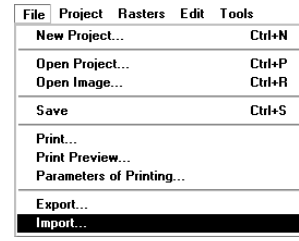
Lesson 1. New project
Vectorizing of black objects

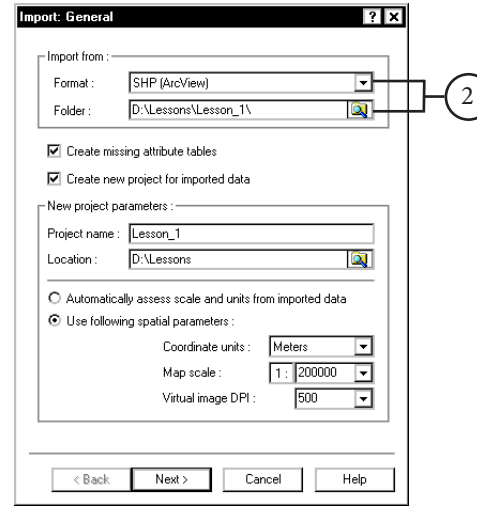
Step 1. Project creation

It is senseless to vectorize an image ignoring the target GIS. Suppose, it's ArcGIS and the map image is already georeferenced and enclosed in a vector frame.
Let us import the map's vector frame from ArcGIS into Easy Trace. As it should be placed somewhere to, Easy Trace automatically generates a new project.

1. Invoke Easy Trace.
   Select *Import* from *File* menu.



2. Select SHP format and specify the folder, which contains the SHP-file of vector frame.
   In this case it is:
   D:\Lessons\Example\SHP Frame



3. Specify new project parameters: name Lesson_1 and folder D:\ Lessons. This directory will contain a subdirectory of the project.

4. The image in our example is a scan of topographic map. Map scale is 1:200000. Coordinate units of the map - meters.

   Input these parameters and specify additionally resolution of the image - 500 DPI.

5. Click *Next* to open the dialog box where layers may be selected for import.

6. The SHP-file we need is already marked. Click *Next* to open the next dialog box.

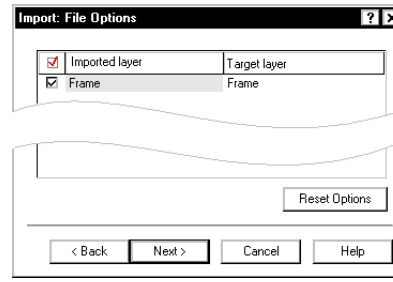
7. Select the *Without coordinate transformation* option.

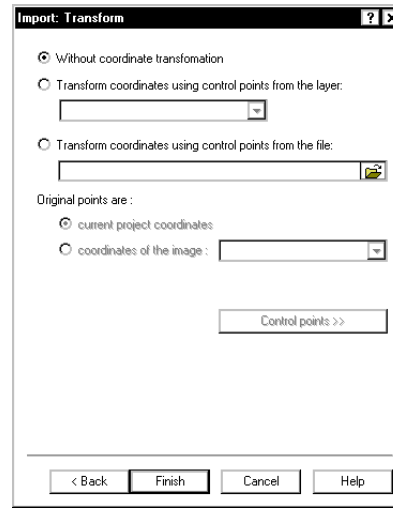
8. Parameter input is over. Click *Finish*.

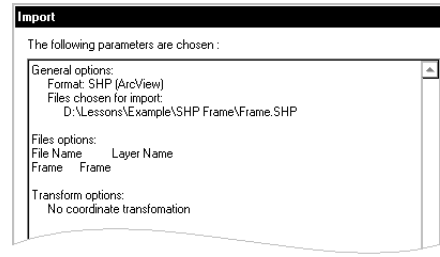
9. Check accuracy of chosen import parameters.
   Click *Back* if they require correction.

10. Click *Start* to import data.

11. Review information window of the *Import* utility and click *Close*. Lesson_1 project is created.







The project was automatically generated at import of the vector frame.

Project boundaries were calculated from the frame extent.

Step 2. Raster adding to project

We have already imported the vector frame encompassing the area of future vectorizing. Now we shall add the image itself applying a TFW-file of raster registration. The file will be taken from ArcGIS as well.

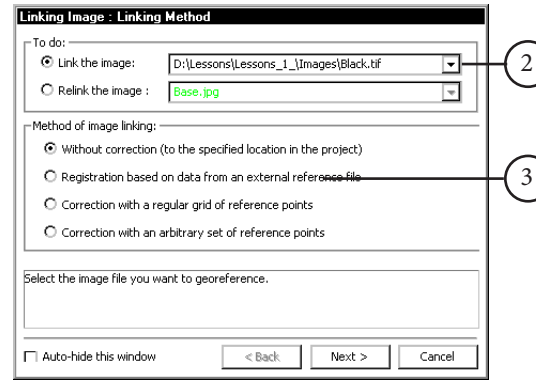
1. Select *Add Image* in *Project* menu.

2. Select the image in the *Linking Image* dialog box:
   D:\..\Example\Raster\Base.jpg

3. Select linking method - based on an external reference file.

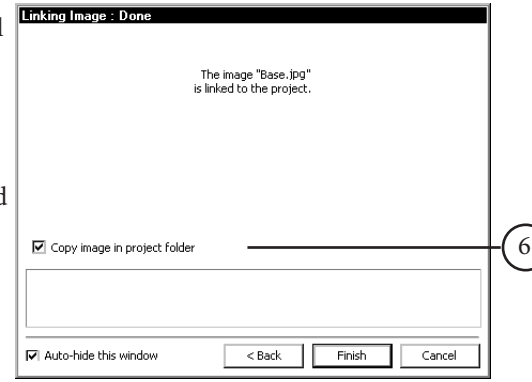
4. Click *Next*.

