

ILWIS objects

4.1 Data objects

ILWIS data objects are maps, tables and columns; that is the GIS material to work with. Data objects can be created, edited, displayed, etc., and most important operations can be performed on them. Except for columns, data objects in the current directory are listed in the Catalog by a name and an icon.

Data objects are:

	raster maps	(containing pixels)
	polygon maps	(containing closed area features)
	segment maps	(containing line features)
	point maps	(containing point features)
	map lists	(containing a set of raster maps)
	tables	(containing columns)
	columns	(not listed in Catalog)

Each data object (a map, table or column) has a domain in which the valid IDs, Class names, values etc. of the object are defined. Other service objects that a data object may need are for instance a representation, a georeference, or a coordinate system. For more information on relations between ILWIS objects, see Help topic Appendices : relations between ILWIS objects.

Object names should 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. Except for column names, object names cannot exceed 8 characters.

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- ☞ To select the type of objects shown in the Catalog, use the Catalog command on the Options menu of the Main window. See also Help topic How to customize the Catalog.
 - ☞ To copy or delete ILWIS objects, you MUST:
 - use the Copy Object or Delete Object commands on the Edit menu of the Main window, or
 - choose the Copy or Delete commands on the context-sensitive menu which appears when clicking with the right mouse button on an object in the Catalog.
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It is strongly discouraged to copy, delete or rename files in DOS or in the File Manager.

4.1.1 Introduction on maps

A map contains certain features and refers to the geographic position of those features:

-  point maps: a point map contains point features;
-  segment maps: a segment map contains line features;
-  polygon maps: a polygon map contains closed area features; and
-  raster maps: a raster map contains pixels. In ILWIS, most spatial operations are performed on raster maps.

When using satellite images, you already have raster maps. Pixels in a satellite image have values ranging from 0 to 255, although not every value may occur in your image. In ILWIS, satellite images are stored with domain Image.

When starting from an analog paper map, you start by:

- digitizing point features of interest with the point editor,
- digitizing line features of interest with the segment editor, and/or
- digitizing areas of interest with the polygon editor.

Afterwards, point, segment and polygon maps can be rasterized into a raster map. Before you begin to digitize, you have to know that features in any map can be identified in the following manner:

- by ID: each feature is identified by its own name or number; each feature occurs in general only once in the map;
- by Classes: features are identified by their class name; features may occur in several places in the map;
- by Value: features are identified by a measurable value.

The following scheme illustrates the above:

Map type:	Features in map:	Identification of features by:	Example:
Point map	<ul style="list-style-type: none"> * Points: indiv. sample points * Points: classes of farms * Points: height information 	<ul style="list-style-type: none"> IDs Class names Values 	1,2,3 small farm, large farm 500, 600, 700 (m)
Segment map	<ul style="list-style-type: none"> * Lines: individual rivers * Lines: classes of roads * Lines: isolines for height 	<ul style="list-style-type: none"> IDs Class names Values 	... prim. roads, sec. roads 500, 600, 700 (m)
Polygon map	<ul style="list-style-type: none"> * Areas: indiv. cadastral plots * Areas: land use classes * Areas: concentration values e.g. air pollution (NO₂, SO₂) 	<ul style="list-style-type: none"> IDs Class names Values 	plot 234a, plot 345b rice, maize, forest 1000, 2000, 5000 (mol/ha/y)
Raster map	<ul style="list-style-type: none"> * Pixels: rasterized points, lines or areas with IDs * Pixels: rasterized points, lines, or areas with class names * Pixels: rasterized points, lines or areas with Values * Pixels: value outcome of calculations 	<ul style="list-style-type: none"> IDs Class names Values Values 	plot 234a, plot 345b or river... rice, maize, forest values any value
Raster map	<ul style="list-style-type: none"> * Pixels (satellite images) 	pixel values:	-

The user-defined collection or set of IDs, Class names or values that may be used in a map is called the domain of a map. In ILWIS, we speak of maps of the ID, Class or Value type, meaning that the elements in that map are either identified by IDs, Class names or values.

Only maps with features identified by IDs or Class names can have attributes; i.e. extra information about the point, segment, polygons or mapping units, in so-called attribute tables. When creating an attribute table, this table should have the same domain as your ID or Class map. Afterwards you can add extra columns with the attribute information.

The Class names (or Identifiers) in a domain type Class (or a domain type Identifier) provide the relational link between the units in a map and the records in a table.

Maps containing values, for example a satellite image or a height map, cannot have attributes in an attribute table.

4.1.2 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 x 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 colors in which a map appears on the screen are stored in a representation. For maps that use a class domain or a value domain, you can create your own representation. For value maps, there are also a number of system representations available. For maps that use an ID, Bit, or Bool domain, you have to specify colors each time you display the map.

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. A Display Options dialog box appears, in which you can specify how the map should be displayed in a map window. For other display methods, see How to open objects.

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 dependent maps, see Basic concepts : dependent data objects. 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. For dependent maps, you can also manage dependencies: break dependencies, make dependent maps up-to-date, delete the dependent map's data file, etc.

For more information, see Basic concepts : properties of objects.

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.

4.1.3 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 colors in which a map appears on the screen are stored in a representation. For maps that use a class domain or a value domain, you can create your own representation. For value maps, there are also a number of system representations available. For maps that use an ID or Bool domain, you have to specify colors each time you display the map.

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

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. Optionally create a point map which will contain the label points for your polygons. Digitize the polygon boundaries in the segment editor; then polygonize your segments in the segment editor. For a more detailed description, see How to create a polygon map.

To display a polygon map

The easiest way to display a polygon map is to double-click the map in the Catalog. A Display Options dialog box appears, in which you can specify how the map should 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. For other methods, see How to display maps and tables.

To edit a polygon map

You can edit a polygon map by clicking it 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 mainly edit the class names, IDs, or values of polygons. 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 dependent maps, see Basic concepts : dependent data objects. For more information on operations, refer to ILWIS 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. For more information, see Basic concepts : properties of objects.

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).

4.1.4 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 colors in which a map appears on the screen are stored in a representation. For maps that use a class domain or a value domain, you can create you own representation. For value maps, there are also a number of system representations available. For maps that use an ID or Bool domain, you have to specify colors each time you display the map.

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. A Display Options dialog box appears, in which you can specify how the map should 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.

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 dependent maps, see Basic concepts : dependent data objects. For more information on operations, refer to ILWIS 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. For more information, see Basic concepts : properties of objects.

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).

4.1.5 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, 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 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.

For point maps that use a class domain, you can create a representation. For maps that use a value, ID or Bool domain, you have to specify the symbol set, symbol size(s), colors, etc. each time you display the map. For point maps that use a value domain, the size of symbols can be stretched according to the values of the points.

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.

To display a point map

The easiest way to display a point map is to double-click the map in the Catalog. A Display Options dialog box appears, in which you can specify how the map should 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.

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. The point map itself may use a value domain but you can also use point maps with a class or ID domain 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 dependent maps, see Basic concepts : dependent data objects. For more information on operations, refer to ILWIS 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. For more information, see Basic concepts : properties of objects.

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.

4.1.6 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 domain and georeference.

A map list is used:

- for sampling and image classification,
- for a principal components analysis or factor analysis,
- for the calculation of multiband statistics (variance-covariance matrix or correlation matrix),
- to obtain some insight in the bands of a satellite image; create a map list of the bands of a satellite image and show it as a slide show,
- 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. Further, you can display all maps of the map list as a slide show in one map window; one map is displayed after the other. To show a time series map list as a slide show, click a map list in the Catalog with the right mouse button, and subsequently choose Open from the context-sensitive menu or use the Operations menu in the Main window.

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, double-click the map list in the Catalog or click the map list with the right mouse button and subsequently 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 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 the maps in the map list. For more information, see How to calculate the OIF of a map list.

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.

