As-Built
for AutoCAD® Software

Photogrammetry Tools

Manual
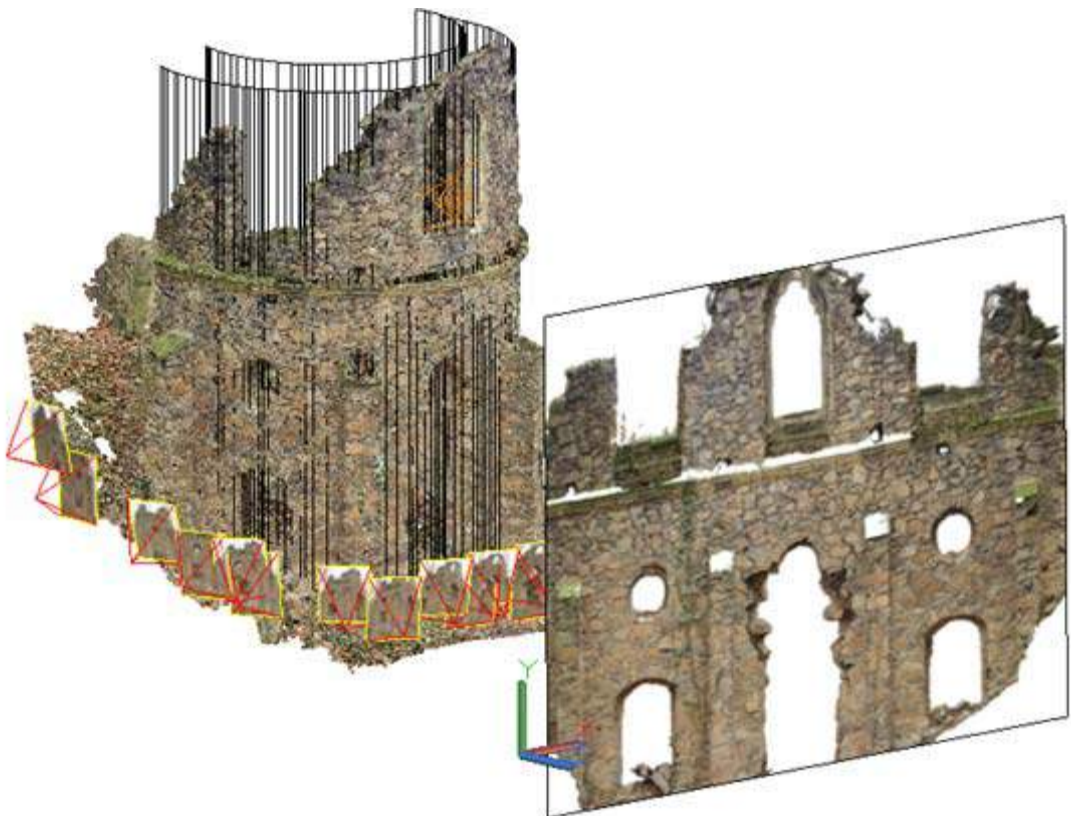
FARO

SYNERGY
POSITIONING SYSTEMS

As-Built Photo 2018.0

As at May 2018

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A few Words concerning this Manual

Dear users,

We would like to thank you for the trust you put into us and wish you much success in the daily work with our software.

This manual is part of the As-Built for AutoCAD user documentation. **Please refer to the As-Built manual for installation and system requirements.**

In order to give you an optimal introduction to the operation of the photogrammetry tools this manual contains two examples that will lead you step by step through a rectification project. Tutorial 1 and 2 in section **3 Getting Started – Image Rectification**are intended to give you a first impression of how it works. Tutorial 3 in section **4 Image Rectification** helps you to become acquainted with the most important details of the single commands and enables you to process own projects. Therefore we recommend that you first read these sections carefully.

Chapter **5 Working with** gives you an insight into the functions of image orientation as well as the three-dimensional single and multiple image evaluation. Unwinding photos of cylindrical and other objects into a plane and the generation of orthophotos are also possible (see chapter **6 Unwrapped images and more**).

Please feel free to take advantage of our support in case of any questions and problems. We are grateful for any queries and suggestions. A system like As-Built depends on the ideas and creativity of its users.

Content

1   What Can Photogrammetry Tools Do?

The tools described in this manual are used for photogrammetric image processing directly in AutoCAD. They enable the true-to-scale rectification of digital photographs, maps and plans as well as their subsequent interpretation and evaluation. Facade photographs, pictures of wall and ceiling paintings or floors can be processed, but also old maps and plan material can be brought back into a true-to-scale form. The results are true-to-scale image plans that combine photographic condition documentation with precise geometric information.

Other tools allow you to orientate photos by means of control points and to use these oriented photos for both 2D and 3D image evaluation. Photos of non-planar facades can be processed into true to length image plans. This creates three-dimensional models or 2D image plans.

Reference information of the depicted object is required for image rectification. Depending on the kind of this reference data, there are three different approaches: rectification according to control points, map rectification according to control points and photo rectification according to geometry.

For the **rectification according to control points** the reference information is obtained through at least four control points. They are marked on the measured object so they can be identified unambiguously in the image. They should lie almost in one plane (the so-called rectification plane). Their co-ordinates are defined with the help of geodetic methods, e.g. with a total station. During the rectification process these points are assigned to the image. With the help of this information the image can be transformed (rectified) arithmetically. The result is an image in which all the features that lie on or close to the rectification plane are displayed true to scale.

In addition to this the image will be positioned exactly above the control points in AutoCAD. The rectified image will thus be in a 1:1 scale at the position of the photographed object. When you print the image you may of course select a scale of your choice.

The reference information for **map rectification according to control points** is also taken through control points. Depending on the type of (polynomial) rectification, at least three, six or ten control points are necessary. Your coordinates are either determined by geodetic methods or result from the grid of a given map. Within the rectification process these points are matched with the distorted map. With the help of this information, the map can then be rectified. The result is a map or plan that is to a very large degree conformal with the used control points.

For the **Photo rectification according to geometry** you work with reference measurements and use known object geometries. The typical measured objects like facades, floors or paintings almost always contain lines that are orthogonal to each other. This knowledge is used to determine the projective distortion. A 'rectification grid' will be put over the image which the user will adapt visually into the image according to the distortion. Additionally three reference measurements must be taken on the object for which simple means of measuring like a tape measure or a hand-held laser will be sufficient. These lines will also be assigned to the distorted image. With the help of this information the image can be rectified. The result is a true to scale image plan as well from which geometrical data of the measured object may be taken.

For the for the photogrammetric evaluation **(Image modeling), the unwinding of images** and **the generation of orthophotos** oriented photos are needed.

Control points are necessary for the **image orientation**. The number of points depends on the fact, if the camera parameters (focal distance, photo centre, distortion, etc.) are already known, or if those have also to be calculated from the control points. The control points are marked on the measuring object, so they are clearly identifiable within the image. Spatially they should be well spread. Their coordinates are determined with geodetic methods. During the image orientation process the control points are assigned to the according image points. With the help of this assignment the photo can be oriented via a complex algorithm. The result is a photo, whose centre of projection as well as position and orientation within space is known. The oriented image is placed at exactly the position of the camera at the moment of the shot with viewing direction to the photographed object.

There are two ways to draw three-dimensional in AutoCAD when using oriented images.

When **drawing 3D with one oriented image** a surface (e.g. plane or cylinder) has to be selected, additionally to the image. On that surface may be drawn with the help of the photo. The optical ray (image ray) of the point clicked within the photo is spatially joined with the selected surface. This way the points of the three-dimensional drawing elements are generated.

When **drawing with multiple oriented images (Image modeling)** AutoCAD viewports are opened after selection of the images to be used. Within those the corresponding points are clicked one after another within every image. The three-dimensional coordinate of the corresponding object point is generated through the spatial join of the image rays.

The result is a three-dimensional model from which geometric information of the photographed object can be gathered. By means of multiple image evaluation also plans can be produced in a fast and efficient way (see chapter 5.5).

For the **unwinding** of photos of cylindrical or prismatic objects at least one oriented photo and the surface to be unwound are needed. It is then possible to draw to scale on the photo unwound into the plane. That way 2D-plans of towers, columns, arches and many more can be generated.

Orthophotos are generated by help of oriented images and surface information (planes, cylinders, meshes, etc.). This way central projective distortions will be eliminated. Object edges and areas which are parallel to the projection plane will be mapped according to scale.