5. Select the registration file for Base.jpg image:
   D:\..\Example\Raster\Base.jgw.
   Click *Open*.



6. Switch on the option *Copy image into project folder.*
   Easy Trace will use a copy of the source image.
   It is convenient for project delivery to operators and protects the initial image from accidental alterations.

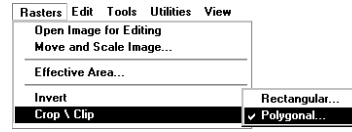
7. Click *Finish*.
   The Base.jpg image is copied to the folder of project's rasters and linked to the vector field.



Let us hide the image outside the vector frame around the area of vectorizing. This option is useful for correct represenation of mosaic raster field made of several nonrectangular map sheets.

1. Select *Crop / Clip* from *Rasters* menu.

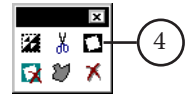
2. Select *Polygonal* option.



3. Keep the Ctrl key pressed and click the vector frame of the map sheet.

4. Click the mouse right button and select *Set clipping* from the contextual menu

.



Step 3. Extraction of the black subject layer

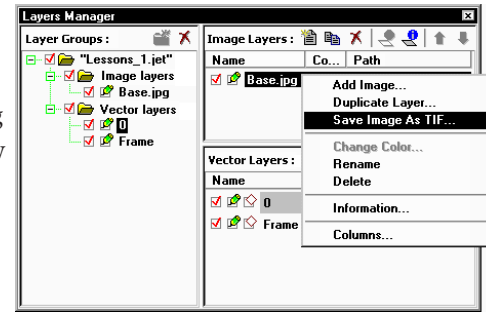
Black-and-white images only are suitable for effective automatic vectorizing. Forming of such images out of the initial color one we call Extraction of subject layers.

There is a ceratin succession of raster operations for extraction of every subject layer. Main tools to be used are Diffuse, Unsharp Mask, and Subject Layer Extraction .

The latter tool exploits the fact that different colors dominate in lines of different subject layers. It is reasonable usually to extract the black, red, blue, and green layers.

Main complexity of the process is connected with absence of solid colors both on the paper and in the raster. Every color is represented by numerous tints.

1. Press Ctrl+L to open *Layer Manager*.



2. We are going to extract black-and-white subject layers from the Base.jpg image. But JPG format does not allow saving of binary rasters. That's why we shall save Base.jpg as Base.tif.

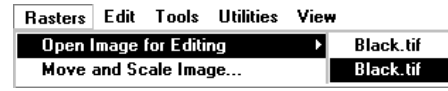
   Click the mouse right button on the Base.jpg layer name and select *Save Image as TIFF* option.

3. Let us make a copy of Base.tif and change it into the «Black» black-and-white image by means of successive modifications.

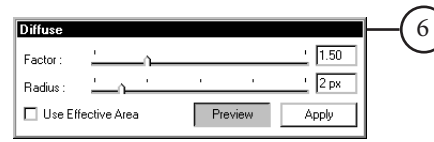
   Click the mouse right button on the Base.jpg layer name and select *Duplicate Layer* option.

4. Type Black as the new raster layer's name and click *OK*.

5. Select *Open Image for Editing* option from *Rasters* menu.
   Specify Black.tif.



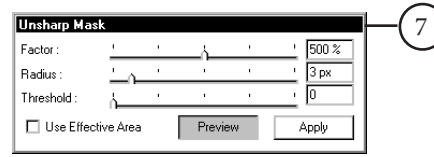
6. Pixels of «black» lines are of different tints in fact.
   We shall average the color with the help of *Diffuse Tool*  .



   Specify operation parameters:
   Factor = 1,5
   Radius = 2 pixels

7. *Unsharp Mask*  now to increase contrast of lines.

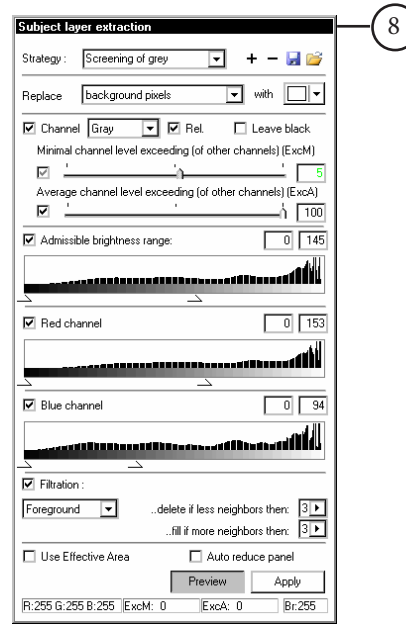
Specify operation parameters:
Factor = 500%
Radius = 3 pixels
Threshold = 0



8. Now we want to substitute all bright and distinctly non-grey colors for white.

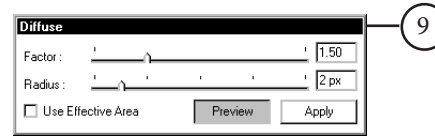
Select *Subject Layer Extraction* . Specify operation parameters as it is shown in the figure.

Create a new strategy to save these settings of the tool, call it *Grey-Based Filtering* and click .



9. *Diffuse* again to delete white pixels in black lines and small "rubbish" on the white background.