4.1.7 Tables 

A table is a data object storing columns. A table usually contains tabular information which refers existing geographic information stored in maps. The table then contains extra information on the mapping units, polygons, segments or points in your maps, for instance cadastral information, soil information, etc. Such a table is called an attribute table. Raster, polygon, segment and point maps with a class or ID domain can have an attribute table. The domain of an attribute table should always be the same as the domain of the map to which the table relates.

Further, tables may store columns that contain the answers of an operation on a map, for instance an output cross table or output tables of a statistical operation. The domain of a table generated by an operation may be created by the operation itself or the table may use domain None. Tables that use domain None cannot be linked to a map.

Tables can be displayed and edited in a table window. A table window also offers you the possibility to display graphs. You can calculate with the columns in a table by typing a Table Calculation formula on the command line of a table window. For more complicated calculations, you can use the Columns menu in the table window.

Contents and structure of a table

A table consists of records and columns. The smallest unit in a table is called a field.

Record names in a table are defined by the domain of the table:

- In a table window which displays a table in Table View, record names appear on (gray) record buttons that are arranged along the left side of the table.
- Attribute tables use the same class or ID domain as the map to which they refer. When, for instance, you have an attribute table for a soil map (both using class domain Soils), then the classes of that domain appear as units in the map and as records in the attribute table. Or, when you have an attribute table for a map with cadastral plots (both using ID domain City), then the IDs of that domain appear as units in the map and as records in the table. Attributes on the classes or identifiers in a map are stored in attribute columns which have their own domain (class, ID, or value), see below.
- Tables cannot have a value domain because conceptually spoken you cannot have extra information on value maps; extra tabular information on maps that represent interpolated height values, measured rainfall figures, or the calculated total number of people per building block, etc. does not exist.
- A table that uses domain None cannot be linked to a map. Records in a table that uses domain None are simply identified by record numbers.

Columns in a table have a name, a description, and each column uses a domain:

- In a table which displays a table in Table View, column names appear on (gray) column buttons that are arranged along the top of the table, just below the command line and the menu bar.
- The domain of each column depends on the kind of data you want to store in that column: select or create for example a value domain if you want store pH values for your soil classes or the String domain if you want to store a text-description for each soil class.
- You can add as many columns to a table as you like. Also by performing calculations, you can obtain new columns.
- When a column uses a value domain, the column also has a value range and a precision.
- Optionally, the domain of a column may have a representation, which is handy in case you wish to display a map that has an attribute table by one of the attributes, i.e. using the Attribute check box in the Display Options dialog box of that map.

- If a table has a certain domain that also exists in another table, or if a column of a table has a certain domain that also exists in another table, then you can join columns of the other table into the current table.

For more information on columns, see ILWIS objects : columns.

Names of tables

Any table 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 table

The easiest way to create an attribute table is to open the Properties dialog box of a map, and then select the Attribute check box in the dialog box. Subsequently, create the table by clicking the little create button that appears next to the Attribute drop-down list box. The Create Table dialog box appears in which you can specify a name and description for the table. The domain of the table is already filled out and is the same domain that is used by the map. For other methods, see How to create a table. A table with domain None cannot be linked to a map.

To display and edit a table

The easiest way to open and edit existing tables is to double-click a table in the Catalog; the table is shown in a table window. For other methods of opening tables, see How to display maps and tables.

In a table window, a table can be displayed and edited in Table View and in Record View: Table View gives you an overview of the whole table and Record View displays the contents of a table record by record. For more information, see How to edit a table. It is not possible to edit the fields of dependent and read-only columns or the fields of table-owned columns in dependent tables. Table information can also be shown as graphs.

When an attribute table is linked to a map or to its domain, and the map is displayed in a map window, you can also double-click in the map to edit the attributes in the attribute table. For more information on the double-click action, see Map window : advanced functionality.

Operations on tables

Calculations within tables are usually performed on columns. You can calculate with columns by typing a Table Calculation formula on the command line of a table window. When the definition symbol = is used in a calculation, the output column is dependent. For more complicated column operations such as aggregations, calculating cumulative values, joins, and least square fit calculations, you can use the Columns menu. For more information on columns, see ILWIS objects : columns.

When a table is the result of an operation such as the Cross operation or the statistical operations, the table itself is dependent and the columns created by the operation are table-owned. For more information on dependent objects, see Basic concepts : dependent data objects.

With the Transpose Table operation, all records become columns and all columns become records.

Technical information

A table consists of an ASCII object definition file (.TBT) and a binary data file (.TB#). The object definition file of a table stores the table name, table description, whether the table is dependent or not, the number of columns in the table, column names, column descriptions, and for dependent columns the column definitions, etc. Further, the object definition file contains references to the table's domain, the table's data file, and the domains that are used by the individual columns. The .TB# file stores the data of the columns.

By viewing the properties of a table, you can see which domain the table is using and whether the table is dependent or not. For dependent tables, you can manage dependencies: break dependencies, make dependent tables up-to-date, delete the dependent table's data file, etc. For more information, see Basic concepts : properties of objects.

Limitations

In principle, the maximum number of columns in a table is 32000 and the maximum number of records in a table is 2 billion. In practice however, limitations will occur by memory and available disk space.

4.1.8 Columns

A column is a data objects that is part of a table; a column can be used to store attributes, results of calculations, results of operations, etc. Fields in a column may contain class names, IDs, values, X- and Y-coordinates, colors, text, etc.; this is determined by the domain of the column.

Columns are displayed and edited in a table window. You can calculate with columns by typing a Table Calculation formula on the command line of a table window. For more complicated calculations, you can use the Columns menu in the table window.

Contents of columns

The contents of a column is defined by the domain that the column is using. For each new column that you add to a table, you have to select (or create) a domain which fits the kind of data you want to store in that column, similar to the selection or creation of a domain when you make a new map. In a Soil table for example, you can select the system String domain for a column Description that should store descriptions of soil types, and you can select the system Value domain or create your own value domain pH for a column pH that should store pH values.

When calculating with columns, it is normally enough to select system domain Value or one of the other system domains. You only have to create a new value domain, if the column will contain values that have a special 'standardized' meaning.

A column may store for example:

- names of districts, provinces, regions, etc. for instance in a table containing all building blocks of a city, the district of the city in which each building block occurs (for aggregations); the column uses an ID domain,
- class names like suitable, moderately suitable, not suitable or slope classes that apply for the records; the column uses a class domain,
- rainfall values, pH values for boreholes, number of people per building block, etc.; the column uses a value domain,
- free text for instance to describe the records of the table; the column uses the String domain,
- true or false values; the column uses the Bit domain,
- true, false or undefined values; the column uses a Bool domain,
- percentage values; the column can use the Perc domain,
- colors; the column uses the Color domain,
- X- or Y-coordinates; the column uses a value domain,
- output values after a table calculation (any domain),
- output values (any domain) in tables that are the result of an operation, e.g. values and percentages after a Histogram operation, classes of two input maps and values after a Cross operation on two class maps, distances and probabilities (values) after the Pattern Analysis operation, directions, lengths and number of segments (all values) after the Segment directions operation, etc.

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

The domain of a column may have a representation. This may be useful if the table is an attribute table; when displaying a map, you can directly display the map by an attribute column, thus without physically creating an attribute map. To display a map by attribute, select the Attribute check box in the Display Options dialog box which appears when opening the map. For more information, see How to display a map by one of its attributes.

Types of columns

Source columns: Normal editable columns.

Dependent columns: Columns that store the result of a calculation: ColumnCalculate, ColumnJoin, ColumnAggregate, ColumnCumulative, ColumnLeastSquares.

Table-owned columns: Columns that are part of a dependent table and store the results of an operation e.g. output columns of the Histogram and Cross operation, and other statistical operations. Also objects that internally use a table for storage (point maps; class, ID and picture domains; class representations; georeference tiepoints) and which thus can be opened as a table have table-owned columns.

