map is displayed in a map window, choose the Create Georeference command from the File menu of the map window; the Create Georeference (in map window) will appear; you can create a georef tiepoints, a georef direct linear or a georef orthophoto.
▪   when you want to create a 3D view of your study area, start the Display 3D operation, and click the create georeference button in the dialog box; the Create Georeference 3D dialog box will appear; you can create a georef 3D.

Other general ways to create a georeference are:

▪   by choosing the Create Georeference command on the File menu of the Main window,
▪   by double-clicking the New Georef item in the Operation-list,
▪   by opening the Properties dialog box of a raster map: click the Edit button in the Properties dialog box and click the create button in the subsequent Edit Properties dialog box.

For more information, refer to How to create a georeference, How to add coordinates to an image, How to screen digitize, How to monoplot, How to create an orthophoto or How to create a 3D view.

To view or edit a georeference

You can view and edit a georef corners, a georef tiepoints, a georef directlinear, a georef orthophoto and a georef 3D. The easiest way to edit a georeference is to double-click a georeference in the Catalog. When a raster map, which has a georeference is displayed in a map window, you can also open the Edit menu in the map window and choose Georeference.

Depending on the type of georeference you open (or the georeference which is used by the raster map in the map window), a dialog box will appear or an appropriate editor will be opened:

▪   for a georef **corners**: the Edit Georeference Corners dialog box will appear;
▪   for a georef **tiepoints**, a georef **direct linear**, or a georef **orthophoto**: the Tiepoint editor will be opened. When editing a georef orthophoto, the Locate Fiducial Marks dialog box will appear first;

▪ for a georef **3D**: the Display Options - 3D Grid dialog box appears, in which you can specifying how the 3D view should be displayed in the map window. When the 3D view is displayed in a map window, you can select the Georeference command from the Edit menu of the map window to edit the georeference 3D. The Georeference 3D editor is started.

A georef factor, a georef mirrorrotate or a georef submap cannot be edited. Information on these georeferences can be found in their properties dialog box.

Advanced users may wish to open a georef tiepoints, a georef directlinear or a georef orthophoto as a table.

☞ To have a raster map use another georeference than its current one, perform the Resample operation.

Technical information
A georeference consists of an ASCII object definition file (.GRF); in case of a georef tiepoints, a georef direct linear or a georef orthophoto, also a binary data file (.GR#) is available. The object definition file contains further references to:
▪ the coordinate system that is used by the georeference;
▪ in case of a georef tiepoints, georef direct linear or a georef orthophoto, the background map on which tiepoints are positioned;
▪ in case of a georef direct linear or a georef orthophoto, the DTM from which height values should be obtained.
These are properties of a georeference.

By viewing the properties of a georeference, you can see for instance the type of the georeference and find out which raster maps are using this georeference. By clicking the Additional Info button in the properties dialog box of a georef tiepoints, a georef direct linear or a georef orthophoto, you will get extra information on transformation or orientation results.

The system georeference None is available for raster maps that do not have coordinates.
Georeference corners:
    Stores minimum and maximum XY-coordinates, and whether these refer to the corners of the corner pixels or to the centers of the corner pixels.
    $Col = a_1 X + b_1$
    $Row = a_2 Y + b_2$

- Georeference tiepoints:
    Stores a set of tiepoints in RowCol and XY-coordinates and a transformation method. Parameters are found by a least squares method. Height values are not taken into account. Available transformation methods and their formulas are:

- Conformal:
    minimum of two tiepoints required;
    $Col = aX + bY + c_1$
    $Row = bX - aY + c_2$
- Affine:
    recommended for satellite images; minimum of three tiepoints required;
    $Col = a_{11}X + a_{12}Y + b_1$
    $Row = a_{12}X + a_{22}Y + b_2$
- Second order bilinear: minimum of 4 tiepoints required;
    $Col = a_1 + b_1X + c_1Y + d_1XY$
    $Row = a_2 + b_2X + c_2Y + d_2XY$
- Full second order: minimum of 6 tiepoints required;
    $Col = a_1 + b_1X + c_1Y + d_1XY + e_1X^2 + f_1Y^2$
    $Row = a_2 + b_2X + c_2Y + d_2XY + e_2X^2 + f_2Y^2$
- Third order: minimum of 10 tiepoints required;
    $Col = a_1 + b_1X + c_1Y + d_1XY + e_1X^2 + f_1Y^2 + g_1X^3 + h_1X^2Y + i_1XY^2 + j_1Y^3$
    $Row = a_2 + b_2X + c_2Y + d_2XY + e_2X^2 + f_2Y^2 + g_2X^3 + h_2X^2Y + i_2XY^2 + j_2Y^3$
- Projective:
    recommended for normal camera, i.e. small format, photographs;
    conventional rectification; minimum of 4 tiepoints required;
    $Col = (aX + bY + c) / (gX + hY + 1)$
    $Row = (dX + eY + f) / (gX + hY + 1)$
- Georeference DirectLinear:
    Recommended for normal camera, i.e. small format, photographs when a
    DTM is available; also corrects for tilt and relief displacement; Direct Linear
    Transformation (DLT). Stores a set of tiepoints in RowCol and XYZ-
    coordinates. Height values can be supplied by the user, otherwise these are
    obtained from the DTM. Orientation parameters, i.e. camera position (X_0, Y_0,
    Z_0) and angles (κ, φ, ω), are calculated from the tiepoints. Minimum of 6
    tiepoints required; tiepoints must not be co-planar, i.e. the tiepoints should not
    be on a (tilted) plane.
- Georeference OrthoPhoto:
    Recommended for photogrammetric camera aerial photographs when a DTM
    is available; also corrects for tilt and relief displacement; Differential
    rectification. Stores fiducial marks, principal distance, and a set of tiepoints in
    RowCol and XYZ-coordinates. Height values can be supplied by the user,
    otherwise these are obtained from the DTM. The user needs to specify
    fiducial marks and principal distance; orientation parameters, i.e. camera
    position (X_0, Y_0, Z_0) and angles (κ, φ, ω), are calculated from the tiepoints
    (outer orientation). Minimum of 3 tiepoints required.
- Georeference 3D:
    Stores a number of 3D view parameters: view point, location height, scale
    height, horizontal and vertical rotation, distance, view angle.

- Georeference factor:
    Stores a factor of the pixel size of another raster map and horizontal and
    vertical offset of another raster map.
- Georeference mirrorrotate:
    Stores whether another georeference is mirrored horizontally, vertically,
    diagonally or is transposed, or rotated 90°, 180°, or 270°.
- Georeference submap:
    Stores offset and size related to another georeference.

4.2.3   Coordinate system

A coordinate system contains information on the kind of coordinates you are using
in your maps; you may for instance use user-defined coordinates, coordinates
defined by a national standard or coordinates of a certain UTM zone. A coordinate
system defines the possible XY- or LatLon-coordinates that can be used in your
maps.

Point, segment and polygon maps always have a coordinate system. Raster maps
have a georeference, which uses a coordinate system. A coordinate system is a
service object for point, segment and polygon maps, and for georeferences of raster
maps.

In ILWIS, XY-coordinates are supposed to be in meters and the 90° angle between
the positive X-axis and the positive Y-axis is counter-clockwise.

Coordinate system types
There are five main types of coordinate systems:
- **coordinate system boundary only**: to define XY-coordinates for maps by only
  specifying the boundaries of your study area. This type of coordinate system
  should only be used when you are sure that you will not use projections at all;
  furthermore, *maps using a coordinate system boundary only, cannot be
  transformed into any other coordinate system*.
- **coordinate system projection**: to define XY-coordinates for maps by specifying
  the boundaries of your study area and when you want to have the possibility to
  add projection information, ellipsoid information and/or datum information. You
  can add the projection information later on or right away. Maps with different
  coordinate systems and different projections can be transformed into one
  another.
- **coordinate system latlon**: to define LatLon-coordinates for maps by specifying
  the boundaries of your study area in Latitudes and Longitudes and when you
  want to have the possibility to add ellipsoid information and/or datum
  information. You can add the ellipsoid information and/or datum information
  later on or right away.
- **coordinate system formula**: when you obtained data which is using different
  XY-coordinates than the coordinate system of your project, and when you know
  the relation between the two coordinate systems. You can create a coordinate
  system formula for maps with artificial coordinates, i.e. starting at (0,0) or
  digitized in millimeters. The coordinate system formula uses a 'related'

coordinate system; this is the coordinate system with correct coordinates. When you have defined the formula and when the map with artificial coordinates uses the newly created coordinate system formula, then you can transform the map to the correct coordinate system.