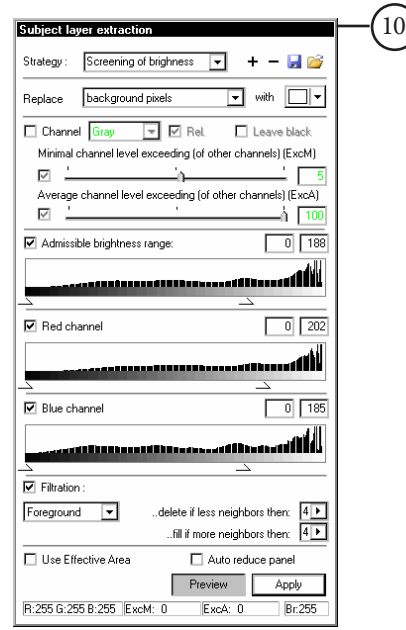
Specify operation parameters:
Factor = 1,5
Radius = 2 pixels.



10. Remnants of diffused small rubbish objects and halos around lines should be deleted.

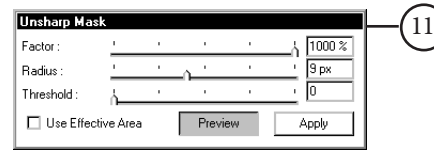
Select *Subject Layer Extraction* . Specify operation parameters as it is shown in the figure.

Create a new strategy to save these settings of the tool, call it *Brightness-Based Filtering* and click .



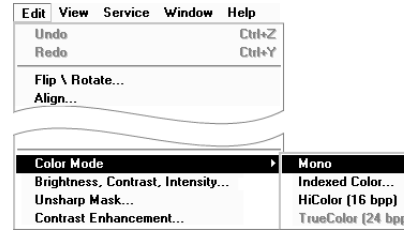
11. Apply *Unsharp Mask* for drastic increase of line contrast .

Specify operation parameters:
Factor = 1000%
Radius = 9 пкс
Threshold = 0



12. Now we transform the image into a black-and-white one (it remained TrueColor yet (24 bpp)).

Select *Color Mode -> Monochrome* in *Edit* menu.



13. Easy Trace always vecrorizes WHITE lines on BLACK background.

    Invert the image with *Inversion* tool  .

14. Press Ctrl+S to save the extracted Black.tif.

15. Close the window of image editing.

The «black» subject layer we have extracted depicts topographic symbols well enough and will be used later for automatic object recognition and tracing of dotted lines.

But it is overladen for vectorizing of linear objects.
As we are going to recognize the coordinate grid, let us prepare one more version of this subject layer - a thinned image.

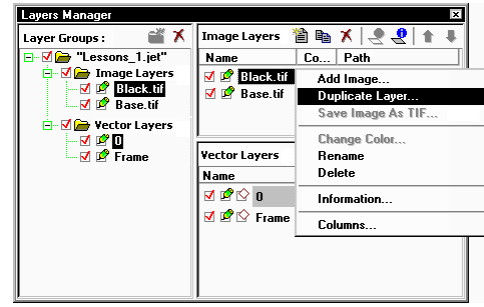
1. Press Ctrl+L to open *Layer Manager* and duplicate the Black.tif image as Black_thin.tif

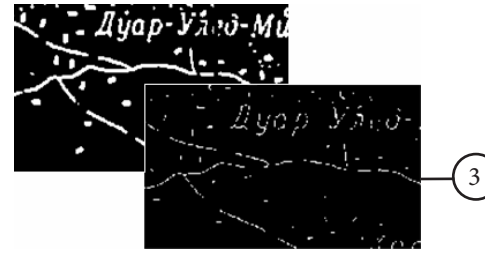
2. Select *Open Image for Editing* in *Rasters* menu.
   Select the Black_thin.tif image

3. Select *Image Thinning* command in *Edit* menu to thin («skeletonize») the current image.

4. Press Ctrl+S to save changes in Black_thin.tif.

5. Close the window of image editing.



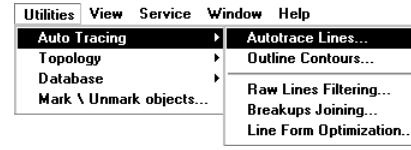


Step 4. Image vectorizing.
Recognition of grid lines

Grid lines in the image hinder vectorizing badly. They make gaps in lines of color sibject layers and complicate tracing of black lines.

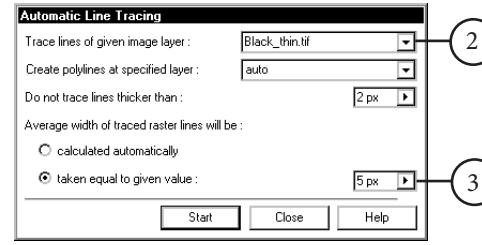
Easy Trace can recognize grid lines automatically. The grid may be used later for exact correction of the image in every grid cell and at subsequent extraction of other subject layers.

1. Automatic vectorizing of the Black_thin.tif image.
   Select *Auto Tracing -> Autotrace Lines* in *Utilities* menu.



2. Select the Black_thin.tif raster layer for tracing.

   Vector lines will be attributed to the Auto layer by default. The program generates this layer automatically.

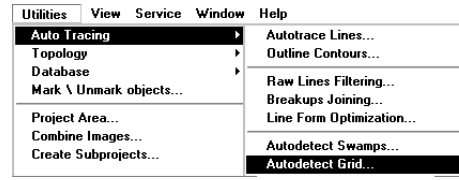


3. As the «black» image is thinned, it is impossible to determine width of source raster lines automatically, and we must input it manually.