To protect the results of calculations or operations, fields of dependent columns and table-owned columns in a dependent table are not editable unless you break the dependency links of the dependent column or unless you break the dependency links of the dependent table.

Names of column

Any column 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. Contrary to names of other objects, column names can be as long as you like.

To create a column

An easy way to add a new column to a table is to open the Columns menu and select the Add Column command. In the appearing Add Column dialog box, enter a name and description for the column and select or create a domain. For other create methods, see How to add a column to a table. Columns added in this way are always source columns, i.e. editable columns. Even if you use such a column later on as the output column of a calculation, the column remains a source column. You can also directly add a new column to a table by typing a Table Calculation formula on the command line of the table window which contains a new column name, or by using the Columns menu to join columns from another table, to perform aggregations or to calculate cumulative sums of columns or perform a least squares fit.

New columns created by typing a TabCalc formula on the command line in which you use an equal symbol (=) are dependent columns. Columns that contain the result of a join, aggregation, cumulative sum or least squares fit obtained through a dialog box are also dependent columns. When you use the assignment symbol (:=) in a TabCalc formula, the new column is an editable source column.

You may add as many columns to a table as you like. To change the order and width of columns or to sort the records of a table, see Table window : functionality.

To edit fields of a column

When a table is displayed in a table window, you can edit the fields of source columns directly both when a table is displayed in Table View or in Record View. First select a field in the table, then type a new value of ID when the column uses a value or identifier domain, or open the drop-down list box of the field and then select a class name from the drop-down list box when the column uses a class domain. For more information, see How to edit a table.

Fields in dependent columns are not editable unless you break the dependency link of the column; you can do this in the Properties dialog box of the column. Further, fields in table-owned columns in dependent tables are not editable unless you break the dependency links of the table; you can do this in the Properties dialog box of the table. However, the fields in table-owned columns in objects that are internally stored as a table and that can be opened as a table (e.g. point maps and class representations), can usually be edited.

Operations on columns

Mostly, you will calculate with columns using the operators and functions that are available in Table Calculation. You can type your table calculation formulae on the command line of a table window.

When you use the definition symbol = in a TabCalc formula that contains a new column name, a dependent column is created. For more information, see also Basic concepts : dependent data objects and Table Calculation.

When you use the assignment symbol := in a Table Calculation formula, a source column is created.

Further, you can use the Columns menu to join, aggregate, calculate a cumulative sum or a least squares fit. Subsequently, fill out the appearing dialog box of that column operation and click the OK button; this generates an expression on the command line of the table window. Output columns that are obtained through an operation's dialog box are always dependent. Advanced users can type these complete expressions on the command line of a table window, or ILWIS expressions on the command line of the Main window or create a script to execute a series of expressions. For more information, refer to Appendices : ILWIS expressions.

Lastly, the columns of a dependent table in which the results are stored of an operation such as the Histogram operation or statistical operations on maps are table-owned columns. For more information, refer to the Histogram operation, etc.

When calculating with columns and you want to store values in a column, you can usually select the system domain Value, and specify value range and precision, see below.

Technical information

Columns have no object definition file of their own. All necessary information to display, edit and calculate with columns is stored in the object definition file of the table (.TBT) to which the column belongs. Column data is stored in the binary file of the table (.TB#).

Each column has a domain, which is a property of a column. By viewing the properties of a column, you can see whether the column is dependent or not, which domain the column is using and in case of dependent columns which other columns the column is using, etc. For dependent columns, you can also manage dependencies: break dependencies, make dependent columns up-to-date, delete a dependent column's data file, etc. For more information, see Basic concepts : properties of objects and How to view the properties of objects.

Columns are stored as bit, byte, 2-byte, 4-byte or 8-byte columns. The store type of a column is primarily defined by the domain that the column is using. For value columns this is determined by the value range and precision that you specify for the output column 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 the column values.

Limitations

In principle, the maximum number of columns in a table is 32000 and the maximum number of records in a table is 2 billion. In practice however, limitations will occur by memory and available disk space.

4.1.9 Link between maps and tables

The relational link between point, segment, polygon or raster maps and an attribute table, is provided by the domain. The domain should be of the ID or Class type. The domain should be used both by the map(s) and the table. The table contains additional columns with the attributes.

An attribute table can also be linked to a domain (domain Class or ID). Then all maps using that domain automatically use the attribute table which has the same domain.

It is the class names in a domain Class and the IDs in a domain Identifier that provide the relational link between the elements in a raster, polygon, segment or point map and the records in an attribute table.

Whether a map or a domain has an attribute table can be seen by viewing the properties of the map or the domain.

4.2 Service objects

Service objects are used by data objects; they contain accessories required by data objects besides the data itself. Service objects define for example the valid type of values for a data object (ID, Classes, Values), the colors assigned to the data, and, coordinate information for the data object.

Service objects are:

-  domain
-  representation
-  georeference
-  coordinate system

Service objects can be selected to serve one or more data objects, created, changed, etc. through the properties dialog box of a data object or another service object. For more information, see Appendices : Relations between ILWIS objects.

Object names should 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.

-
-  1. To show service objects in the Catalog, use the Catalog command on the Options menu in the Main window. See also How to customize the Catalog;
 -  2. It is advised to use the same service objects for several data objects:
 - if you have several thematic maps with the same kind of class names (not every class has to exist in each map), you should use the same domain for all maps,

- if you have several raster maps of the same study area, you should use the same georeference for all maps.
- ☞ 3. To copy or delete ILWIS objects, you **MUST** use the Copy Object or Delete Object commands on the Edit menu of the Main window, or choose the Copy or Delete commands on the context-sensitive menu, when clicking with the right mouse button on an object in the Catalog. It is strongly discouraged to copy, delete or rename files in DOS or in the File Manager.
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4.2.1 Domains

A domain defines, i.e. stores, the information that can be available in a map, a column, etc. A domain consists of a set of class names or IDs, a range of values, colors, etc. All elements in a map or column must use one of the classes, IDs, or values of the domain that is used by the map or column; if not, these elements will appear as undefined.

General use of domains

All maps and all columns need a domain:

- When a map contains for instance information on land use types, the map should use a class domain. The class domain contains the complete list of all land use classes that should be available for all your land use maps.
- When a map contains for instance information on height values, the map should use a value domain in which your height values fit.
- When a column contains calculated values, the column should use a value domain in which your calculated values fit.

A table needs a domain when the records in the table contain further information on units in a map. To establish a relation between a map and a table, the table needs to have the same domain as that map. Such tables are called attribute tables. Further, for a join between tables and columns, the tables or one of their columns should both use the same domain.

A table has domain None when the records in the table contain other 'stand-alone' information, for instance the results of a statistical operation.

A domain is a service object; it is the user-defined collection of IDs, class names, or values that can be used in a certain data object. All ILWIS data objects (maps, tables and columns) have a domain. One domain can be used for several data objects. Domains provide the relational link between maps, tables and columns. For an introduction on domains, refer to Basic concepts : before creating ILWIS maps and tables and Basic concepts : domains.

Domain types

The four main types of domains are:

- | | |
|-------|---|
| ID | used for data objects which contain unique identifiers (e.g. plot 1024, plot 1025). |
| Class | used for data objects which contain classes (e.g. soil units: clay, sandy loam). |

Value	used for data object which contain measured, calculated or interpolated values (e.g. height, concentration).
Image	for satellite images containing values between 0 and 255.

Other domain types are

Bit	system domain Bit is available for raster maps and columns that have to store values 0 and 1.
Bool	system domain Bool and system domain Yes/No are available for point, segment, polygon and raster maps and columns that have to store True, False or undefined values.
Picture	for raster maps which contain merely colors (Red, Green, Blue); the pixels have no meaning e.g. color composites.
Color	for raster maps that are stored in 24-bit colors.
Group	used to classify or slice a value map; a domain group contains upper value boundaries and output class names.
String	system domain String is available for columns that contain text.
None	system domain None is available for tables in which the records do not store information on a map.
Binary	system domain Binary is for internal use only.