2   Supported Image Formats

The As-Built for AutoCAD can import and display a number of different image formats:
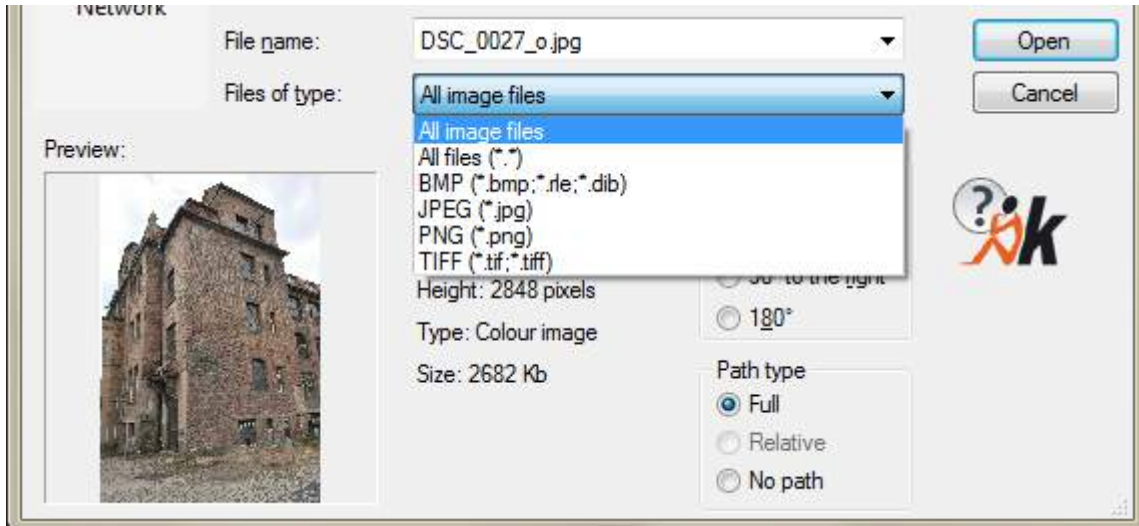
If your images are neither BMP, JPEG, PNG or TIFF, please select 'All files' and try if your image format is supported.

When saving or creating images the format selection is limited to BMP, JPEG, PNG and TIFF. In AutoCAD these image formats have following properties.

BMP	No compression, max. 2GB file size, imprecise image size information
JPG/JPEG	For grey scale and color images only, lossy compression, imprecise image size information, max. 2GB file size
PNG	For grey scale and color images, lossless compression, any file size, correct image size information
TIF/TIFF	All types of images (including bitonal), lossless compression, transparent areas, max. 2GB file size, correct image size information

Which image type is suitable for which application?

Bitonal images (b/w or **one** color and white) e.g. scanned plans: TIFF

Merged images of bitonal images with transparency: TIFF

Images of digital cameras: JPEG; for high quality: TIFF

Large aerial photos: PNG (> 2GB), else TIFF (< 2GB)

Conclusion: TIF/TIFF is the format we suggest for almost all applications. If you create or work with huge images files, PNG would be the format of choice.

3   Getting Started – Image Rectification

This section introduces you to the imkage rectification with the help of a simple example. But we will not take into consideration all the subtleties here. Many points will be explained more closely in the sections to come. A thorough description of all commands can be found in section **7 Command Reference**.

We recommend that you follow the following practical examples Tutorial 1 and Tutorial 2 step by step in order to get a first impression of the opportunities. The Tutorial 1 describes the procedure of the rectification according to control points, Tutorial 2 the rectification according to the geometry.

3.1   Preparation

For processing the examples a completely installed version of AutoCAD (LT) 2015-2018 is required in which As-Built for AutoCAD has to be included.

3.2   Tutorial 1 – Your first photo rectification according to control points

Preparation

Choose menu point 'As-Built Photo – Help – Open Tutorial 1' in AutoCAD. The drawing TUTORIAL1.DWG will then be opened. The drawing is saved on your computer in the user data directory. The path varies depending on the operating system. The fastest way to access the user data directory is to run the command 'As-Built Modeler – Help – About...'. There the path is shown and via a button you may open a Windows Explorer for this folder.
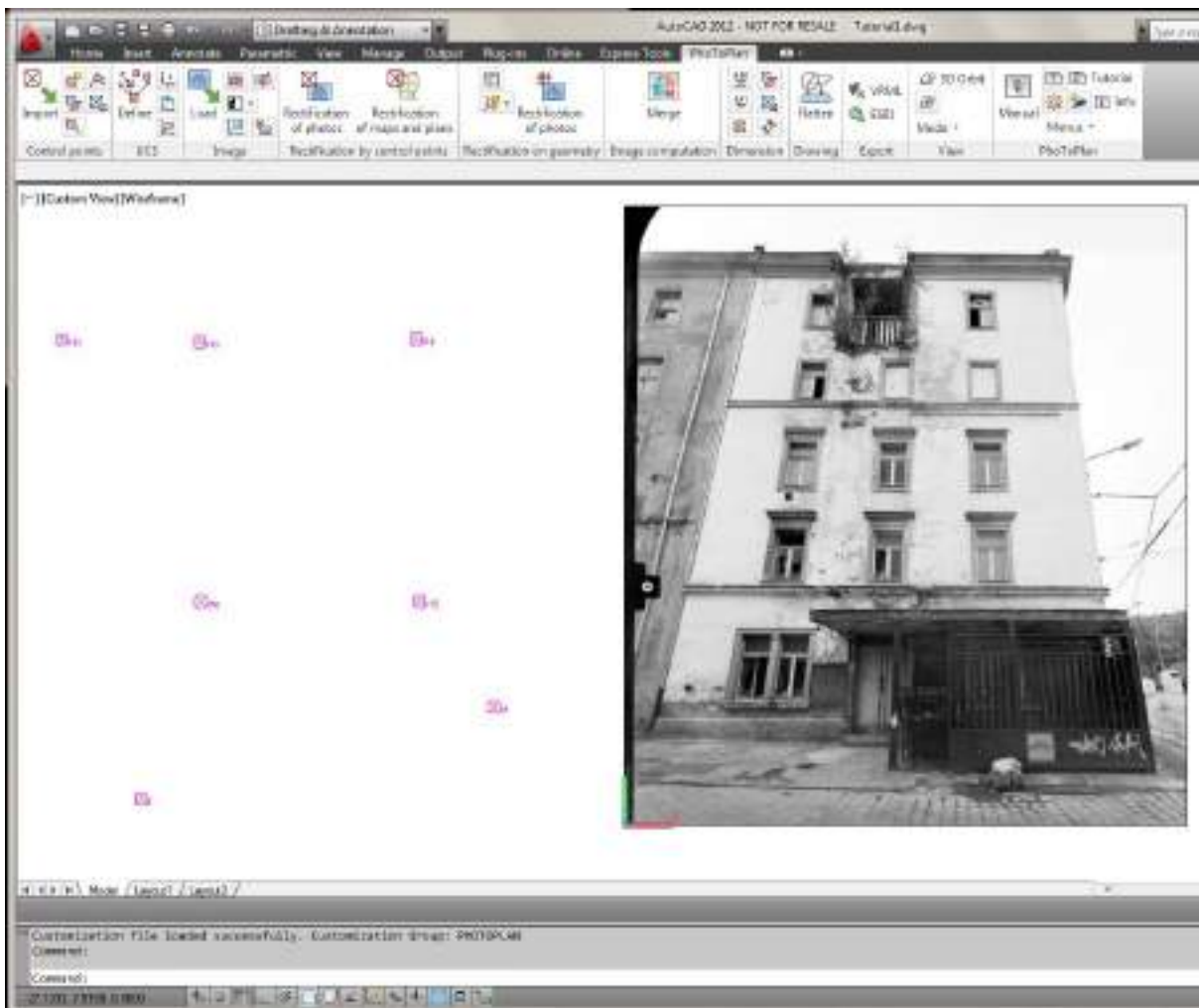
In this drawing you see the measured control points as well as the image to be rectified. In order to present a fast and easy tutorial, this file has been set up and prepared.

The control points serve as reference information. They have three-dimensional co-ordinates and a number for unambiguous identification. They were previously measured in with geodetic procedures and imported into AutoCAD. The rectification plane (UCS) has been defined, using the control points. The image to be rectified is already loaded so you can start at once. You will find a detailed description of the complete rectification process in section **4.1 Photo Rectification according to Control Points**.