- **coordinate system tiepoints**: when you obtained data which is using different XY-coordinates than the coordinate system of your project, and when you do not know the relation between the two coordinate systems. You can create a coordinate system tiepoints for maps with artificial coordinates, i.e. starting at (0,0) or digitized in millimeters. The coordinate system tiepoints uses a 'related' coordinate system; this is the coordinate system with correct coordinates. When you have specified the tiepoints and transformation method, and when the map with artificial coordinates uses the newly created coordinate system tiepoints, then you can transform the map to the correct coordinate system.

Furthermore, two coordinate systems are available in the \SYSTEM directory:
- coordinate system Unknown: when you do not care about coordinates.
- coordinate system LatLon: when you obtained raster or vector data which are supposed to use LatLon-coordinates on a sphere (world-wide).

General use of coordinate systems
- For general analysis purposes, it is advised to use **one** coordinate system for all your maps. This coordinate system should be wide enough to cover all X- and Y-coordinates that should be stored in your maps.
- Coordinate systems enable you to transform vector maps from one coordinate system to the other. There are 3 possibilities:
  - When maps use a coordinate system projection or a coordinate system latlon and when this coordinate system actually contains projection, ellipsoid or datum information, then you can transform the map to any other coordinate system of type projection or latlon which contains projection, ellipsoid or datum information.
  - When maps use a coordinate system formula (which uses a related coordinate system with correct coordinates), then you can transform the map to the related coordinate system.
  - When maps use a coordinate system tiepoints (which uses a related coordinate system with correct coordinates), then you can transform the map to the related coordinate system.
- A map window has the capability to transform vector maps on the fly or temporarily. When a point, segment or polygon map with a certain coordinate system is displayed in a map window, you can drag or add another coordinate system to the map window. If a transformation between both coordinate systems is possible, the map window will use the newly added coordinate system; the vector maps displayed by the map window will be shown in the new coordinate system, i.e. the maps are temporarily transformed.
- When you use pixel information and the map is currently using one coordinate system, you can add another coordinate system to the pixel info window. When a transformation is possible between both coordinate systems, the pixel information window will also show you the coordinates in the new coordinate

system. The pixel information window can also retrieve information from maps with another 'transformable' coordinate system.

▪ The following maps can be displayed with a graticule:

– maps which use a coordinate system projection with a projection,

– maps which use a coordinate system latlon,

– maps which use a coordinate system formula, where the related coordsys is a coordsys projection with a projection or a coordsys latlon,

– maps which use a coordinate system tiepoints, where the related coordsys is a coordsys projection with a projection or a coordsys latlon.

▪ When resampling raster maps from one georeference to another georeference, which uses another coordinate system, then a transformation is automatically performed.

☞ When you receive data in different projections (and you have created correct coordinate systems with correct projections for these maps), it is advised to use the Transform operations to transform vector data from the current coordinate system into one other coordinate system, or to use the Resample operation to resample pixels of a raster map the current georeference into one other georeference (with another coordinate system).

Names of coordinate systems

Any coordinate system name must start with a character from A to Z. For the other characters in an object name, you are allowed to use: characters A through Z, numbers 0 through 9, and underscores. Object names cannot exceed 8 characters.

To create a coordinate system

To create a coordinate system, you can select the Create Coordinate System command on the File menu of the Main window or double-click the NewCrdSys item in the Operation-list. The Create Coordinate System dialog box will appear: you can create any type of coordinate system.

When one or more vector maps which do not have correct coordinates yet are displayed in a map window, you can also select the Create Coordinate System command on the File menu of the map window. The Create Coordinate System (in map window) dialog box will appear: you can create a coordinate system formula or a coordinate system tiepoints.