Names of domains

Any domain 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 domains in the Catalog, refer to How to customize the Catalog.

To create a domain

When creating a new map, table or column, you have to select an existing domain or create a new domain for the object. When you do not have a suitable domain yet, you can usually click the create button  next to a domain list box in a dialog box. Of course you can also use the Create commands on a File menu, or double-click the New Domain item in the Operation-list. For more information, see How to create a domain.

When calculating with value maps or columns or performing operations, you can generally accept the default system domain Value for the output map or column and adjust the value range and precision for the output map or column if necessary. You only have to create a user-defined value domain for a calculated map when the output values in the map have a specific meaning for which you have or want to create a meaningful representation value.

- When creating a new class or group domain, a representation class is automatically created with the same name as the class domain. You can open and edit this representation with the Representation Class editor.

- When creating a new value domain, a representation is not automatically created. You can always show a map with any value domain with existing representation graduals (in percentages). The easiest way to create a representation value for a map with a user-defined value domain is to click the create button  in the Display Options dialog box of the map. You can insert boundary values and assign colors to these boundaries and in between the boundaries in the Representation Value/Gradual editor.

To view and edit a domain

To view and edit a class domain, an ID domain and a value domain, you can for instance double-click them in the Catalog. Class and ID domains are shown and can be edited in the Domain Class/ID editor; a value domain can be viewed in the Edit Domain Value dialog box. It is usually not necessary to edit a value domain. When a map of domain type Class or ID is displayed in a map window, you can also open the Edit menu in the map window and choose Domain. For more information, see How to edit a domain.

Advanced users may wish to open a domain class, ID or picture as a table. For more information, see How to open objects as a table. System domains and read only domains cannot be edited. Information on these domains can be found in their properties dialog box.

Domains and representations

A domain may use a representation which defines the colors, line widths etc. with which a map can be displayed.

- A class domain, a group domain and a picture domain have an editable representation class.
- When a map uses the system Value domain: you can create your own representation gradual (in percentages), or use one of the existing system representations gradual.
- When a map uses the Image domain or any other value domain: you can create your own representation value (in values), or use one of the existing system representations gradual.

For more information on representations and the relations to domains, refer to ILWIS objects : representations.

 When you want to be sure that you cannot change the representation of a domain, you can make the domain read only in the Properties dialog box of the domain.

Choosing a value domain for output maps and columns

When calculating with value maps and value columns, you can usually accept the default system domain Value and you can adjust the value range and precision for the output map if necessary. When you adjust for instance the value range for an output map or column to minimum 5 and maximum 500 and a precision of 0.001; the output map or column will only store values in between 5 and 500 with 3 decimals; in case the calculation or operation results in values smaller than 5 and larger than 500, these will appear as undefineds (a question mark).

You only need to create a user-defined value domain (for instance Height, pH, Yields, or concentration values):

- if the output values have a specific 'standardized' meaning that you want to document and
- if you have, or want to create, a specific representation value for these values where colors or ranges of colors are linked to the values.

Technical information

A domain consists of an ASCII object definition file (.DOM); in case of a domain class, ID or group a binary data file (.DM#) is also available. In case of a domain class or picture, the object definition file stores further references to a representation class; in case of a domain value, the object definition file stores a reference to a representation value or gradual.

By viewing the properties of a domain, you can see for instance the type of the domain and select a representation for the domain. Furthermore, you can also see by which maps and in which tables this domain is used. Optionally, you can create a new attribute table for a class or ID domain or link an existing attribute table to a class or ID domain.

For more information on the key role of domains within ILWIS, refer to Appendices : Relations between ILWIS objects.

Available system domains

The following value domains are available in your ILWIS\SYSTEM directory:

- system domain Value
- system domain Image
- system domain NOAA
- system domain Radar
- system domain Distance
- system domain Count
- system domain Min1to1
- system domain Perc
- system domain Bit
- system domain Bool
- system domain YesNo
- system domain String
- system domain Color
- system domain ColorCmp
- system domain None
- system domain Binary

Limitations

ID domains	Maximum number of IDs in a domain ID: 2 billion. The domain ID editor however has a limitation of 5440 items. ID names can have any length; the width to display IDs is set in the properties of the domain.
Class/Group domains	Maximum number of classes in a class domain is 255 as a representation class cannot contain more than 256 colors. Class names can have any length; the width to display class names is set in the properties of the domain.
Value domains	When you use a value domain, values can either be stored as fixed point reals using 1, 2, or 4 bytes storage per pixel (max. 4 billion different values) or as floating point reals according to the 8 byte real IEEE standard.
Picture domains	Maximum number of colors is 256.

4.2.2 Representation 

A representation defines the manner in which classes of a domain Class map, or values in a domain Value or domain Image map should be shown and colored. For raster maps, a representation contains merely colors; for segment, polygon and point maps there are also possibilities to define for instance: line widths, patterns, and symbols. Furthermore, a representation is needed for raster maps with a domain Picture. A representation is a service object for a domain.

Maps with a Bool, the Bit or an ID domain do not have stored representations on disk. For maps with a Bool or the Bit domain, you can 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, however in most cases you will display an ID map by one of its attributes from its attribute table; the options are available in the Display Options dialog box.

Furthermore, special options for point symbols available in the Display Options dialog box of a point map. Raster maps with the Color domain store colors in each pixel, so no representation is needed.

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;
- representation gradual: for ranges of values (as percentages) in any value domain;
- representation value: for ranges of values in the Image domain or a value domain, except system domain Value.

General use of representations

- All maps which use the same class domain (e.g. Landuse), use by default the same representation class, and are thus by default 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 use by default the same representation value and are thus displayed in the same colors; you can also create or select another representation value which has this domain. You can also create or select a representation gradual.
- For maps which use the system domain Value, you can only select a representation gradual; you can also 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.

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- ☞ To show representations in the Catalog, refer to Help topic: How to customize the Catalog.
 - ☞ To view which representation is used by a domain, check the properties of the domain.
-

To create a representation

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 is opened. In the Representation Class editor, you can edit the colors, etc. of each class. You can double-click a class in the editor and select or create a color, etc.

When creating a new value domain, a representation value is not automatically created. You can always show a map with any value domain with existing representation graduals. The easiest way to create a representation value for a map with a value domain (except the system Value domain) 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 is 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 or lower boundary.

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. 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 or lower boundary.

Furthermore, you can create representations through the File menu of the Main window, the New Repr item in the Operation-list, or in 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.

Advanced users may wish to open 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 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 and a pattern (polygon form);
- a color and a line width (segment form);
- symbol type, size, pen width, color and fill color (point form).

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 or 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 real 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 or 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.
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4.2.3 Georeference

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 three main types of georeferences:

- georeference corners: for North-oriented rasterized vector data or resampled raster data;
- georeference tiepoints: for satellite images, scanned photographs, scanned maps, etc.;
- georeference 3D: to create three dimensional views of maps.

Georeference `None` is available for raster maps that do not have coordinates.

Other types of georeferences can be 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;
- overlay vector data on raster maps;
- rasterize vector data to raster maps;
- resample raster data which uses a particular georeference to another georeference;
- check if raster maps fit on top of each other (requirement for MapCalc and Cross);
- inspect the pixel size of raster maps in meters.

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

To rasterize vector maps, select one of the Rasterize operations on the Operations menu of the Main window, in the Rasterize dialog box you can directly create a new georeference corners by clicking the create button . The Create Georeference Corners dialog box appears in which you can specify the pixel size and the boundaries of the map. When rasterizing maps of the same area, it is usually sufficient to only once create a georeference corners; for the other maps to be rasterized, select this same georeference.