From the 'As-Built Photo' ribbon tab in the group 'Rectification by control points' choose 'Rectification of photos' . This opens the following dialogue.
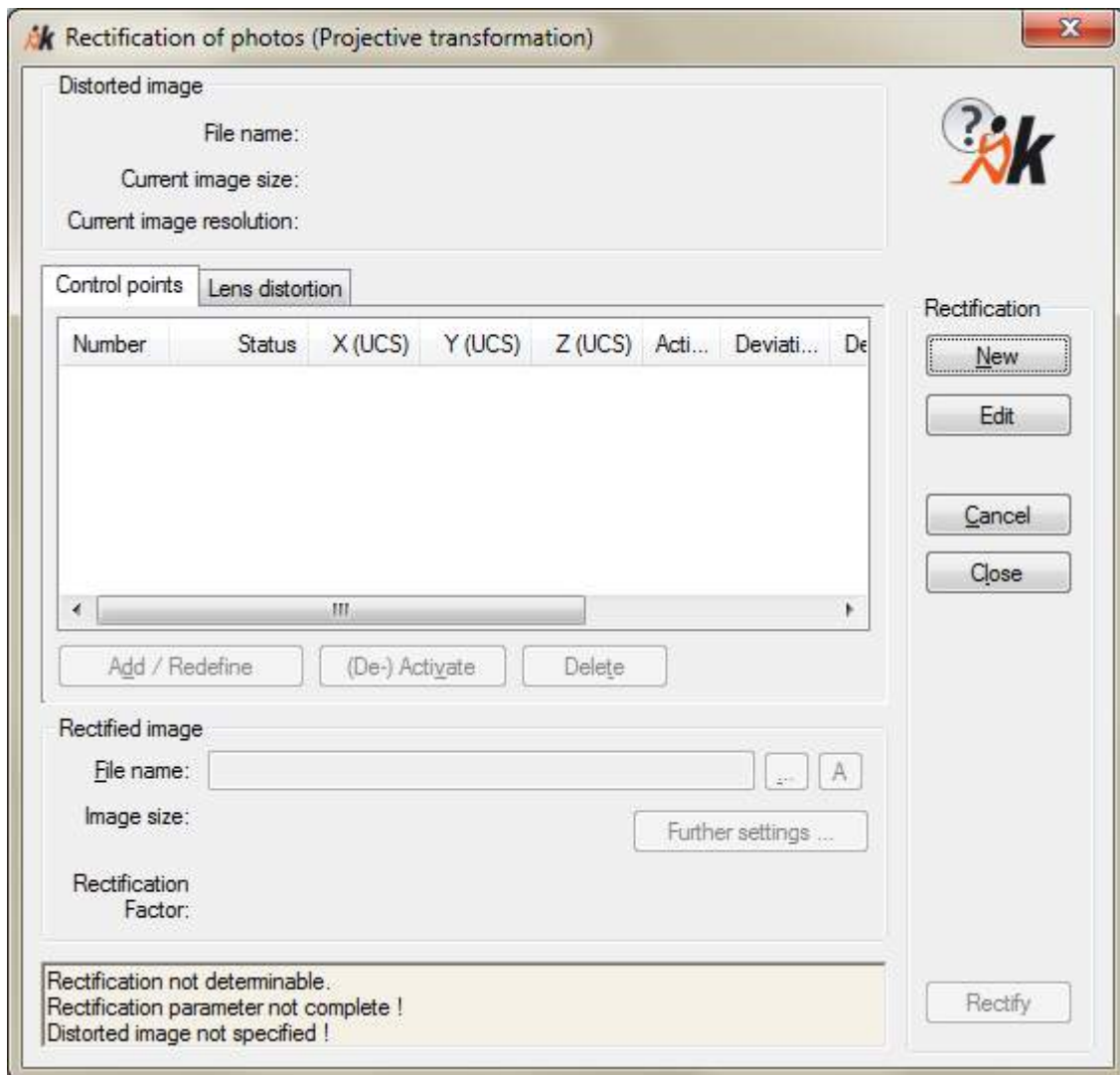
From here the rectification process will be controlled.

First select the image to be rectified. In order to do so click on the button [New]. The dialogue will disappear and via the AutoCAD-command line you are asked to select the image. Click with the mouse on the periphery of the image. After that the dialogue window will re-appear.

In the next step the control point information must be linked to the image to be rectified. This means that a corresponding image point will be assigned to each relevant control point. The resulting pairs of points will then appear in the control point list in the dialogue.

For the control points to be measured in, tags were attached in some places to the building's facade. Easily identifiable features like for example window corners serve as control points as well. The position of each of the control points can be seen in the sketch below.
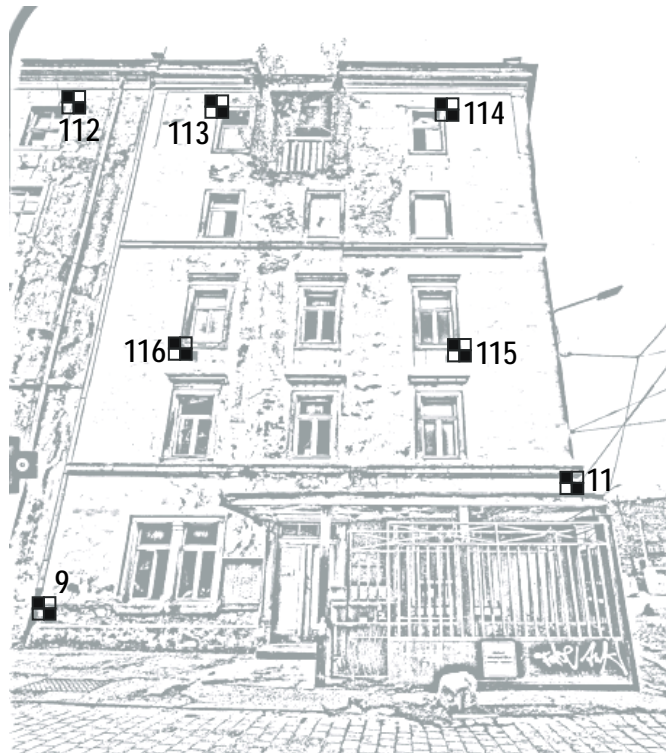
Assigning the Image Points

First assign the control point no. 11. In order to do so click in the frame 'Control Points" on the left-hand side of the dialogue window on **Add/Redefine**. Again the dialogue will disappear and you are asked in the AutoCAD-command line to select a control point.

> Choose control point or [Number/Measure/Finish] <Finish>:

You may pick it directly from the drawing with the mouse or enter its number. In order to do the first just click on the corresponding control point symbol with the number 11. In order to do the latter select the option 'Number" pressing the Enter key. After that the call appears:

> Number of control point or finish with ESC <Choose control point>:

Enter '11' here and confirm with the Enter key.

Now the call to select a zoom region appears:

> First Point for Zoom Region or <Cancel>:
>
> Second point for zoom region or <Cancel>:

Move the mouse cursor into the image and mark a zoom region around the control point tag '11'. If you have selected the correct region the measuring tag is clearly visible. Now you are asked to measure the corresponding point in the image:

> Image point for control point 11 or <Cancel>:

Click on the tag in the image as exactly in the centre as possible. Possibly you have to zoom in even closer first. In order to do so you may use the AutoCAD-zoom function. It may be called up transparently, without cancelling the process of measuring the control points.
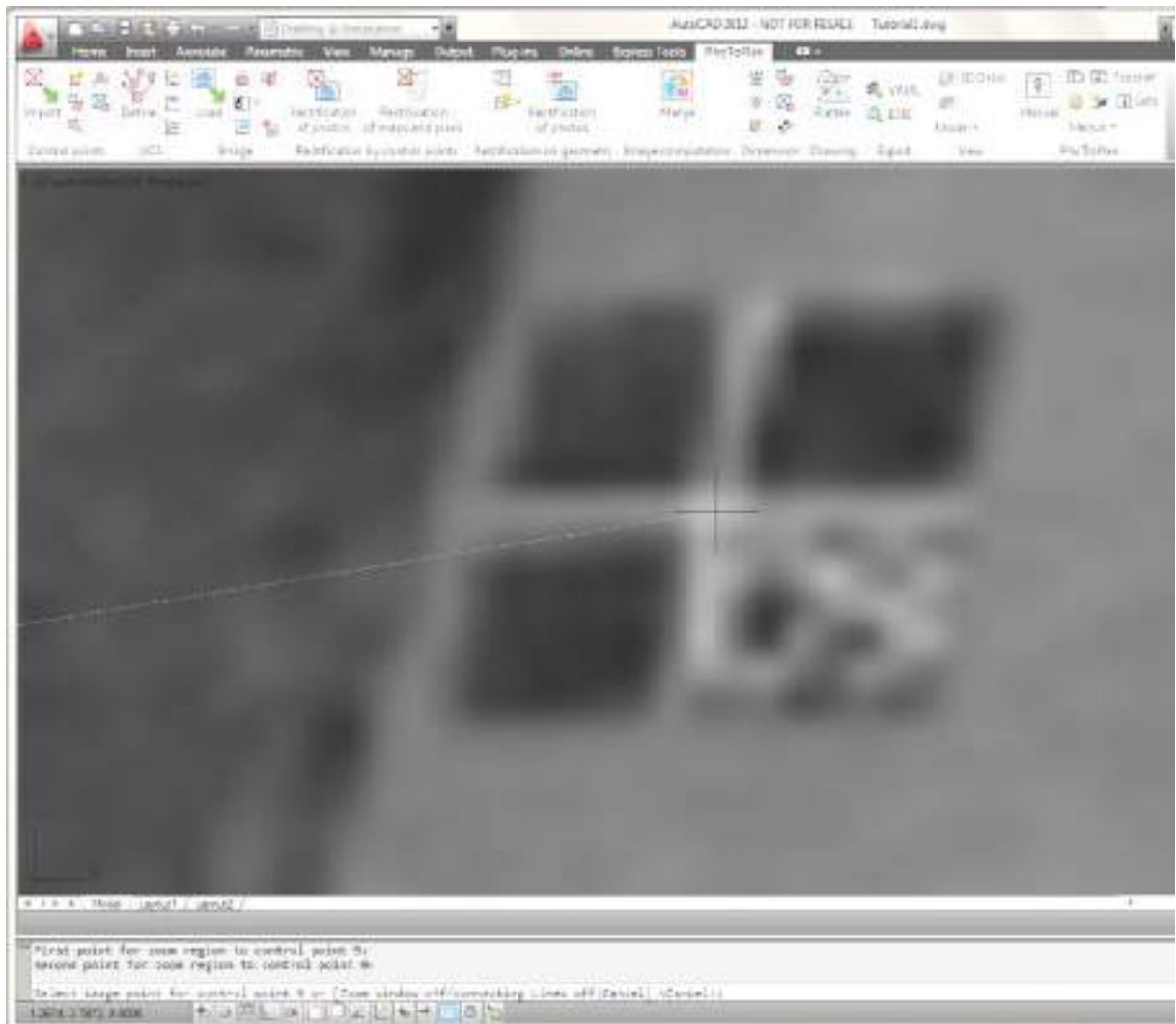
The measured point is marked with a cross and numbered. At the same time you zoom back to the last view. You will see that the control point has been connected with the measured point in the image by a line. This line serves for clarity and better orientation during the measuring.