Other ways to create a coordinate system are:

▪ by clicking the create button in the dialog box when creating a point, segment or polygon map, or a georeference,

▪ by opening the Properties dialog box of a vector map: click the Edit button in the Properties dialog box and click the create button in the subsequent Edit Properties dialog box.

For more information, refer to the Create Coordinate System dialog box. It is advised that within one project, all maps use the same coordinate system.

To view or edit a coordinate system
The easiest way to view and/or edit an existing coordinate system, is to double-click
a coordinate system in the Catalog. When one or more raster and/or vector maps are
displayed in a map window, you can also open the Edit menu in the map window
and choose Coordinate System.

Depending on the type of coordinate system you open (or the type of coordinate
system that is currently used by the map window), a dialog box will appear or an
appropriate editor will be opened:
▪ for a coordsys **boundary only**: the Edit Coordinate System Boundary Only
  dialog box will appear;
▪ for a coordsys **projection**: the Edit Coordinate System Projection dialog box
  will appear;
▪ for a coordsys **latlon**: the Edit Coordinate System LatLon dialog box will
  appear;
▪ for a coordsys **formula**: the Edit Coordinate System Formula dialog box will
  appear;
▪ for a coordsys **tiepoints**: the Coordinate System Tiepoints editor will be opened.

Of course, to open and edit a coordinate system, you can also click a coordinate
system with the right mouse button in the Catalog and choose Open from the
context-sensitive menu, use the Edit Object command on the Edit menu in the Main
window, double-click the Edit item in the Operation-list, etc.

☞   To show coordinate systems in the Catalog, refer to How to customize the Catalog.
☞   To view which coordinate system is used by a georeference of a raster map or by a
     point, segment or polygon map, check the properties of a georeference or the
     properties of a point, segment or polygon map.
☞   Advanced users may wish to open a coordinate system tiepoints as a table.

Technical information
A coordinate system consists of an ASCII object definition file (.CSY); in case of a
coordsys tiepoints also a binary data file (.CS#) is available. The object definition
file stores the coordinate boundaries and, if available, projection information, a
formula, etc.

By viewing the properties of a coordinate system, you can see for instance the type
of the coordinate system, the boundary coordinates of the coordinate system, and
find out by which vector maps and by which georeferences this coordinate system is
used. For a coordinate system formula and a coordinate system tiepoints, also the
related coordinate system is listed. Furthermore, for a coordinate system tiepoints,
you can find the transformation results by clicking the Additional Info button.

Introduction on Projections
A projection defines the relation between the map coordinates (X,Y) and the
geographic coordinates latitude and longitude (φ, λ).

The Earth's surface is curved, however in maps it is presented as a flat surface. Therefore, the display of an area on a map will always lead to some deformation or distortion; there is no 'perfect' projection. If you show only a small part of the Earth, like a town, the distortion will be almost insignificant. If, on the other hand, a map shows a continent, deformations and distortions will be a major problem. To correctly represent the curved Earth's surface on a flat map, you need a special projection. The geographic coordinates are converted to a metric coordinate system, measuring the X- and Y-directions in meters. Each projection has unique equations for the transformation from geographic to metric coordinates.

Because of the earth's rotation, the shape of the earth is not a perfect sphere. The earth is flattened towards the poles: the equatorial axis (line from the center to the Equator) is longer than the polar axis. The shape of the earth can be represented by an ellipsoid, or as it is sometimes called, a spheroid (shapes that are generated by revolving an ellipsis around its minor axis). The choice of the ellipsoid which fits best a certain region of the earth surface to be mapped depends on the surface curvature and undulations in that region. Hence every country has its own 'best fit' ellipsoid.

General characteristics of projections

Projection types
Based on the shape of the projection surface, one can classify the projections in azimuthal, conical and cylindrical projections. Therefore, the cone or cylinder needs to be 'unrolled' to form a plane map.