To add tiepoints to an image, i.e. create a georeference tiepoints: display in a map window an image (for instance a color composite) on which you can clearly distinguish the tiepoints, also called control points, and select from the File menu in the map window, Create Georeference. Have an analog paper map at hand to find the XY-coordinate for each row-column number at which you want to position a tiepoint. For more information, see Georeference tiepoints editor : functionality.

To create a three-dimensional view of your study area, select the Display 3D operation from the Operations menu in the Main window, a Digital Elevation Model (DEM) of your area is required. For more information, see Georeference 3D editor: functionality.

Of course, you can also use the Create Georeference command on the File menu in the Main window, or double-click the NewGeoref item in the Operation-list. For more information, see How to create a georeference, How to add coordinates to an image, or How to display a DEM.

To view or edit a georeference

You can view and edit a georeference corners, a georeference tiepoints and a georeference 3D. The easiest way to edit such a georeference is to double-click such 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 and choose Georeference. Depending on the type of georeference you open (or which is used by the raster map in the map window) the Georeference corners dialog box appears, the Georeference tiepoints is opened or the Georeference 3D editor is opened. For more information, see How to edit a georeference.

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

Advanced users may wish to open a georeference tiepoints as a table. For more information, see How to open objects as a table.

Technical information

A georeference consists of an ASCII object definition file (.GRF); in case of a georeference tiepoints, a binary data file (.GR#) is also available. The object definition file contains further references to the coordinate system that is used by the georeference and in case of a georeference tiepoints, the background map is also mentioned; 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. 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.

$$\text{Col} = a_1X + b_1$$

$$\text{Row} = a_2Y + b_2$$

Georeference tiepoints: Stores a set of tiepoints in RowCol and XY-coordinates and a transformation method. Parameters are found by a least squares method.

Available transformation methods and their formulas are:

Conformal: minimum of two tiepoints required;

$$\text{Col} = aX + bY + c_1$$

$$\text{Row} = bX - aY + c_2$$

Affine: recommended for satellite images; minimum of three tiepoints required;

$$\text{Col} = a_{11}X + a_{12}Y + b_1$$

$$\text{Row} = a_{12}X + a_{22}Y + b_2$$

Second order bilinear: minimum of 4 tiepoints required;

$$\text{Col} = a_1 + b_1X + c_1Y + d_1XY$$

$$\text{Row} = a_2 + b_2X + c_2Y + d_2XY$$

Full second order: minimum of 6 tiepoints required;

$$\text{Col} = a_1 + b_1X + c_1Y + d_1XY + e_1X^2 + f_1Y^2$$

$$\text{Row} = a_2 + b_2X + c_2Y + d_2XY + e_2X^2 + f_2Y^2$$

Third order: minimum of 10 tiepoints required;

$$\text{Col} = a_1 + b_1X + c_1Y + d_1XY + e_1X^2 + f_1Y^2 + g_1X^3 + h_1X^2Y + i_1XY^2 + j_1Y^3$$

$$\text{Row} = a_2 + b_2X + c_2Y + d_2XY + e_2X^2 + f_2Y^2 + g_2X^3 + h_2X^2Y + i_2XY^2 + j_2Y^3$$

Projective: recommended for near vertical aerial photographs and oblique photographs; minimum of 4 tiepoints required;

$$\text{Col} = (aX + bY + c) / (gX + hY + 1)$$

$$\text{Row} = (dX + eY + f) / (gX + hY + 1)$$

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.

4.2.4 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 minimum and maximum X's and Y's that can be used in your maps.

To be able to convert one coordinate system into another, a projection with parameters needs to be attached to both coordinate systems. If a projection is added to a coordinate system, the maps using this coordinate system can be displayed with a graticule.

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.

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.
- When you receive data in different projections (coordinate systems), it is advised to use the Resample operation to resample pixels of a raster map the current georeference into one other georeference (coordinate system), or to use the Transform operations to transform vector data from the current coordinate system into one other coordinate system.
- For presentation purposes of small scale maps (countries, continents, etc.) however, you can create a number of coordinate systems with different projections. Then make copies of your maps and link the coordinate systems to these copies by editing the Properties of the maps. When you subsequently display the maps in a number of map windows and add a graticule to each map, you can clearly see the effect of the projection used, select the favourable ones and print these.

For an introduction to projections, see below.

Creating a coordinate system

To create a coordinate system, select the Create Coordinate System command on the File menu of the Main window or double-click the NewCrdSys item in the Operation-list. Furthermore, you can click the create button  in the dialog box when creating a point, segment or polygon map, or a georeference. For more information, refer to the Create Coordinate System dialog box.

Editing a coordinate system

The easiest way to edit an existing coordinate system, is to double-click it in the Catalog. Furthermore you can 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.

When a map is displayed in a map window, you can also open the Edit menu of the map window, and choose Coordinate System.

-
- ☞ To show coordinate systems in the Catalog, refer to Help topic: How to customize the Catalog.
 - ☞ To view which coordinate system is used by a georeference or a point, segment or polygon map, check the properties of the georeference or of the point, segment or polygon map.
-

Technical information

A coordinate system consists of an ASCII object definition file (.CSY). This file stores the coordinate boundaries and, if available, projection information.

By viewing the properties of a coordinate system, you can see for instance by which vector maps and by which georeferences this coordinate system is used.

Projections

A projection defines the relation between the map coordinates (X,Y) and the geographic coordinates latitude and longitude (f, l).

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, 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 into 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 ellips 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.

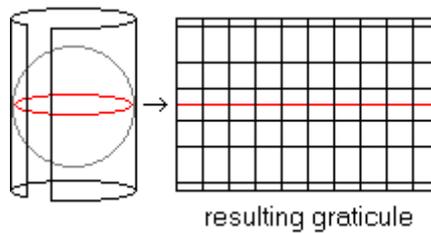


Figure 1: Principle of cylindrical projections.

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.

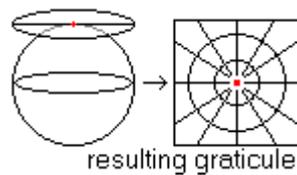


Figure 2: Principle of azimuthal projections.

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 has the same length as on earth.

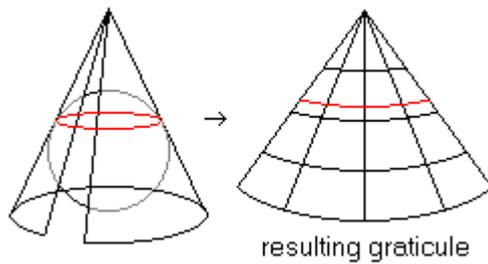


Figure 3: Principle of conical projections.

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.

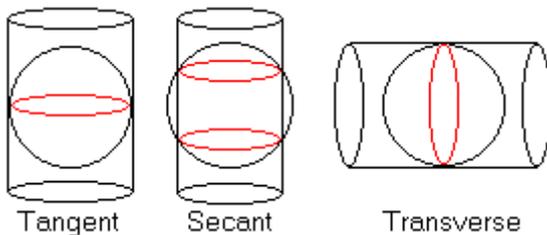


Fig 4: Different aspects for cylindrical projections.

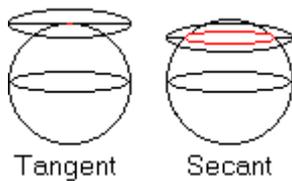


Fig. 5: Different aspects for azimuthal projections.

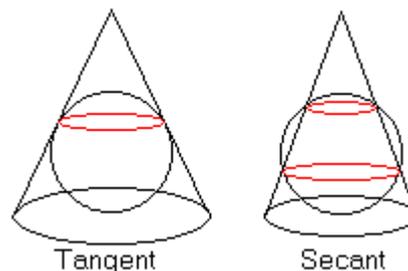


Fig 6: Different aspects for conical projections.