According to this scheme you have to measure in six more points. In the command line you are already asked for a new control point. Again use the sketch to find the position of the points on the facade. Point 9 is a control point tag, points 112 to 116 are natural points. Here the outer corners of the stone window frames were measured in as control points.
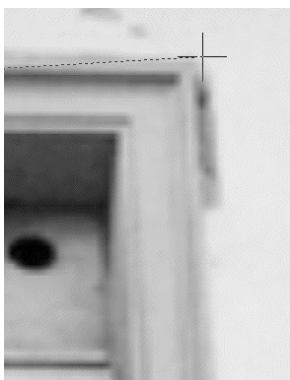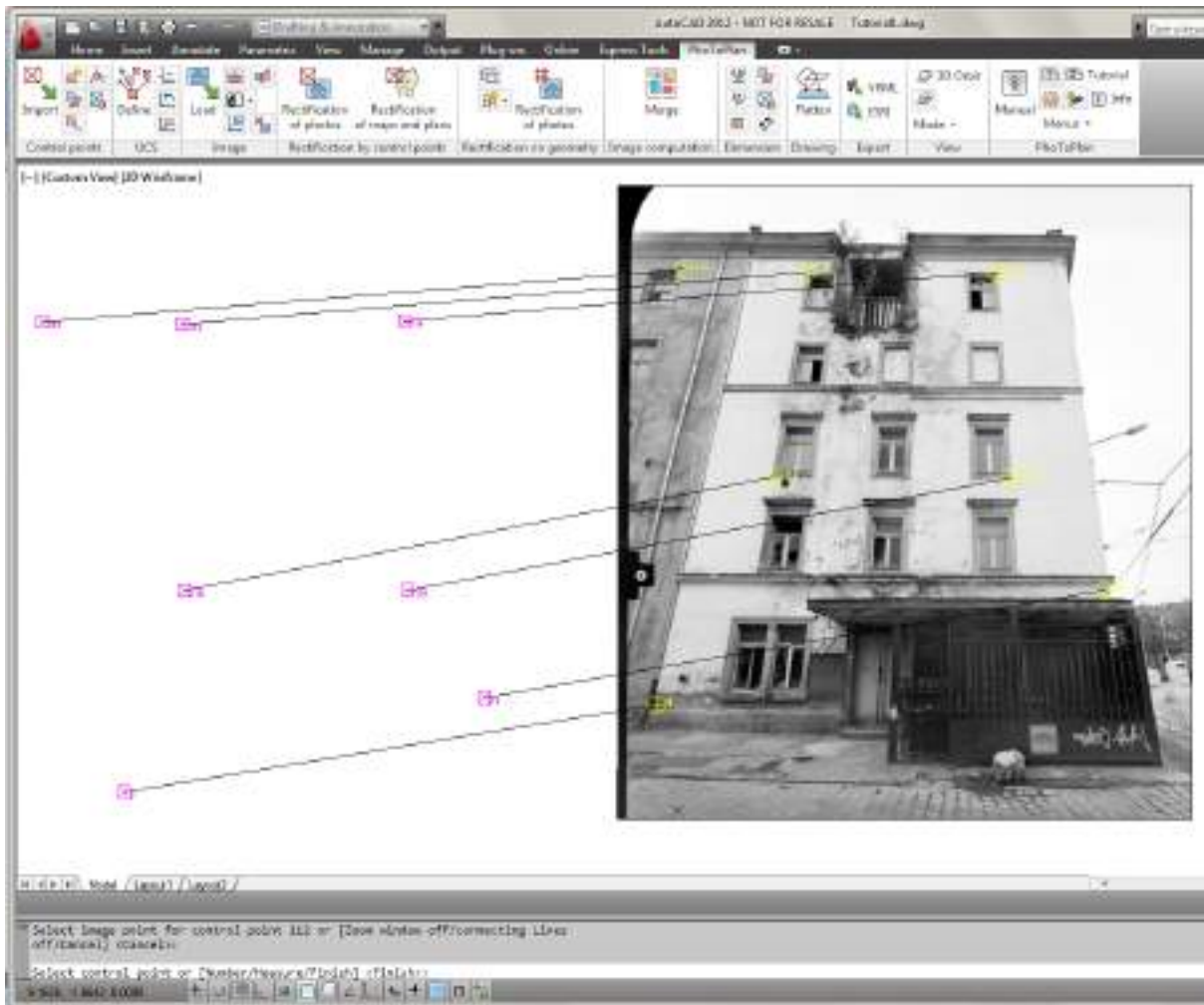
Calculating the Rectification Parameters

When you have measured in all control points enter 'F' for 'Finish' in the command line and confirm with the Enter key. Now you will see your measured points listed in a chart. Since you have measured more than four control points, the rectification problem is over-determined. The software carries out a least-square adjustment and calculates error values (standard deviation). With the help of these values you may recognize how well the measured image points 'fit together' with the control point coordinates. In order to carry out a high-quality rectification the values have to be as small as possible. For this example, 0.01 to 0.02 m should be a guideline. Right now this estimated value will be sufficient, you will find a closer explanation and the background of the exactness of the rectification in section **4.1.2 The Rectification Process** under '**5. Step – Calculation and Exactness of the Rectification**'. If the error values are higher, that means an error or an inaccuracy during the assignment of the image points. In order to locate the source of the error you may take single points out of the calculation. In order to do so mark the relevant point with a click on the point number and then click on the button [**(De)activate**]. If the error values suddenly shrink to an acceptable value just repeat the image assignment for this point. With [**Add/Redefine**] you will return to the drawing to do so.

The Rectification

Finally you still have to choose the name under which the rectified image is to be stored. The lower part of the dialogue serves for this purpose. With **[…]** you will come to a relevant selection window for the storage path. You will find a detailed description about saving image data and the different path options in the command reference under →**Image - Load image**.