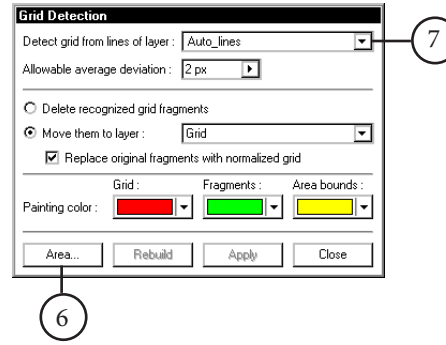
   Select *Taken equal to given value* option and specify line width equal to 5 pixels.

4. Click *Start*.
   When tracing is over, close the dialog box of *Autotrace Lines* utility.

5. Select *Auto Tracing -> Autodetect Grid* in *Utilities* menu.



6. Specify the area of grid recognition. Click *Area* button, then keep the Ctrl key pressed while pointing the vector frame (attributed to the Frame layer) with the cursor. Click *Area* button again to «release» it.



7. Select the Auto vector layer, which contains vector data generated at automatic vectorizing of the Black_thin.tif image.

8. Specify allowable deviation of grid lines from due position (search distance for grid segments) equal to 2 pixels.

9. Select *Move segments to layer* option and type the name Grid for the new vector layer, which will contain found grid segments

10. Switch on the option *Replace original segments with normalized grid*.

11. Click three nodes of one grid cell somewhere in the center of the map.

12. Click *Apply* and close the dialog box.

Step 5. Grid line deletion from the Black image

Ideally, vectorizing should be INTERRUPTED after vector grid getting (not mathematically accurate one but the grid corresponding to coordinate lines IN THE IMAGE). Depature of real grid from ideal one is often too big - several times more than line width

So, it is reasonable to georeference the image again applying information about due position of every grid node. Easy Trace has a special Relink Image command for this purpose illustrated by video.

But we shall skip the operation and continue. The grid will be used to facilitate vectorizing of other raster objects.

1. Select *Rasterize Vector Data* command from *Utilities* menu.

2. Select (tick off) the Grid vector layer, which contains grid lines.

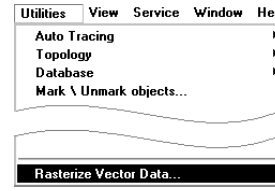
3. Select theBlack.tif raster layer into which lines from the Grid layer will be inprinted.

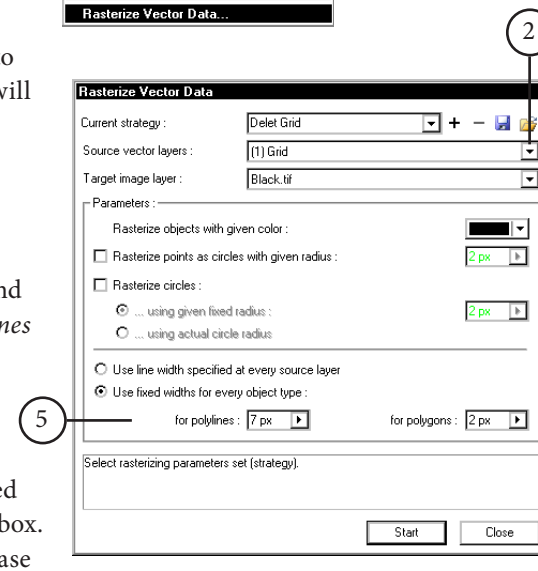
4. Select color for rasterized vector objects – black.

5. Select *Use fixed width...* option and specify width of rasterized *polylines* - 7 pixels.

6. Click *Start*.

7. If grid lines are completely deleted from the image, close the dialog box. Otherwise apply *Undo* and increase the width of rasterized polylines.

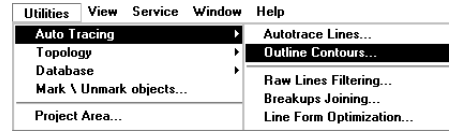




Step 6. Automatic recognition of orthogonal objects

There may be thousands of black rectangles - blocks in one sheet of a topographic map, especially in densely populated areas.
It is simple enough to vectorize them automatically.

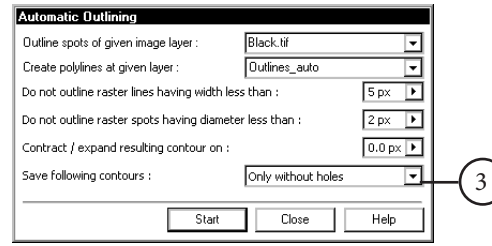
1. Select *Auto Tracing -> Outline Contours* in *Utilities* menu.



2. Specify outlining parameters as it is shown in the figure:

   - outline spots of raster layer Black. tif.
   - create polylines on vector layer Outlines_auto.

   Skipping parameters exclude small spots and thin lines from vectorizing.



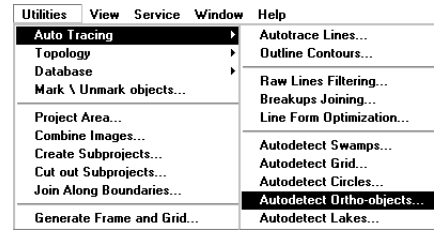
3. Select *Only without holes* in the field *Save the following contours* to exclude objects without continuous filling from vectorizing.

4. Click *Start*.

The utility has generated dense vector contours - one polyline vertex per one image pixel. Easy Trace applies a series of characteristics to identify orthogonal contours among others.

The program has a special utility for recognition of ortho-objects. Its parameters are rather numerous, but easily understandable. At that, many parameters may be specified by selection of samples just on the screen.