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 Select Projection dialog box.

4.3 Special objects

Special objects are:

-  map views
-  histograms
-  sample sets
-  matrices
-  user-defined filters
-  user-defined functions
-  scripts

Each special object name should start with a character between A to Z. Object names cannot exceed 8 characters.

☞ To have service objects appear in the Catalog, use the Catalog command on the Options menu in the Main window. See also Help topic How to customize the Catalog.

4.3.1 Map views

A map view stores all data and annotation layers as displayed in a map window, for instance a raster map with a vector map, legend, north arrow, etc. together with the display options of these layers. Saving the contents of a map window in a map view ensures quick and easy re-display of all layers when opening the view later on.

The description you give to a map view will be visible in the title bar of the map window. If you save a map view when zoomed in on a map, the zoomed area will be displayed when opening the map view.

Names of map views

Any map view 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 map view

Display the required data layers and/or annotation layers in a map window. Then, from the File menu in the map window, select the Save View or the Save View As command.

For more information on the creation and editing of map views, refer to How to use layers in a map window.

To display a map view

The easiest way to display a map view is to double-click it in the Catalog. All the maps and annotation that was stored as the map view is directly displayed in a map window.

☞ To show map views in the Catalog, refer to Help topic: How to customize the Catalog.

Technical information

A map view consists of an ASCII object definition file (.MPV). This file stores references to all map names that were stored as the map view and further contains the display options of all map and/or annotation layers. Furthermore, the georeference of the map window is stored.

4.3.2 Histograms



A histogram is a dependent table which stores frequency information on values, classes or IDs in a raster, polygon, segment or point map. A raster histogram is automatically calculated when displaying a value raster map which is stored using one or two bytes per pixel. Further, the Histogram operation can be used to calculate a histogram. The values in a histogram are presented as a table. A histogram always has the same name as the map from which it is calculated.



A raster histogram lists, depending on the domain of the map, for each value, class name or ID, the number of pixels in the map, and for each value, class name or ID the size of the area of these pixels as a percentage of the total area in square meters. If the input raster map uses a Value domain, the cumulative number of pixels, the cumulative percentages of the areas and the percentage of pixels of the total area that are not undefined are also calculated.

Furthermore, summary information can be viewed in the properties of the histogram such as mean, predominant value, standard deviation, and percentage intervals.



A polygon histogram lists, depending on the domain of the map, for each value, class name or ID, the number of polygons, and the perimeter and the area in square meters of these polygons. If the input polygon map uses a Value domain, the cumulative number of polygons, cumulative perimeters and cumulative areas are also calculated.



Furthermore, summary information is available in the properties of the histogram. A segment histogram lists, depending on the domain of the map, for each value, class name or ID, the number of segments and their length. If the input segment map uses a Value domain, the cumulative number of segments and the cumulative lengths are also calculated.



Furthermore, summary information is available in the properties of the histogram. A point histogram lists, depending on the domain of the map, for each value, class name or ID, the number of points. If the input point map uses a Value domain, the cumulative number of points is also calculated. Furthermore, summary information is available in the properties of the histogram.

Names of histograms:

A histogram always obtains the same name as the map from which it is calculated.

To calculate a histogram

You can double-click the Histogram operation in the Operation-list and select the map from which you want to calculate a histogram. You can also click a map in the Catalog with the right mouse button and choose Statistics, Histogram from the context-sensitive menu. For other methods, see How to calculate a histogram. Furthermore, a histogram is automatically calculated when you display a value raster map (domain Image, system domain Value, another system value domain or a user-defined value domain) which is stored using 1 or 2 bytes per pixel.

To display a histogram as a table and as a graph

The easiest way to display a histogram is to double-click a histogram in the Catalog. To show the histogram as a graph, choose from the Options menu in the table window the Show Graph command: choose the domain column for the X-axis, and the Npix column for the Y-axis; then choose Needle.



To show histograms in the Catalog, refer to Help topic: How to customize the Catalog.

Editing a histogram

As a histogram is a dependent table, depending on the values, class names, or IDs in a map, the values of the calculated (table-owned) columns in a histogram table cannot be edited. You can always perform further calculations using these columns by typing expressions on the TabCalc command line.

If you really want to manually edit the values of calculated table-owned columns, you first have to break the dependency link of the histogram table in its Properties dialog box.

- ☞ For histograms of domain Class or ID maps: as the domain of the histogram is the same as the domain of the map, all columns of the histogram can be joined to an attribute table of a map. See also How to join areas from a histogram to an attribute table.
-

Technical information

A histogram consists of an ASCII object definition file (.HIS, .HSA, .HSS or .HSP) and a binary data file (.HI#, .HA#, .HS# or .HP#). The object definition file contains references to the map from which the histogram was calculated and the domain of that map. The domain of the map is also the domain of the histogram.

By viewing the properties of a histogram, you can see whether the histogram is up-to-date. If this is not the case, i.e. after editing the map from which the histogram was calculated, you can easily recalculate the histogram by clicking the Make Up-to-Date button. The properties of a value histogram also present a histogram summary: the Mean, Standard Deviation, Median, Predominant value and the number of times this value occurs in the map. Furthermore, the values in the map which define the 0%, 0.5%, 1.0%, 2.0%, 5.0% and 10.0% percentage intervals in the histogram are listed.

Limitations

The maximum number of entries in a histogram is 2 billion.

4.3.3 Sample sets

A sample set stores training pixels for supervised classification. Prior to an image classification, sample pixels or training pixels have to be selected in a sample set. A map list, containing the set of images used for classification and a background map on which you can locate training pixels and a class domain have to be specified. Then, during sampling, class names need to be assigned to groups of pixels that are supposed to represent a known feature on the ground and that have similar spectral values in the maps in the map list. A sample set is used as input in the Classify operation.

A sample set consists of

- a reference to a map list, that is the set of images you want to classify in a later stage. The spectral values of the images in the map list, at the position of the training pixels provide the basis on which decisions are made in the classification. During sampling, these values can be inspected in the sample statistics of a certain class of training pixels, and can be visualized in feature spaces. Usually, you will use a set of satellite images in the map list, but you can also work with the Principal Components.
- a reference to a class domain, that is the collection of class names that you want to assign to your training pixels and that are the classes that you want to obtain from the classification. The representation of this domain determines in which colors the training pixels are displayed during sampling. You can also add classes to the domain during sampling, or delete or merge classes;

- a reference to a background map, that is the map on which you can locate your training pixels; this background map can for instance be a color composite;
- a reference to a raster map which is automatically created and obtains the same name as the sample set. This so-called sample map contains the locations of the training pixels and the class names assigned to them.

Names of a sample set

Any sample set name must start with a character between 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. Names cannot exceed 8 characters.

To create a sample set

A sample set can be created by for instance double-clicking the Sample Map item in the Operation-list, or select Sample from the Operations menu, Image Processing. For other methods, see How to create a sample set. The sample set editor is opened.

Editing a sample set

The easiest way to edit an existing sample set is by double-clicking it in the Catalog. See also, How to edit a sample set. For other methods, see How to edit a sample set. The sample set editor is opened.

☞ To show sample sets in the Catalog, refer to Help topic: How to customize the Catalog.

Technical information

A sample set consists of an ASCII object definition file (.SMS). This file contains further references to a domain (containing the class names of sampled pixels), a map list (containing the satellite bands), a background map, and to a raster map that is automatically created and is stored with the same name as the sample set which contains the locations of training pixels and class names assigned to them (this map is called the sample map).

By viewing the properties of a sample set, you can see the domain, the name of the sample map, the map list and background map used in the sample set. These are properties of the sample set.

Limitations

The maximum number of raster maps that can be included in a map list is 5440; no other limitations.