1. Cylindrical projections
   Cylindrical projections may be imagined as the projection to a plane that is wrapped around the globe in the form of a cylinder (see Figure 1). After unrolling, the outline of the world map would be rectangular in shape; the meridians are parallel straight lines which cross at right angles by straight parallel lines of latitude. Examples: Mercator, Plate Carree.
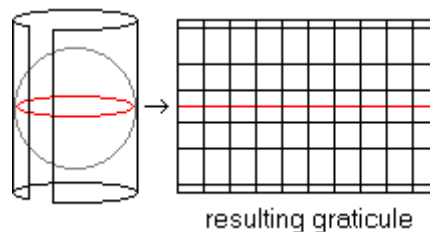

Figure 1: Principle of cylindrical projections.

2. Azimuthal projections
   Azimuthal projections may be imagined as the projection on a plane tangent to the globe (Figure 2). The characteristic outline of the world map would be circular. If the pole is the central point, the meridians are straight lines, spaced at

their true angles intersecting at this center point. Parallels are represented as concentric circles. Examples: Gnomonic, Stereographic.
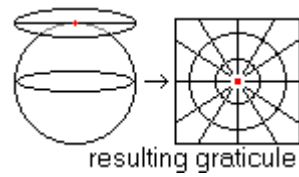

Figure 2: Principle of azimuthal projections.

3. Conical projections
   Conical projections may be imagined as the projection to a plane that is wrapped like a cone around the globe (Figure 3). After unrolling the outline of the world would be fan shaped. The meridians are represented as straight lines and parallels as concentric circles. Only the parallels where the cone touches the globe have the same length as on earth.
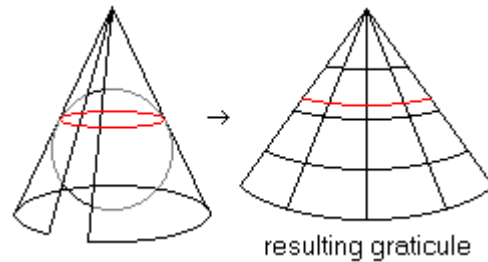

Figure 3: Principle of conical projections.

Aspect
Furthermore, projections can be subdivided according to the direction in which a cylinder, plane or cone is oriented with respect to the globe, the so-called aspect. In the text above, it is assumed that the projection only touches the Earth. However, it is also possible to use a secant cylinder, plane or cone, which intersects the sphere. Figures 4, 5, and 6 show some aspect types for different types of projections.

- For cylindrical projections a normal aspect is a cylinder that touches the equator. A transverse aspect is a cylinder that touches the poles.
- Similarly the normal and secant aspects of azimuthal projections can be visualized.
- The aspect may also be oblique; in that case the cylinder, plane or cone is not horizontally or vertically oriented, but something in between.
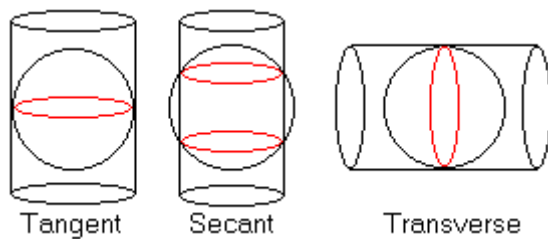
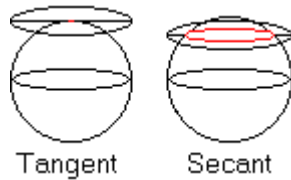Figure 4: Different aspects for cylindrical projections.

Figure 5:   Different aspects for   Figure 6:   Different aspects for
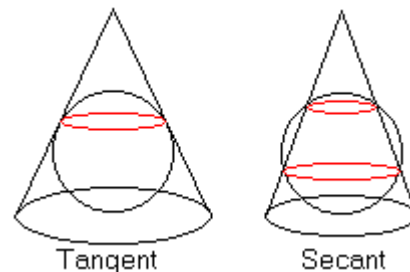   azimuthal projections.   conical projections.

Projection characteristics

As mentioned before a map projection always results in some deformation or
distortion. Depending on the type of projection, these distortions will be different.
This is indicated by the characteristics of a projection:

- Conformality: a conformal map is one in which all angles are indicated
  correctly. Angles between two points in a map with a conformal projection and
  between two points on Earth are the same. As all angles are maintained, the
  shape of the objects is also preserved. Examples: Mercator, Stereographic.
- Equivalence: a map with an equivalence property is an equal-area map.
  Although the shape of objects is distorted, the areas of all regions are shown in
  the same proportion to their true areas. Examples: Mollweide, Sinusoidal.
- Equidistance: an equidistance map has the characteristic that in one direction the
  distances are preserved.