5. Select *Auto Tracing -> Autodetect Ortho-Objects* in *Utilities* menu.

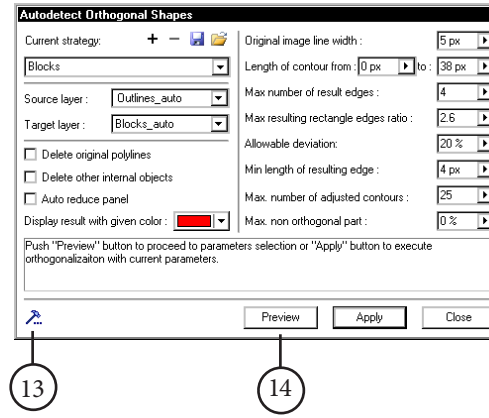


6. Specify the layer of source contours Outlines_auto and a new layer, which will contain results of contour recognition - Blocks_auto.

7. Switch on *Delete original polylines* option to simplify review of recognition results.

8. *Original image line width* is equal to 5 pixels, i.e. to the average width of black lines in the color image.

9. To determine *Contour length* range, select contour samples with the Editor. It is from 25 to 38 vertices in our example.



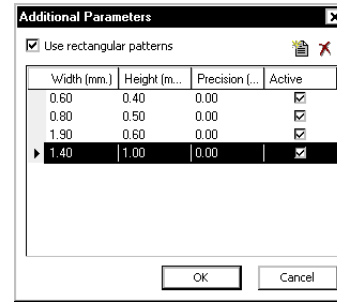
10. We want to recognize rectangles only, hence *Maximal number of result edges* is 4.

11. Let us exclude contours around long strokes of thick dashed lines. *Maximal resulting rectangle edges ratio* (long side to short one) = 2.6.

12. *Allowable deviation* (of object form from rectangularity) = 20% - to be chosen by review of samples selected with the Editor.

13. If we deal with a stipulated set of topographic symbols, it is reasonable to specify standardization patterns for rectangular objects.

Click the icon  in the lower left corner of the dialog box and specify parameters as shown in the figure. Click *OK*.



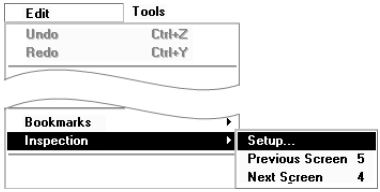
Minimal length of resulting edge and Maximal number of adjusted contours are parameters provided for complex orthogonal contours in 1:2 000 and 1:500 schemes. Maximal non-orthogonal part allows recognition of partly orthogonal objects.

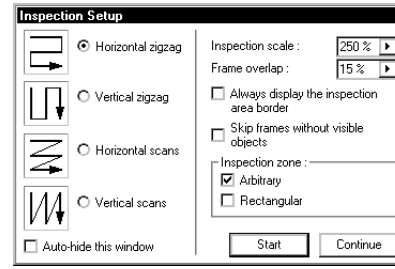
14. Click *Preview* to estimate results. Alter operation parameters if necessary.

15. Click *Apply* to recognize ortho-objects.

Some blocks are basically unfit for automatic recognition. They are cut by grid lines or «stuck» to road lines. Thus, the next stage consists in regular review and correction of recognition results.

Apply Inspector for this purpose with parameters shown in the figure. Keys 4 / 5 (next / previous frame) enable systematic review of the project. Do not move to the next frame before you have corrected all defects in the current one.





Use Rectangle tool  *to vectorize unrecognized rectangular objects in manual*  *mode.*

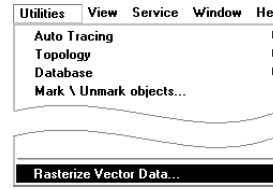
The tool can capture vectorized contours if you point them with the mouse right button and copy them at left click. Press Escape to leave copying mode.

Mouse wheel rotates the captured contour slowly if Shift key is pressed and quickly if you press Ctrl.

Deletion of vector «rubbish» and gross distortions of object shape should be done by Vector Eraser tool  *(Q hot-key). At that, «Red Eraser» is provided for object deletion (keep Shift pressed), whereas «Blue Eraser» (Ctrl key pressed) cuts the object up.*

Step 7. Deletion of block contours and grid lines from the thinned image Black_thin

1. Select *Rasterize Vector Data* command from *Utilities* menu.



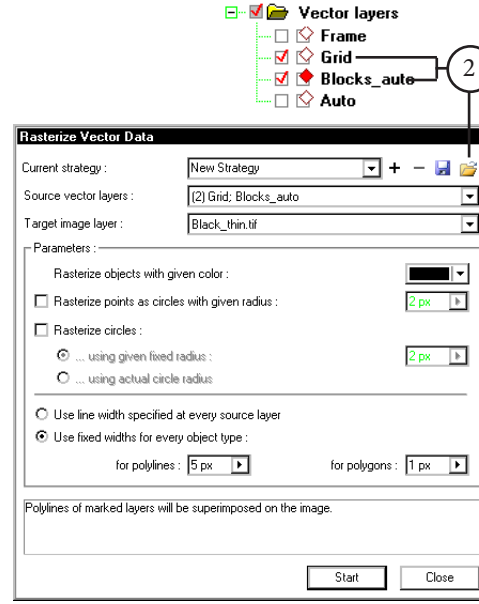
2. Select (tick off) source layers - Grid and Blocks_auto.
   The Blocks_auto layer should be rasterized as polygonal - click the rhomb left of its name.

3. Specify Black_ thin, as the target raster layer, into which objects of the layers Blocks_auto and Grid will be inprinted.

4. Select color for rasterized vector objects – black.

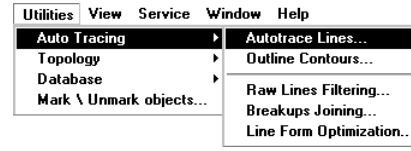
5. Select *Use fixed width...* option and specify:
   for polylines - 5 pixels,
   for polygons - 1 pixel.