Now there is enough information to carry out the rectification.
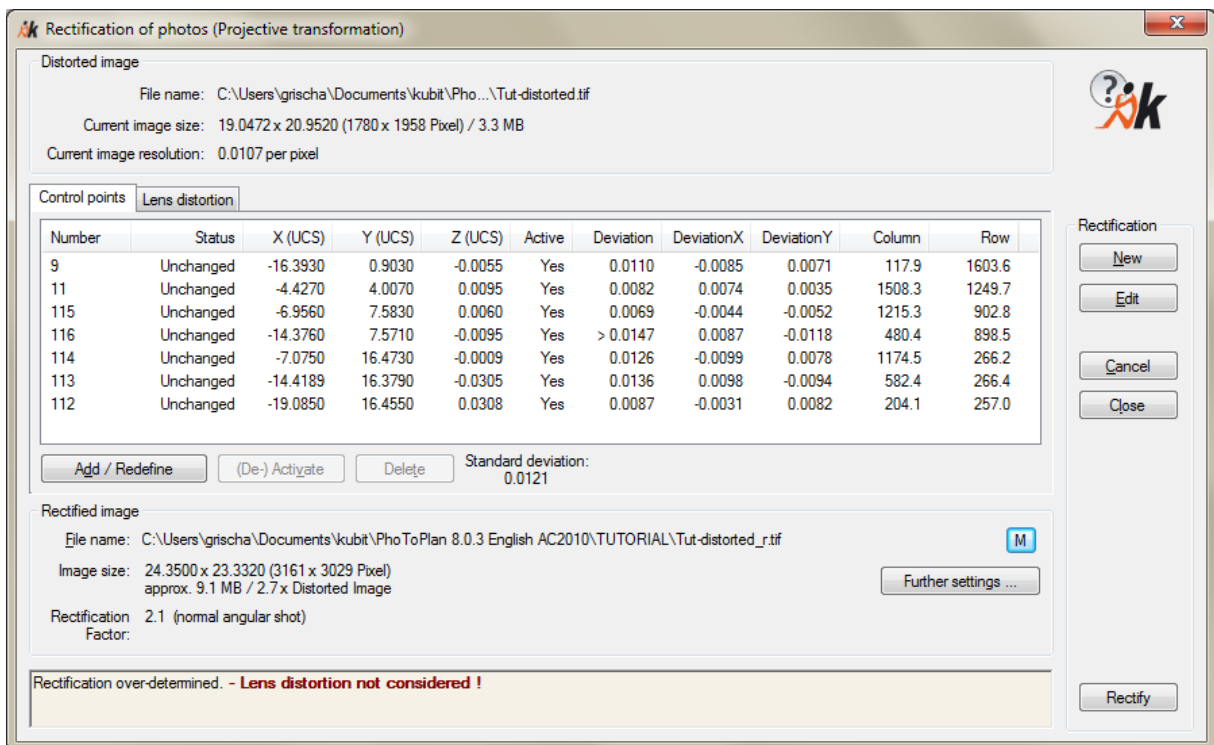
Start the process with [**Rectify**]. In the status line of AutoCAD you may follow the run with the help of a display of the progress. As the complete image has to be calculated anew the rectification will take a few moments.

After the completion of the process you may view the rectified image. You will see that the formerly slanted lines of the facade are now parallel and the measured image points are congruent with the control points. You may now take measurements directly from the image with AutoCAD that correspond to the measurements of the original object. For example the width of the upper right-hand side window measures 1.22 m from outer edge to outer edge.
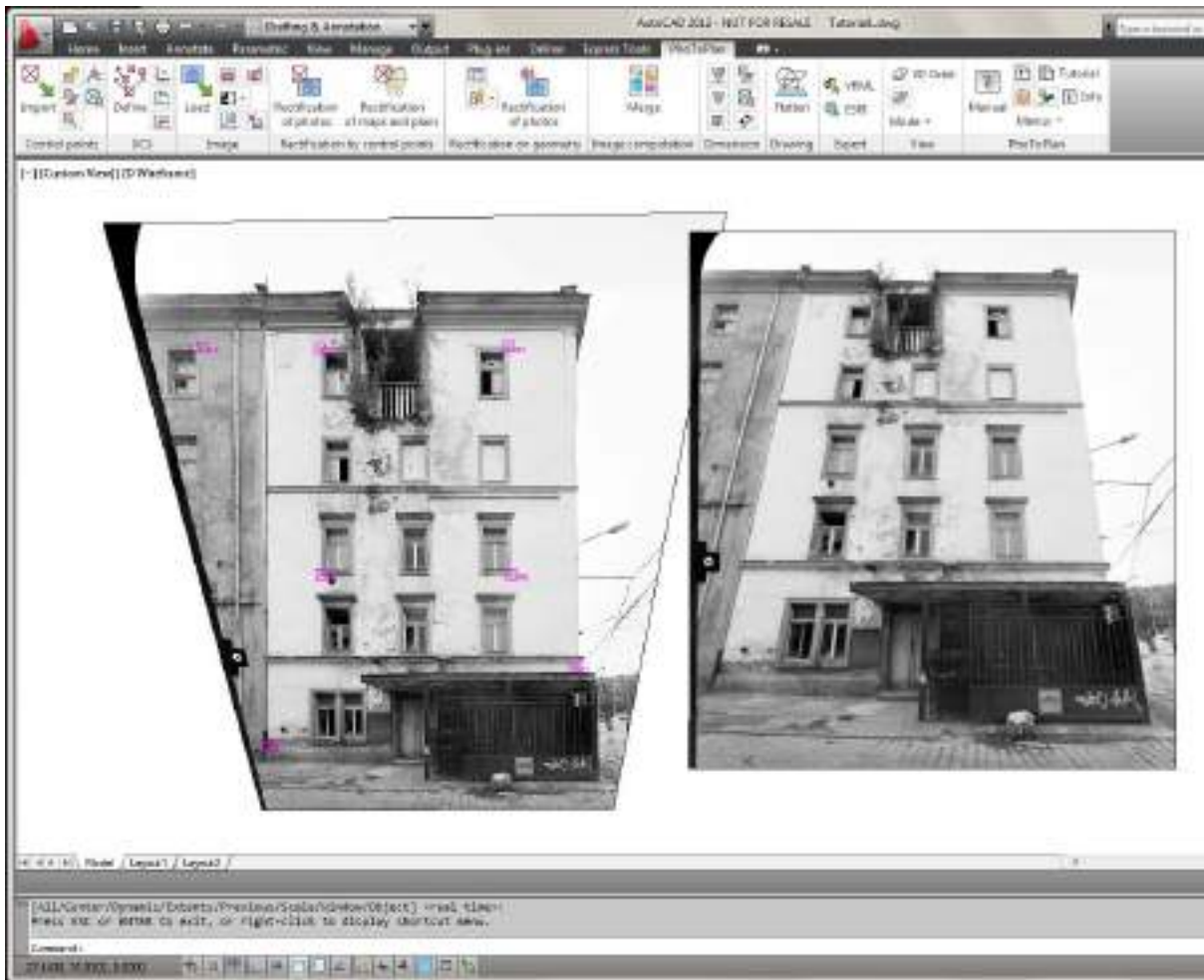
The photo, used in this tutorial, has been taken with a photogrammetric camera and is therefore free of distortions. In contrary, photos, which have been taken with a regular digital camera have, depending on the quality of the lens, more or less distortions. Therefore As-Built offers the possibility to determine the distortion and to correct it during the rectification. You will find detailed information regarding the distortion correction in the command reference under →Rectification according to geometry - Correction of lens distortion. On page 7-34 is explained, how to determine and correct the lens distortion parallel to the rectification process.