Available projections

Map projections are named according to the class, the aspect, the property, the name
of the originator and the nature of any modification. For an overview of available
projections, refer to the Select Projection dialog box. For hints on what projection to
use, refer to Suggested projections.

Coordinate system Formula

You can create a coordinate system formula for maps with artificial coordinates, i.e.
starting at (0,0) or digitized in millimeters. The coordinate system formula uses a
'related' coordinate system; this is the coordinate system with correct coordinates.
When you have defined the formula and when the map with artificial coordinates

uses the newly created coordinate system formula, then you can transform the map to the correct coordinate system.

Transformation formulae:

In the formulae below, $\begin{pmatrix} x \\ y \end{pmatrix}$ is used for the related coordinates, $\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix}$ for the

coordinates of the coordsys formula which you are creating, $\begin{pmatrix} x_0 \\ y_0 \end{pmatrix}$ for the origin in

the related coordsys, and $\begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$ for the origin of the coordsys formula which you

are creating.

Conformal:

$$\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix} = k \begin{pmatrix} \cos\varphi & \sin\varphi \\ -\sin\varphi & \cos\varphi \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

k = scaling
φ = rotation

Differential scaling:

$$\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix} = \begin{pmatrix} k_1 & 0 \\ 0 & k_2 \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

k_1 = X-scaling
k_2 = Y-scaling

Skew along X-axis:

$$\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix} = \begin{pmatrix} 1 & \tan a \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

α = skew

Skew along Y-axis:

$$\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \tan b & 1 \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

β = skew

Affine:

$$\begin{pmatrix} X_{out} \\ Y_{out} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

$a_{11}, a_{12}, a_{21}, a_{22}$ = matrix coefficients

User-defined expression:

$X_{out} = f_x (x - x_0, y - y_0) + X_0$
$Y_{out} = f_y (x - x_0, y - y_0) + Y_0$

4.3 Annotation

4.3.1 Annotation Text 🖺

An Annotation Text object, also called an annotation text layer, is designed to display and store multiple texts at multiple positions. While simple annotation types can only be stored by saving a map window as a map view, an Annotation Text object can be stored itself.

When creating an Annotation text object, you can base the texts that will appear in the text object on an existing point, segment, or polygon map. If you do so, the text object will contain a text (class name, ID or value) for each point, segment or polygon in the selected map.

An Annotation Text object can be edited with the Annotation Text editor or in a table window. In the Annotation Text editor, you can easily insert more text items, change and refine the position of texts (move), make text duplicates, and specify fonts, font sizes, appearance (bold, italics, underline), colors, rotations, etc. for (multiple) selected texts.

To create an annotation text object
In a map window, open the File menu and choose Create Annotation Text. You can also open the Layers menu, choose Add Annotation, Text Layer and then click the Create button in the appearing Add Annotation Text dialog box.

To display annotation text
The easiest way to display an existing annotation text object in a map window is to drag the annotation text object from the Catalog to a map window. In a map window, you can also open the Layers menu and choose Add Annotation, Text Layer and then select an annotation text object in the appearing Add Annotation Text dialog box.

To edit annotation text
Annotation text objects can be edited in the Annotation Text editor or in a table window. In the annotation text editor, you can insert new texts and delete selected existing texts, move one or more selected texts to another position, make text duplicates, and specify fonts, sizes, colors, etc. for (multiple) selected texts.
- When you create a new annotation text object, the annotation text editor is directly opened.
- To edit an existing annotation text object in the annotation text editor, first display the annotation text object in a map window, then open the Edit menu in the map window, choose Edit Layer and select the annotation text layer.
- To edit an annotation text object in a table window, you can simply double-click the annotation text object in the Catalog, or open the File menu in the Main window, choose Open As Table and select the annotation text object.

For more information, refer to the Annotation Text editor.