6. Click *Start*.



Step 8. Vectorizing of linear objects

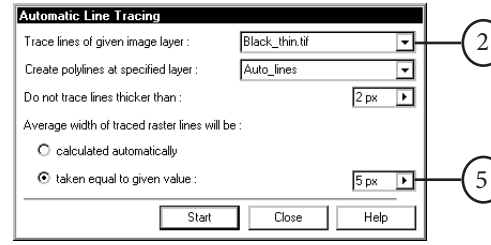
1. Select *Auto Tracing -> Autotrace Lines* in *Utilities* menu.



2. Select the thinned raster layer Black_ thin.tif for vectorizing.

3. Type the name of a new vector layer Auto_lines, wich will contain generated polylines.

4. Parameter *Do not trace lines thicker than* is irrelevant to our example as the image is thinned and has no lines thicker than 2 pixels.



5. *Average width of traced raster lines* should be specified manually as it is indeterminable in thinned images. It is 5 pixels in the example.

6. Click *Start* and close the dialog box.

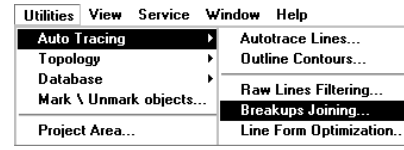
Automatic tracing forms a set of line fragments that correspond to the source image. The lines are «dense» - one vertex per one pixel of the image.

No suppositions about line shape and nature were done at this stage. All joints of three and more lines are represented by nodes.

Such vector data suite well for noise deletion and recognition of vector objects. We deliberately refused from all operations with line segments at the stage of automatic tracing.

7. Delete obvious gaps in lines by the first (short-distance) break-up joining. Angle of convergense of line segments should be close to flat one (180°).

   Select *Auto Tracing -> Breakup Joining* in *Utilities* menu.

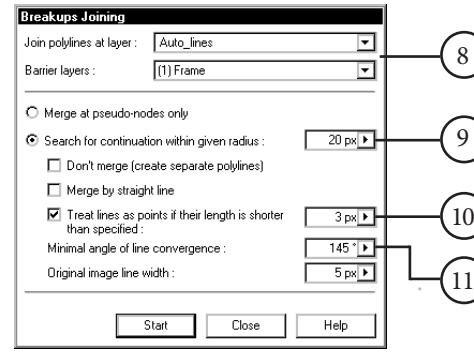


8. Specify the layer of lines to be mended - Auto_lines. Select Frame layer as barrier one.

9. Specify the radius to search line continuation within - 20 pixels.

10. Allow the program not to consider direction of segments shorter than 3 pixels.

11. Input 145° for minimal angle between segments that will be sewn together.
    Line width in the source image may be skipped - this value will be taken from Autotrace utility.



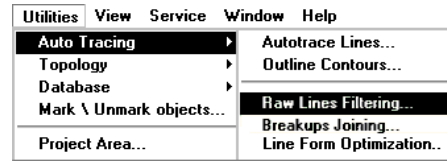
12. Click *Start*.

«Short-distance» breakup joining has eliminated most accidental defects in lines. The defects are usually caused by paper wear and errors of subject layer extraction from «overcompressed» images.

It's better not to avoid too big values of radius and small ones - of convergence angle, otherwise you may «sew» fragments of vectorized inscriptions and other «rubbish» to lines. It will take manual editing to separate them later...

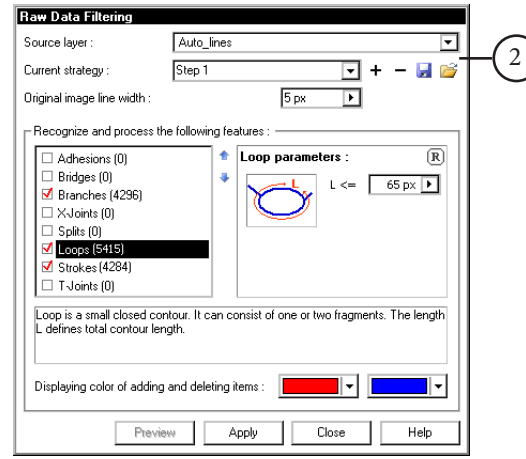
Next step - vector filtering of long («sewn together») line segments.

1. Delete obvious vector «rubbish» with the help of vector filtering. Select *Auto Tracing -> Raw Line Filtering* in *Utilities* menu.



2. Auto_lines remains the source vector layer.
   The object is to recognize lines of road network. Adjusted parameters of this operation are saved in the example as Step_1 strategy.It is enough to select it.

   Branches, Loops, and Strokes are defects to be corrected. They form small «rubbish» and vectorized inscriptions.



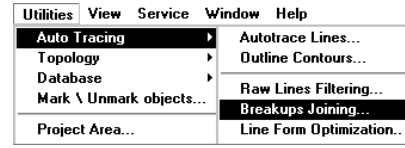
3. Click *Preview* to estimate quality of correction. To select better parameters, click the left button on examples of defects.