3.3   Tutorial 2 – Your first Rectification according to Geometry

In AutoCAD select 'As-Built Photo – Help – Open Tutorial 2' from the Menu. The drawing TUTORIAL2.DWG will be opened. This drawing is saved on your computer in the user data directory. The path varies depending on the operating system. The fastest way to access the user data directory is to run the command 'As-Built Modeler – Help – About...'. There the path is shown and via a button you may open a Windows Explorer for this folder.
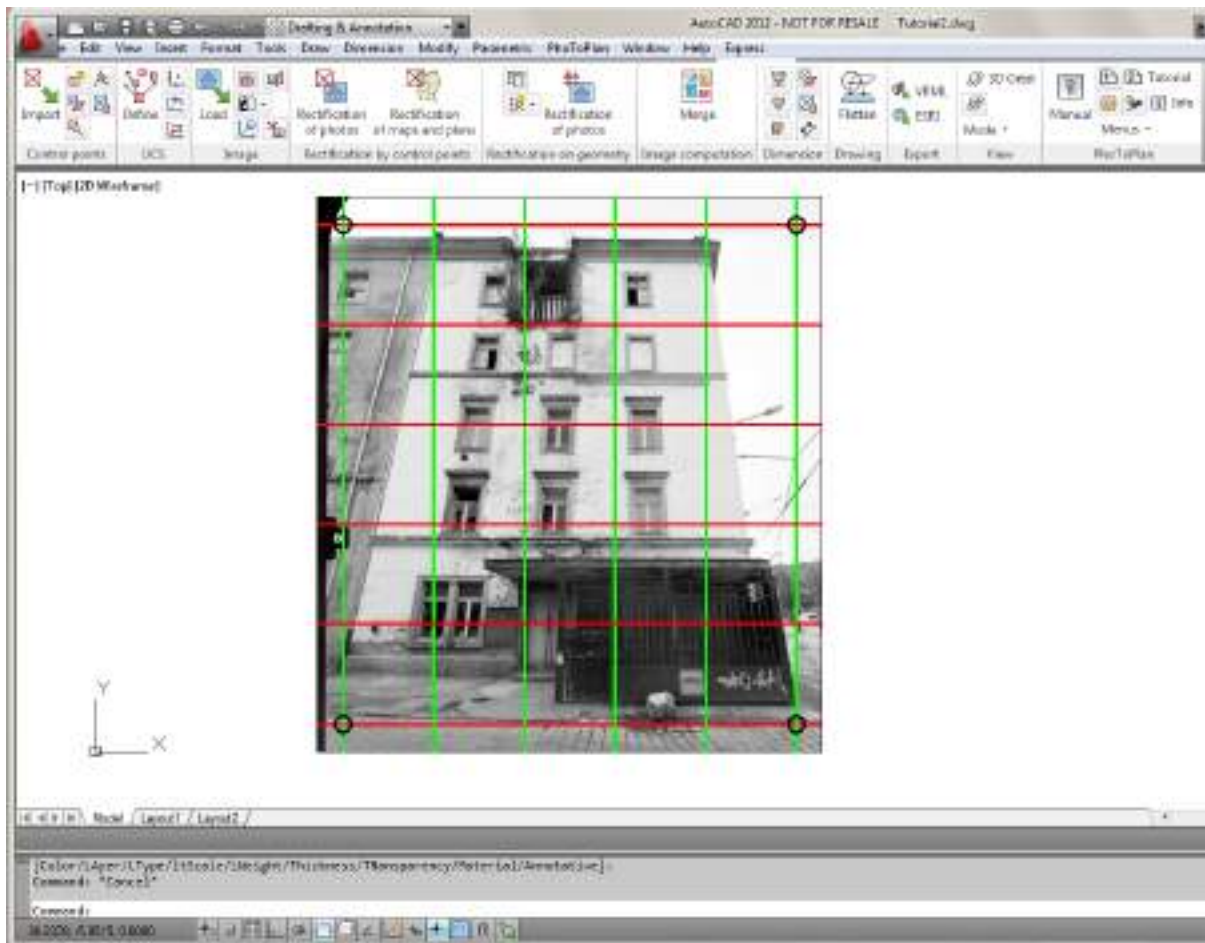
In this drawing you see a distorted photography. A rectangular grid, the so-called rectification grid, has been laid over it. In order to present a fast and uncomplicated result this file has been prepared for you. A detailed description is of the complete rectification process is to be found in section **4.6 Photo Rectification according to Reference Measurements and Object Geometry.**

In the first step you have to **adapt the rectification grid**, in order to give the program necessary information on distortion in the image. The horizontal and vertical grid lines are brought in congruence with the horizontal and vertical lines of the facade on the distorted image. In order to do so mark the grid with a click on one of the grid lines. The blue boxes that will then appear everywhere on the grid are so-called 'grips" with which the grid may be 'gripped' and altered.

Rough Grid Adaptation

At the points of intersection of the outer grid lines the **main grid points** are located, emphasized by circles. Click on one of these points and move it with the mouse. The whole grid is now altered in its geometry. With a further click the main grid point is positioned anew.

Firstly adapt all four main grid points roughly in a way that the grid lines are congruent on the right-hand and left-hand with the edges of the building, at the bottom with the ledge between the first and the second row of windows and at the top with the ledge between the third and the fourth row of windows.
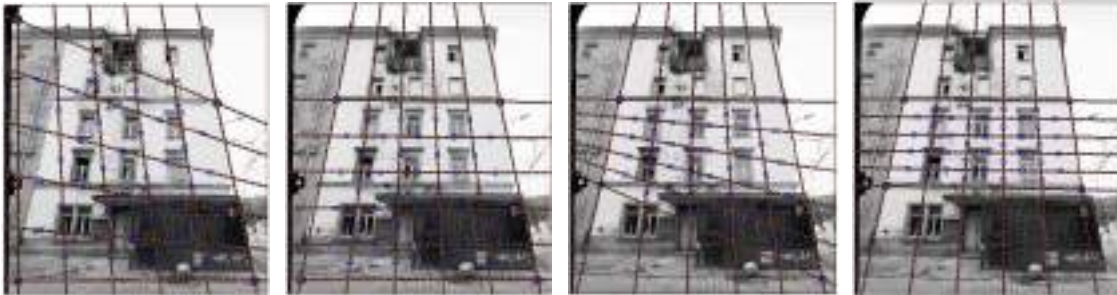
Fine Grid Adaptation

The inner grid lines are auxiliary lines. They have grips between the intersection points with which they can be gripped and moved. Use the auxiliary lines moving them so that they lie at the window edges in vertical and horizontal direction and at the ground floor ledge as well. In that way you can see better how well the grid is already adapted. During the following fine adaptation of the grid (again by moving the main grid points) you try to bring the building's edges in congruence as precisely as possible with the grid lines. This is an iterative process, you will need more than one run. Use the AutoCAD functions 'Zoom' and 'Pan' to zoom into the image and to move the visible section of the image, respectively. These commands may be called up transparently without cancelling the process of the grid adaptation.
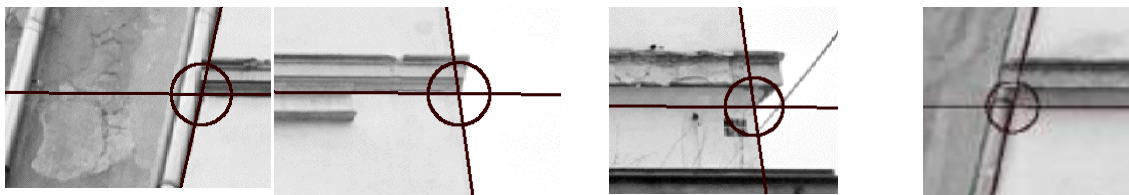
top left-hand side   top right-hand side   bottom right-hand side   bottom left-hand side