4.3.4 Two-dimensional tables

A two-dimensional table is used to combine or reclassify two raster maps with a class or ID domain. It defines a value for each possible combination of input classes or IDs.

A two-dimensional table view consists of rows which represent one domain and of columns which represent another domain. In the two-dimensional table, you have to assign a value, class name or ID to the fields which represent the combination of these domains.

When you apply the two-dimensional table on the command line of the Main window, you need two input raster maps which have the domains as used by the two-dimensional table, the output raster map then contains the values, classes or IDs that you entered in the fields of the two-dimensional table.

To create a two-dimensional table

Open the File menu of the Main window and select the Create Two-Dimensional Table command, or double-click the New 2DimTbl item in the Operation-list. In the appearing Create 2-Dimensional Table dialog box, select two input domains of raster maps on which you want to apply the two-dimensional table later on.

To display and edit a two-dimensional table

When you create a new two-dimensional table, it is directly displayed in a table window where you can also directly edit it.

To open and edit an existing two-dimensional table, double-click a two-dimensional table in the Catalog, double-click the Open or Edit item in the Operation-list, or select the Edit Object command on the Edit menu of the Main window and select a two-dimensional table.

For more information on editing a two-dimensional table, see Table window : editing two-dimensional tables.

 To show two-dimensional tables in the Catalog, refer to Help topic: How to customize the Catalog.

To apply a two-dimensional table

A two-dimensional table can be applied by typing a special expression on the command line of the Main window:

```
OUTMAP = 2dimtablename[map1,map2]
```

For more information, see Map calculation : applying two-dimensional tables.

Technical information

A two-dimensional table consists of an ASCII object definition file (.TA2) and a binary data file (.T2#).

The object definition file contains further references to two domains that contain the classes or IDs that you want to reclassify and to one domain which contains the classes, IDs or values after reclassification; these three domains are properties of a two-dimensional table (see also Appendices : relations between ILWIS objects).

Internally, a two-dimensional table uses system domain None; the table has only one table-owned column named Value which stores the output class names, IDs or values for each combination of input classes or IDs.

4.3.5 Matrices

In ILWIS, there are four Statistical operations which calculate a matrix:

- covariance matrix by the Variance-Covariance matrix operation;
- correlation matrix by the Correlation matrix operation;
- covariance matrix and matrix of eigenvectors by the Principal Components operation;
- correlation matrix and matrix of eigenvectors by the Factor Analysis operation.

All these operations can be found on the Operations menu, Statistics, Map List.

As matrices are the result of an operation, matrices cannot be edited.

Names of matrices

When performing the Variance-Covariance operation or the Correlation operation, the matrix is not stored as a separate object; the matrix is stored in the input map list.

When performing the Principal Components or Factor analysis operation, you can specify a name for the matrix yourself. Any matrix 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 matrices in the Catalog, refer to Help topic: [How to customize the Catalog.](#)

To display a matrix

To display a covariance matrix, perform the Variance-Covariance operation.

To display a correlation matrix, perform the Correlation operation.

To display the output matrices of the Principal Components and Factor Analysis operations:

- double-click a matrix in the Catalog, or
- use the right mouse button on a matrix in the Catalog, and select Open from the context-sensitive menu, or
- from the File menu in the Main window, choose Open and select a matrix.

Technical information

A matrix consists of an ASCII object definition file (.MAT).

Variance-covariance matrix:

Shows the variance and covariance values for all bands in the input map list and the mean and standard deviation of each input map. In the properties of the input map list the Optimum Index Factors (OIF) are listed.

Correlation matrix:

Shows the correlation values for all bands in the input map list and the mean and standard deviation of each input map. In the properties of the input map list the Optimum Index Factors (OIF) are listed.

Principal components matrix:

Stores eigenvectors for the new output maps (axes) and the percentages of total variance contributed by each eigenvalue. When the matrix is calculated, the output maps and the output map list are created.

Factor analysis matrix:

Stores eigenvectors for the new output maps (axes) and the percentages of total variance contributed by each eigenvalue. When the matrix is calculated, the output maps and the output map list are created.

4.3.6 Filters



Filters are used in the Filter operation. In ILWIS, there are four main filter types: Linear filters, Rank order filters, Majority filters, and Binary filters. Furthermore, there is a Pattern filter and a Standard deviation filter. For an explanation on the working of these filter types and examples, see Filter types. For examples on the use of filters, see Filter : functionality.

Some 30 filters are predefined in the `SYSTEM` directory. However, the Filter : dialog box offers many possibilities to define most filters on the fly according to your wishes before applying them. This can of course also be done on the command line of the Main window. Further, your own linear filters can be created, edited and stored on disk.

Names of filters

Any filter starts 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 linear filter

You can create your own user-defined linear filter of any odd size. Easy ways to create a new linear filter is to choose Create Filter from the File menu of the Main window, or to double-click the New Filter item in the Operation-list. For more information, refer to How to create a linear filter.

To view or edit a linear filter

All linear filters can be opened to see their contents; you can edit your own user-defined linear filters. The easiest way to view or edit a linear filter is to click it with the right mouse button in the Catalog, then choose Open from the context-sensitive menu. For more information, see How to edit a user-defined linear filter.

-
- ☞ To show filters in the Catalog, refer to Help topic: How to customize the Catalog.
 - ☞ The Average filter, Majority filters, Median filters, Rank Order filters, and the Standard Deviation filter may have a user-defined size, rank or threshold. You can define these filters on the fly in the Filter : dialog box.
-

Technical information

Filters which are stored on disk consist only of an ASCII object-definition file (.FIL). This file stores the name, type and size of the filter, and it may further store matrix values for linear filters, the solution table for binary filters, etc.

By viewing the properties of a filter, you can see whether it is a system filter or not, when it was last edited, object size and the description of the filter. A filter has no relations to other objects.

Limitations

The total size of a filter (nr. of rows in the filter * nr. of columns in the filter) cannot exceed 8000. This means that you can create filters up to 89*89, 49*161, 9*801, 1*7999, etc.

4.3.7 Functions

A function allows you to pre-define complex calculations or calculations which need to be repeated several times; when you use the function in a calculation, you only need to fill out the function's parameters.

Functions can be used in all three calculators in ILWIS: MapCalc, in TabCalc, or in the pocket line calculator. In ILWIS, some 50 internal functions are available (see also MapCalc and TabCalc), but you can also create your own functions. By creating a user-defined function beforehand, your MapCalc and TabCalc formulas may be simplified.

A user-defined function may contain any combination of operators and functions, and may use parameters representing map names, table names and column names. Parameters in a user-defined function can have any name.

Names of user-defined functions

Any function 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 user-defined functions in the Catalog, refer to How to customize the Catalog.
-

To create a user-defined function

- in the Main window, open the File menu, choose Create Function, or
- double-click the New Function item in the Operation-list.

The Create Function dialog box appears in which you can type the expression that the function should perform.

To edit a user-defined function

- in the Catalog, double-click a function, or
- in the Main window, open the Edit menu; choose Edit Object and select a function, or
- in the Catalog, click a function with the right mouse button, and select Open from the context-sensitive menu.

The Edit Function dialog box appears.

When creating or editing a user-defined function, you must take care that the output domain type of the function is declared correctly; by default Value will appear behind the colon in the Edit Function dialog box (see also the example below).

Parameters in user-defined functions

Normally, a function needs parameters on which it should work. This means that you can use parameters when defining a function. Parameters can be as long as you like, should always start with a character from A to Z, and can only contain characters from A to Z, numbers 0 to 9, and underscores. For each parameter, the domain has to be specified.

To apply a function

When you use the function on the command line of the main window or a table window, you have to type the function name followed by brackets in which you type the map name(s) or column name(s) that need to be filled out for the parameter(s) in the function. You can separate parameters with commas. Instead of map names or column names, you can also type complete expressions.