4. When parameter selection is over, click *Apply.*

5. Repeat items 3 and 4 several times in a row, until the utility find no defects any more.

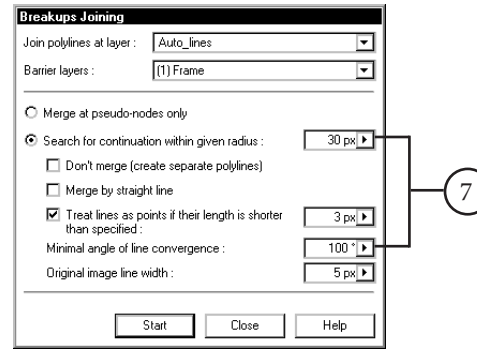
Parameter selection "in the screen" may cause unreasonably large capture of objects. Click (R) *button to reset parameters of the specific type and repeat selection of defect examples.*

6. Most of «rubbish» objects are delited. Probability of false joining has abruptly decreased. Fulfil the second breakup joining with longer radius and weaker restrictions on line convergence angle.



7. Increase search distance up to 30 pixels and allow line joining at minimal convergence angle equal to 100°.

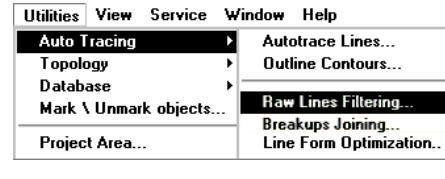
8. Click *Start*.



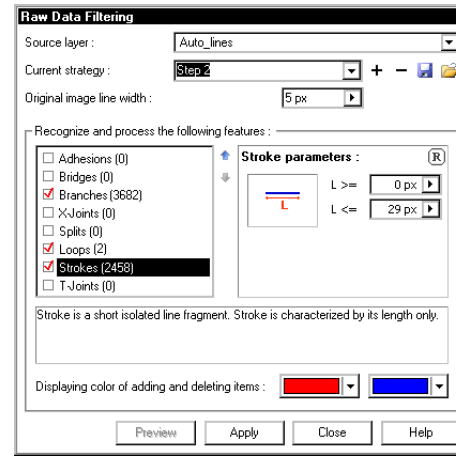
9. Most line segments are joined - they have become significantly longer. Probability of false recognition of defects at filtering has diminished.

   Fulfil the second line filtering with stricter parameters. In our example they are saved as *Step_2* strategy of filtering.

10. Click *Preview* to estimate quality of correction. Specify better parameters of defect selection if necessary and click *Apply*.

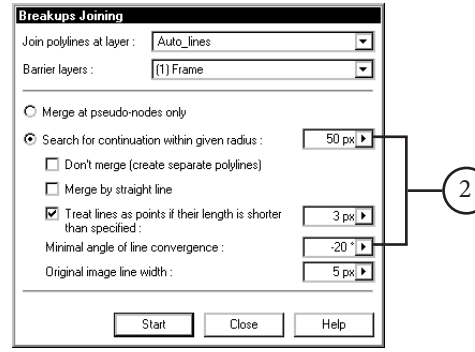


11. Repeat item 11 several times in a row, until the number of defects of any type becomes zero.



1. Fulfil final breakup joining with a big search radius and without any limitation of convergence angle. The object is to delete long gaps and assemble «rubbish» into large objects.

2. Make the radius of continuation search equal to 50 pixels at a negative convergence angle -20°.



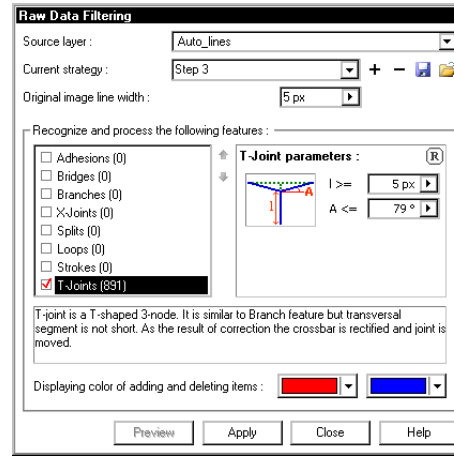
3. Click *Start*.

4. Correct the form of road lines at crossings.
Select *Auto Tracing -> Raw Line Filtering* in *Utilities* menu.

5. Apply *Step_3 strategy*. It corrects only defects of «T-joints» type.

6. Click *Preview* to estimate quality of correction. Improve parameters of defect selection if necessary.

7. Click *Apply*.



Correct remaining defects manually. Don't forget to use Inspector tool for regular check of the project field.

Deletion of vector «rubbish» and gross distortions of object shape should be done by Vector Eraser tool  *(Q hot-key).*

Simply erase spikes in lines, use «Red Eraser» (Shift key pressed) for deletion of irrelevant objects, and «Blue Eraser» (Ctrl key pressed) to cut objects up

Correct gross distortions of object shape with Camber Editor  *(hot-key 3).*

Apply Entity Editor  *(hot-key ~) in the Join Polylines mode (hot-key E) to repair gaps in lines. Joining will be arcwise if you keep Shift pressed when indicating the segment to*

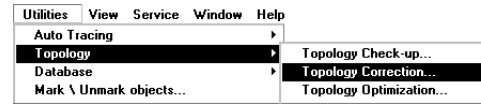
be sewn; otherwise it will be linear.

AVOID UNNECESSARY WORK!

Delete only SERIOUS defects. Small spikes and superfluous vertices will be deleted by Line Form Optimization utility.

It may be reasonable to make a copy of the vector layer, to treat it with Line Form Optimization utility, and then to compare vector lines of both layers to understand, WHAT KIND OF DEFECTS should be corrected manually.

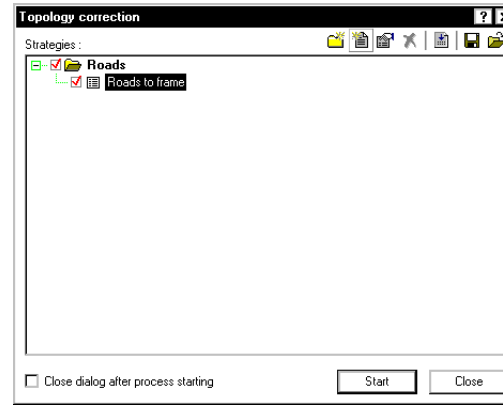
1. Select *Topology -> Topology Correction* in *Utilities* menu.