The completely adapted grid should approximately look like this in the end:
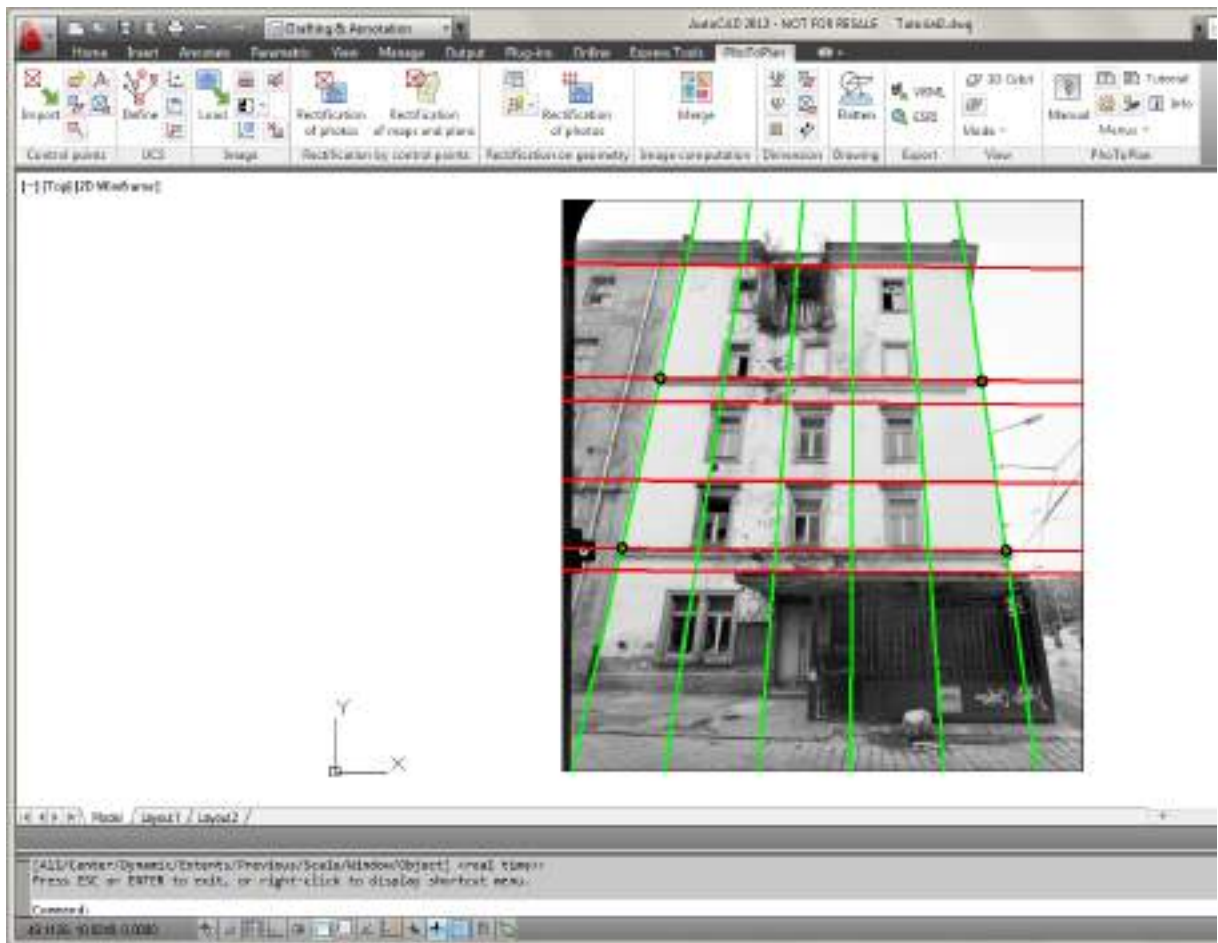
In the next step go to the '**Rectification on geometry**' group on the 'As-Built Photo' ribbon tab and select the entry '**Rectification of Photos**' [icon]. A corresponding dialogue window will open up.
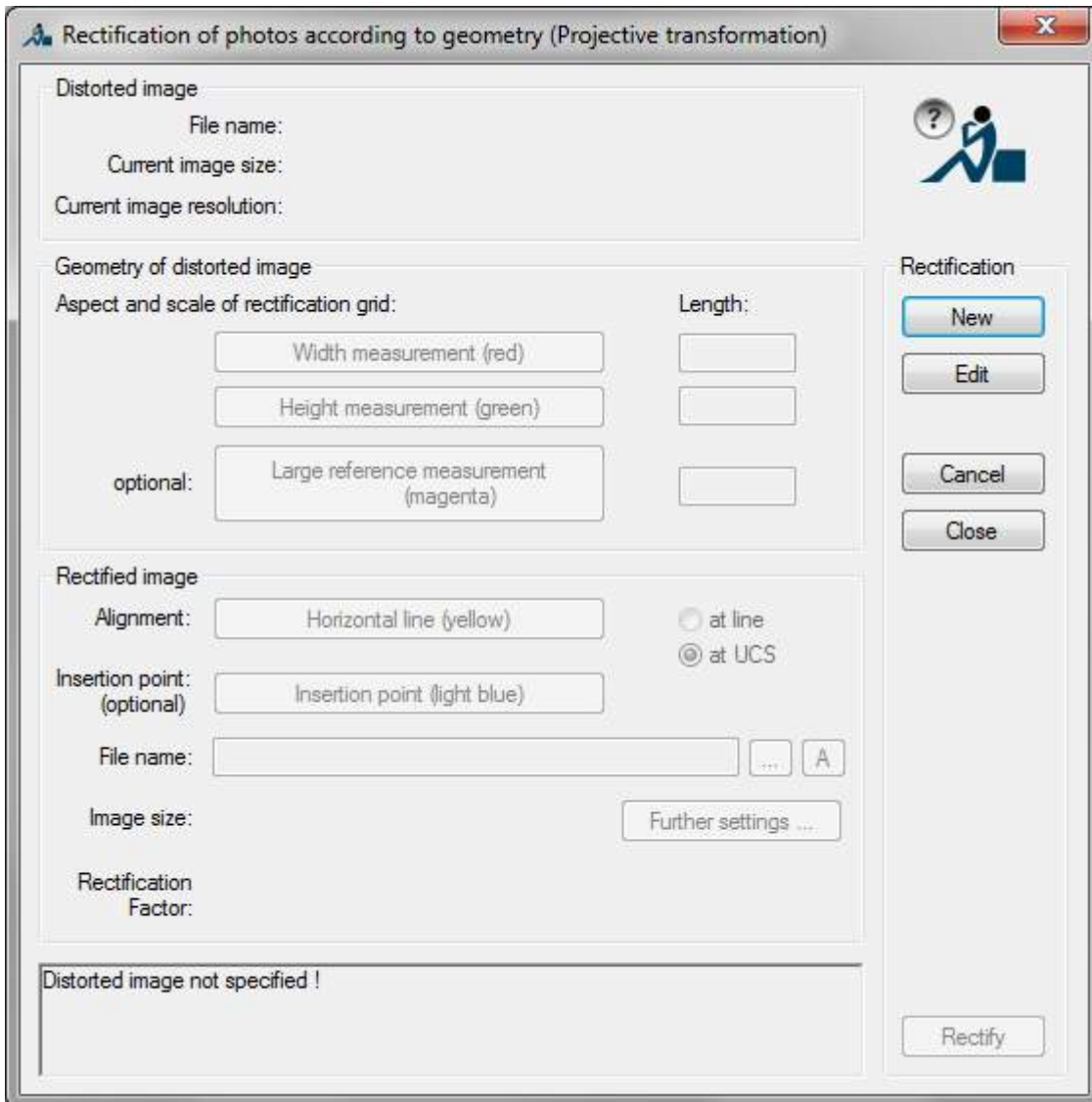
From here the rectification process will be controlled.

First you have to select the image to be rectified. In order to do so click on the button [**New**]. The dialogue will disappear and via the AutoCAD command line you are asked to select the image. Click with the mouse on the periphery of the image. After that the dialogue window will re-appear.

Reference measurements were previously taken at the facade as reference information. Two of these reference measurements run exactly in horizontal and vertical directions, respectively, on the facade i.e. along the directions of the adapted grid lines. Measured were headroom and width of a window. The third line runs diagonally across the complete facade. The distance between two window corners was measured.

These reference information have to be brought in connection to the distorted image i.e. the reference measures are drawn into the image and the measured values assigned.

The position of the single reference measurements and the measured values may be taken from the sketch below. The lines were always measured beginning from the outer window corners.
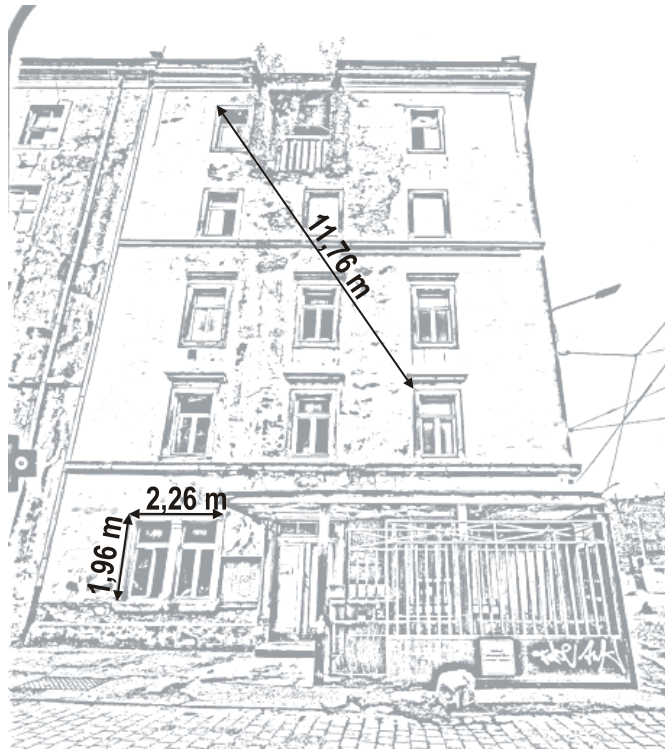
Assigning the Reference Measurements

In the dialogue window you will now see red question marks in all the places where you have to enter information.

First you will be ask for a width and height measurement. Here you have to enter the horizontal and vertical reference measurements (headroom and width of the window). Click on the button **Width measurement (red)** to draw the first line into the distorted image. The dialogue will disappear and in the AutoCAD-command line the following call will appear:

> First point for zoom region or <Cancel>:

Next click to the starting point of the first reference measurement. Now you are asked:

> Second point for zoom region or <Cancel>:

Open a zoom window with the mouse and confirm it with a click. In the command line you will see:

> First point for width measurement:

Click as exactly as possible on the starting point of the window's width. The program will automatically zoom back into the last view. The final point of the line is marked in the same way: first zoom with two mouse clicks to the relevant spot than click the position. You will notice that the red line can only be drawn in the direction of the horizontal grid lines. If you are therefore not able to hit the final point exactly, the rectification grid has not yet been adapted optimally. In this case leave the dialogue with [Close], correct the grid and repeat the process.

Back in the dialogue field you will now see a green hook instead of the first question mark. Enter the corresponding measured value into the field 'Length', in this case 2.26 m.

For the **Height measurement (green) do** exactly the same. It is marked in the image by a green line. The measured value is 1.96 m.

For the third reference measurement click on **Large reference measurement (magenta)**. Unlike the first two reference measures the alignment of this line can be chosen at random. The procedure for entering it is the same, the measured line value equals 11.76 m.

In the frame 'rectified image' you have to enter a few values concerning the result image.

For the alignment of the image first accept the default 'at UCS'.