Technical information
An annotation text object consists of an ASCII object definition file (.ATX) and a binary data file (.AT#). The object definition file contains information on the working scale and information on columns in the table. The object definition file contains no further references to other objects.

4.3.2   Simple Annotation

You can add simple annotation to a map window in the form of texts, legends, boxes, North arrow, scale bar, grid lines, graticule, or bitmaps or metafiles (pictures) from disk. Furthermore, any picture or bitmap that was copied to the clipboard from other Windows application programs can be pasted into ILWIS. You can also paste the contents of another ILWIS map window as annotation into a current map window; for instance as an inset-map giving an overview of a larger area.

These types of annotation can be edited in the Annotation editor. To store this type of annotation, you need to save the map window in which they are displayed as a map view.

☞   You can create an Annotation Text object when you want to store multiple texts at multiple positions. Annotation Text objects are stored as objects and can thus be added to multiple map windows. Texts in an annotation text object can be edited in the Annotation Text editor: you can for instance easily move texts, specify fonts, font size, colors, etc.

Annotation is generally used on top of one or more data layers (displayed maps).

Creating annotation
There are several ways to add annotation to a map window:
- from the Layers menu, choose Add Annotation, and select the type of annotation you want, or
- from the Layers menu, choose Layer Management. In the appearing Layer Management dialog box click the Add Annotation button, and select the type of annotation you want, or
- from the Edit menu, choose Annotation. The Annotation editor is opened directly.

Before annotation is shown, you have to specify some display options for the annotation layer. Then, the Annotation editor is opened. In the Annotation editor, you can use the same possibilities as above, but you can also click one of the add annotation buttons in the button bar (the status line gives an explanation).
For more information, see also How to add annotation to a map window.

Editing annotation
You can edit annotation in the Annotation editor. To open the Annotation editor, choose the Annotation command on the Edit menu of a map window. The Annotation editor is automatically started when a new annotation layer is added to a map window.

In the Annotation editor, texts, legends, boxes, scale bar, North arrow, and bitmaps or pictures can be moved to another position by drag and drop. The size of these types of annotation can be adjusted by dragging the size handles of a selected object. Further, the display options of these types of annotation can be changed by double-clicking. Grid lines and a graticule have a fixed position in a map window according to the georeference of the map window and can thus not be moved or double-clicked. You can always change display options of an annotation layer by choosing the Display Options command from the Layers menu, or through Layer Management. For more information, refer to the Annotation editor or to How to edit annotation.

☞   To create more space in a map window for annotation, select the Extend Window command on the Options menu.

Saving annotation
Annotation should be saved with the contents of your map window as a map view. Either in the Annotation editor or in the map window, open the File menu, and choose the Save View or the Save View As command. All annotation layers and all data layers in the map window are stored with their current display settings. Specify a name for the map view and a title. The title will appear in the title bar when you redisplay the map view.

Annotation types

Annotation Text object
An Annotation Text object, also called an annotation text layer, is designed to display and store *multiple texts at multiple positions*. While other annotation types can only be stored by saving a map window as a map view, an Annotation Text object can be stored by itself.

When you create an annotation text object based on an existing map, you can easily obtain texts for all points, segment or polygons of the selected map. it is advised to create an Annotation Text object. An Annotation Text object can be edited in the Annotation Text editor: you can reposition selected texts, specify fonts, font sizes, appearance (bold, italics, underline), colors, rotations, etc. Texts in an Annotation Text object can only consist of one line.
For more information, see 4.3.1 ILWIS objects: Annotation Text.

Single text
A single text annotation can be used to display *one text at one position* in a map window, for instance a title. Each single text has to be defined in a Display Options - Text dialog box. The text may actually consist of multiple text lines; you can use the Enter key or the Shift+Enter key. Single texts can only be stored by saving a map window as a map view. Single texts can be rotated, and font and colors are user-defined.

Legend
Legends are more or less automatically created from the domain that a map is using and from the representation used by that domain. A legend can be created for maps using a class domain, the image domain or a value domain.

For a legend of a *class map*, color boxes and class names appear in principle for all items in the class domain. The user can hide class names from the legend and manipulate the order in which class names appear in the legend. Further, font and text color are user-defined and the legend can be made transparent or not.