The first filled in parameter is taken as the first parameter encountered in the function, etc.

In this way, you can use the function several times, each time filling out different map or column names on which the function should be applied.

Example of a user-defined function

To define a function SUM to sum some bands of an image, you may create a function SUM defined as: a+b.

In the Edit Function dialog box, this will appear as:

Function Sum(value a, value b): Value

This means that the function Sum has two parameters (a and b) which are of the value type, and the output domain of the function is also a value.

Further, the Edit Function dialog box states the calculation that should be performed with the parameters of the function; in this case:

Begin
Return a+b
End;

This means that parameters a and b will be summed.

When using this function on the command line, you may type:

```
OUT=sum (band1 ,band2 )
```

OUT is the output object, 'Band1' is then used as parameter 'a' and 'band2' is used as parameter 'b'.

File information

Functions consist of an ASCII object definition file (.FUN), and an ASCII data file (.FND).

Internal MapCalc and TabCalc functions are built in in the software and cannot be visualized.

Example 1 (with parameters)

To define a function SUM to sum some bands, you may create a function SUM defined as: a+b.

In the Edit Function dialog box, this will appear as:

Function Sum(value a, value b) : Value

This means that the function Sum has two parameters (a and b) which have a value domain;

after the colon the output domain of the function (system domain Value) is specified. You can specify any domain you like.

Further, the Edit Function dialog box states the calculation that should be performed with the parameters of the function; in this case:

Begin
Return a+b
End;

This means that parameters a and b will be summed.

To use this function, type on the command line:

```
OUT=sum (band1 ,band2 )
```

Where:

OUT	is the output object,
Band1	is used as parameter a, and
band2	is used as parameter b.

Example 2 (without parameters)

To define a function `AVG2B` to calculate the average of two bands, you may create a function `AVG2B` defined as: $(TMB1+TMB2) / 2$.

In the Edit Function dialog box, this will appear as:

Function `AVG2B(value tmb1, value tmb2) : Value`

Remove the parameters between the brackets; and keep the default output domain Value.

Function `AVG2B() : Value`

Further, the Edit Function dialog box states the calculation that should be performed with the parameters of the function; in this case:

```
Begin  
Return (tmb1+tmb2)/2;  
End;
```

To use this function, type on the command line:

```
OUT=AVG2B ( )
```

where:

`OUT` is the output object,

`AVG2B` is the function which already contains the map names.

In the Raster Map Definition dialog box, you have to specify the correct georeference for the output map.

4.3.8 Scripts

Scripts are used to perform a sequenced list of ILWIS operations. By creating a script, you can build a complete GIS or Remote Sensing analysis for your own research discipline. Scripts are more or less equivalent to batch files in ILWIS version 1.4.

Lines in a script may contain commands for object management (e.g. copy or delete), display of data objects (Open or Show), and for the creation and calculation of data objects. All MapCalc, and TabCalc formulas, and all ILWIS expressions to perform operations may be used. Other scripts and other Windows applications can also be called from within a script. A script can use parameters. For more information on valid script expressions, see Appendices : ILWIS script language (syntax). For more information on using parameters in scripts, see How to use parameters in scripts.

Names of scripts

Any script 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 script

- in the Main window, open the File menu and choose Create Script, or
- in the Operation-list, double-click the item NewScript.

The Create Script dialog box appears, in which you can type lines of expressions for calculations and operations.

To edit a script

- in the Main window, open the Edit menu, choose Edit Object, and select a script, or
- in the Catalog, click a script with the right mouse button, and select Open from the context-sensitive menu.

The Edit Script dialog box appears.

-
- ☞ To show scripts in the Catalog, refer to How to customize the Catalog.
 - ☞ When creating or editing a script, you can use the following keystrokes to copy and paste script lines to and from the clipboard:

Ctrl+C	Copy the selected part to clipboard.
Ctrl+Ins	Copy the selected part to clipboard.
Ctrl+V	Paste the contents of the clipboard at the position of the mouse pointer.
Shift+Ins	Paste the contents of the clipboard at the position of the mouse pointer.
-

Using parameters in scripts

Parameters in a script can replace (parts of) object names, operations, etc. Parameters in scripts work as DOS replaceable parameters in DOS batch files, and must be written in the script as %1, %2, %3, up to %9. The parameters of a script have to be filled out on the command line when you run the script. The first text string found after the script name will replace %1 in the script, etc. For more information, see How to use parameters in scripts.

To run a script

To run a script, type on the command line of the Main window:

```
Run scriptname parameter parameter
```

Fill out script name and parameters. The first text string found after the script name will replace %1 in the script, etc. On the command line, script parameters are entered without brackets and separated by spaces. If a script has no parameters, you can directly double-click the script in the Catalog. For more information, see How to run scripts.

Example

For example, you can create a script SumBands, defined as:

```
%3=%1+%2 or as
%3.mpr=%1.mpr+%2.mpr
```

To apply this script, type on the command line of the Main window:

```
run SumBands band1 band2 OUT
```

'band1' is filled out for %1, 'band2' is filled out for %2, and OUT is used as the output object name.

A more elaborate example of a script (to create slope maps in percentages and in degrees) is presented in topic Map & Table calculation : creating and running scripts.

Technical information

A script consists of an ASCII object definition file (.ISL, ILWIS Script Language) and an ASCII data file (.ISF, ILWIS Script File).

4.4 Annotation

Annotation can be added 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.

Annotation is generally used on top of one or more data layers (displayed maps). Annotation can be edited in the Annotation editor. To store annotation, you need to save the map window as a map view.

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

Text

Texts such as titles can be added as annotation to a map window. Texts can be rotated, font and colors are user-defined. A text can be as long as you like and you can add as many texts as you like to a map window.

If you want to obtain (texts) labels of points, display the point map as an extra data layer in the map window: select the Text check box on the Display Options dialog box of the point map. If you want to obtain (text) labels for segments or polygons, use the Segments to Points or Polygons to Points operation, then display the output point map as an extra data layer in the map window.

Legend

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

Class legend:

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 a legend can be made transparent or not.

Value legend:

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 a legend can be made transparent or not.

North-arrow

A North-arrow determines the North of a map from the georeference that is used by a displayed raster map, or when no raster map is displayed, from the coordinate system used by displayed vector maps. Three types of North arrows are available, line width and color are user-defined. Text such as N, E, S, W can be displayed with the North arrow. Font and color for the text are user-defined.

Scale bar and scale information

A scale bar and scale information (e.g. 1 : 100000) can be shown based on the georeference that is used by a displayed raster map, or when no raster map is displayed, on the coordinate system used by displayed vector maps.

A scale bar can be prepared in two forms: as blocks of alternating colors or as a line with tick marks. The distance intervals and colors used in the scale bar are user-defined. Font and colors used for the text below the scale bar and for scale information is also user-defined.

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 borders around the whole mapped area, around a legend, or a title, etc. Two types of boxes are available, line width and color of the border of the box are user-defined. If line width 1 is selected, also three different line styles are available. By default, the inside of a box is transparent, but you can also fill a box with a color.

Grid lines

Grid lines, coordinate ticks, X- and Y-coordinates and a border fitting a map can be shown. Grid lines are regularly spaced usually horizontal and vertical lines based on the georeference of the map window. The spacing of grid lines is specified in meters and also line width and color are user-defined. X- and Y-coordinates of the grid lines can be shown inside or outside the map area, and can appear in a short form. Font and color for the coordinate text are user-defined.

Graticule

A graticule consists of lines that follow longitude and latitude of a geographic projection as used by a coordinate system. Thus, to create a graticule, you need to display a map using a coordinate system that has projection information. The spacing of a graticule is specified in degrees, minutes and seconds, further line width and color are user-defined.

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 lose 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. For more information, see Copying and pasting through the clipboard, and Appendices : Keyboard shortcuts.