2. Select *Roads-to-frame* strategy of topology correction.

   The object is to pulls road lines to the map frame, i.e. ends of lines from the Auto_lines layer to the frame from the Frame layer.

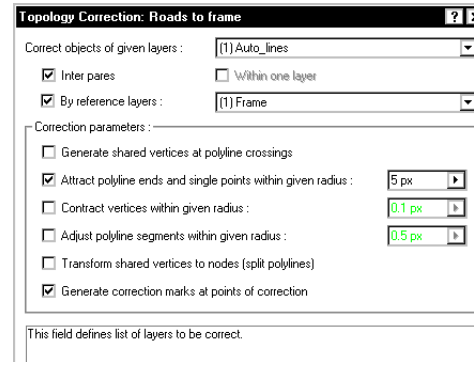
   Strategy parameters may be altered after you have clicked its name.



3. Click *Apply*.

4. Close the dialog box.

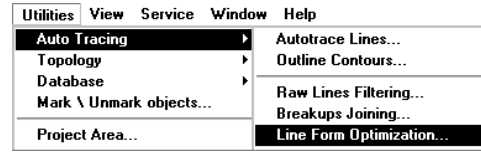
5. Review the near-frame zone and pull «hanging» lines' ends (if any) to the map frame
   Use F (next)/V(previous) hot-keys to move from one correction site to another.



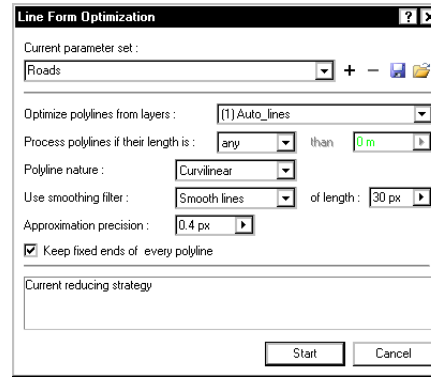
Only now we may get rid of superfluous vertices in «dense» lines. Effectiveness of Vector Eraser and exactness of line end pulling to frame will be far lower if you do it earlier.

It is easy to «brush off» a jut in a dense line with one stroke of Eraser, and Line Form Optimization utility will do the rest. But correction after optimization consists in transfer of individual vertices. It is MUCH LONGER...

1. Select *Auto Tracing -> Line Form Optimization* in *Utilities* menu.



2. Use *Roads set of parameters (strategy) or just specify their values* shown in the figure.



3. Click *Start*.

4. Estimate optimization quality

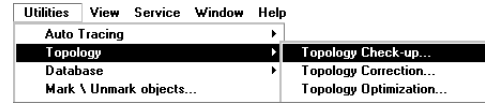
   Apply Undo if necessary, improve parameter values, and run the utility once more.

To make lines smoother, increase filter length but do not overdo it - too long filter can cut off sharp turns of lines.

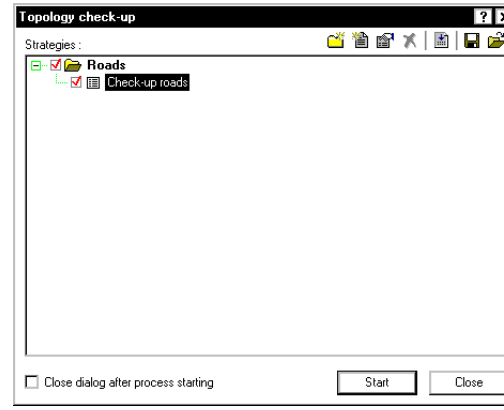
Density of vertices in lines and therefor exactness of raster line tracing depend on Approximation. Big value means small number of points and rough approximation.

ATTENTION! The utility should be applied ONLY ONCE. Repeated data processing with the utility causes gradual straightening of vector lines and their offset from raster ones.

1. Check structure of the road network. Select *Topology -> Topology Check-Up* in *Utilities* menu.



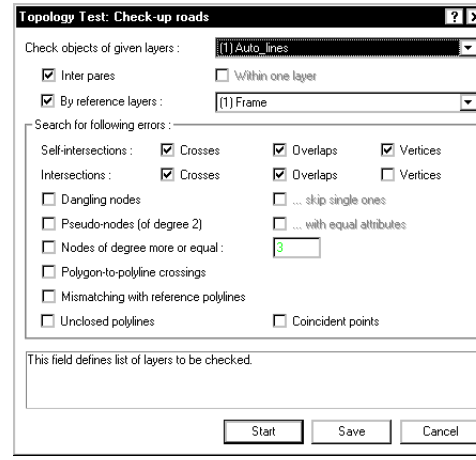
2. Select check-up strategy *Road Network* or specify parameters as shown in the figure.



3. Click *Start*. After check completion, the program opens a window with information about revealed errors.

4. Close the window.

5. The working window shifts automatically to the first found error and the error mark becomes current.
   Delete the mark with *Del* key - the object it concerned to becomes current (selected).



6. Use F (next)/V(previous) hot-keys to move from one error to another.

7. When all errors are corrected, repeat items 1 - 7 until you see the message «No errors found».

Attribute data input, road linking to other objects and other operations remained outside the example. But hopefully you have already grasped basic principles of automatic vectorizing.

Don't be afraid to experiment with utilities - they work fast, and Undo button is ready to cancel an unsuccessful result.