For a legend of an image or a value map, a vertical color bar with gradual colors as used in the displayed map is automatically created. Font and color for the text explaining some of the colors in the color bar are user-defined, and the legend can be made transparent or not. See also Display Options - Legend (Image/Value) dialog box.

North-arrow
A North-arrow points to the North of a map; the North is determined from the georeference of a map window.

In the Display Options - North Arrow dialog box, you can choose between three types of North arrows. Furthermore, you can specify the line width and color. Optionally, text such as N, E, S, W can be displayed with the North arrow. The font and color for the text is of course user-defined.

Scale bar and scale information
A scale bar and scale information (e.g. 1 : 100000) can be shown based on the georeference of a map window.

In the Display Options - Scale Bar dialog box, you can choose whether to create a scale bar as blocks of alternating colors or as a line with tick marks. Furthermore, you can specify the distance intervals and colors used in the scale bar, and the font and colors used for the text below the scale bar.

Optionally, you can also obtain scale information. When you display scale information, the value may seem odd in the map window, however, when you print the map on a certain scale, the scale value is automatically adjusted to the scale that you selected for printing.

Box
Boxes can be used to obtain for instance borders around a legend, a title, etc. In the Display Options - Box dialog box, you can choose between two types of boxes, and you can select a line type and a color of the borders of the box. When you select line type Single, you can also specify the line width. By default, the inside of a box is transparent, but you can also fill a box with a color. You can size a box by dragging one of the size handles of the box in the Annotation editor.

To obtain borders exactly around a mapped area, use the Draw Border check box in the Display Options - Grid Lines dialog box.

Grid lines
Grid lines, coordinate ticks, X- and Y-coordinates and a border fitting a map can be shown. Grid lines are parallel to the X- and Y-axes of the coordinate system.

When a map window displays:
▪ a North-oriented map (e.g. raster map with a georef corners), the grid lines will be straight and exactly horizontal and vertical;
▪ a raster map which has a georef tiepoints with a conformal, affine or projective transformation, the grid lines will be straight but not exactly horizontal and vertical;
▪ a raster map which has a georef tiepoints with a higher order transformation, or a georef direct linear, georef orthophoto, the grid lines will be curved.

In the Display Options - Grid Lines dialog box, you can specify the spacing of the grid lines in meters. Furthermore, you can select a line type and a color for the grid lines.

X- and Y-coordinates of the grid lines can be shown as text inside or outside the map area, and can appear in a short form. The font and color used for the coordinate texts are of course user-defined.

Graticule
A graticule draws parallels and meridians; you require a coordinate system that has projection information.

In the Display Options - Graticule dialog box, you can specify the spacing of the graticule in degrees, minutes and seconds. Furthermore, you can specify a line type and a color for the graticule. Latitudes and Longitudes of the graticule cannot be shown yet as text.

Bitmaps from disk
A bitmap is a standard Windows graphic file format in 'raster' form. Bitmaps can be added as annotation to an ILWIS map window. Bitmaps are stored in device independent bitmap (DIB) format, i.e. bitmaps are not dependent on the graphic board. Bitmaps can use a 2, 16, 256 color palette, or are stored using 24 bits per pixel. The default file extension for bitmaps is .BMP.

When using 256 color bitmaps, and when a lot of windows with many colors are open already, you may loose the colors of pasted bitmaps. When this occurs, you might consider using 16 color bitmaps.

Windows metafile or pictures from disk
A Windows metafile, often called a picture, is a standard Windows graphic file format in 'vector' form. Metafiles or pictures can be added as annotation to an

ILWIS map window. A metafile consists of a set of Windows drawing instructions. The default extension for Windows metafiles is .WMF.

ILWIS maps as inset-maps in other map windows
Prepare an ILWIS map as usual, copy it into the clipboard and paste as a picture into another ILWIS map window. The pasted layer is an annotation layer.

Pasting pictures and bitmaps from clipboard
Any picture or bitmap in the clipboard (copied into the clipboard from any Windows application), can be pasted into an ILWIS map window. You can use the clipboard viewer in Windows to view what is in the clipboard.