With 'Insertion Point' you define at which place the rectified image is to be inserted. You have to enter a reference point in the distorted image and assign it to a randomly chosen point in the drawing. In order to do so click on **Insertion point (light blue)**. First zoom with two mouse clicks to a spot in the distorted image and click a point that serves as reference point. For example use the top left-hand side corner of the window on the ground floor. Next you have to click a zoom region for the insert point of the rectified image. Select a randomly chosen point beside the distorted image. Reference and insert point will be marked and connected by a light blue line.

The definition of an insertion point for the rectified image is optional. If you do not define it, the rectified image is automatically placed right of the distorted image.

Now only the **file name** is missing under which the rectified image is to be stored. With **[…]** you will come to a relevant selection window for the storage path. You will find a detailed description about saving image data and the different path options in the command reference under **Image - Load image**.
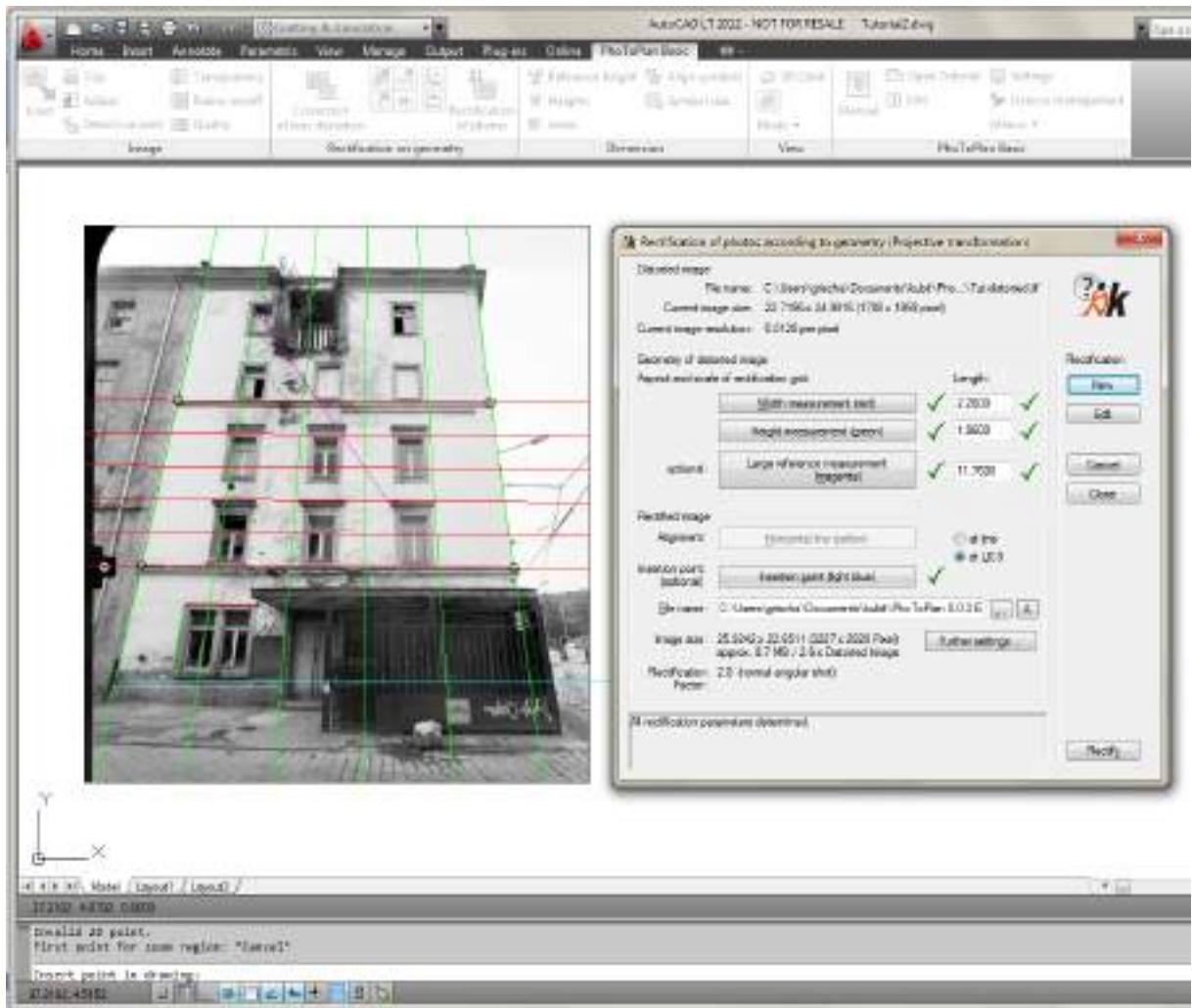
Now As-Built Photo has enough information to carry out the rectification.

Start the process with [**Rectify**]. In the status line of AutoCAD you may follow the run with the help of a display of the progress. As the complete image has to be calculated anew the rectification will take a few moments.

After the completion of the process you will see the rectified image.
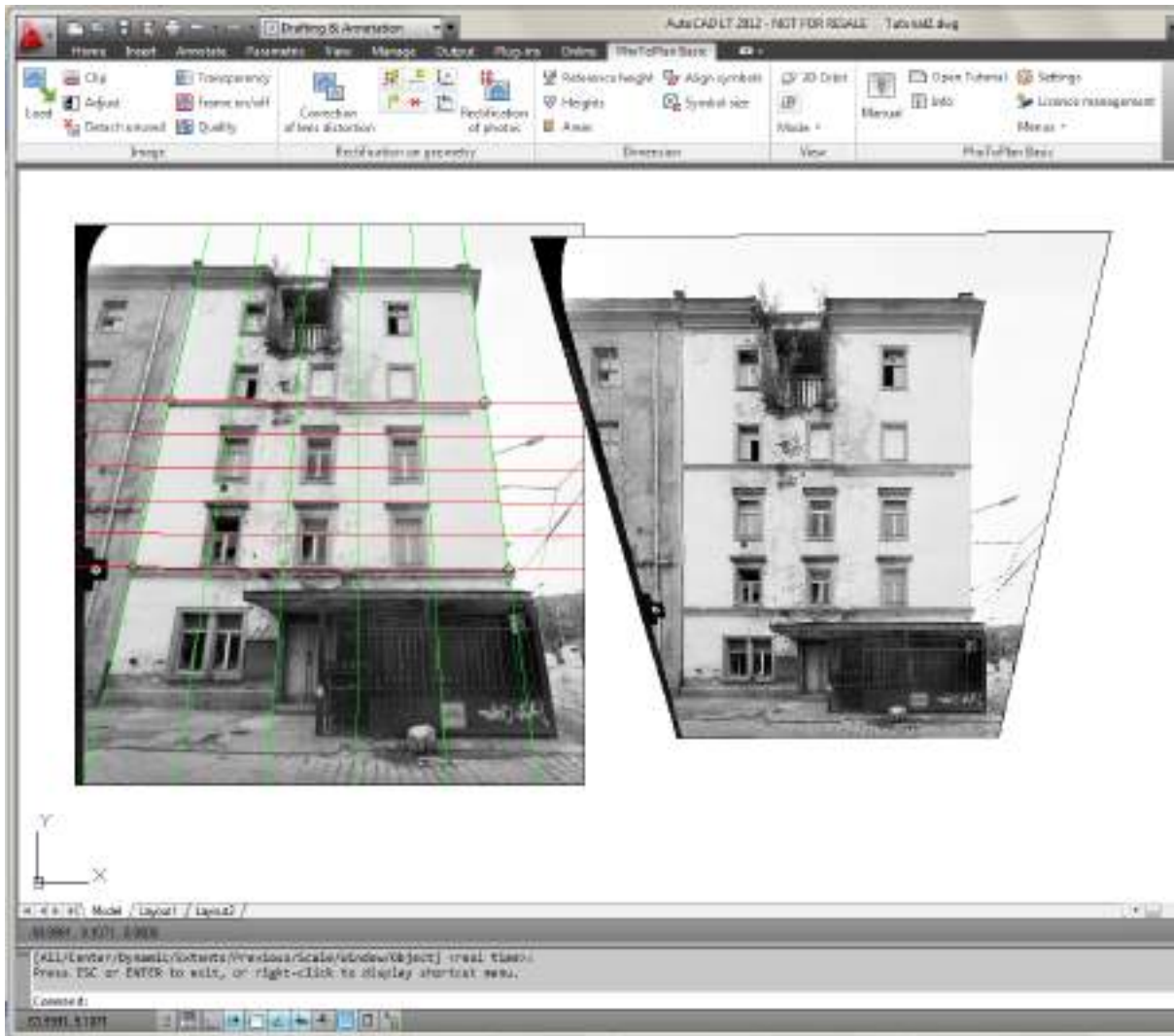
You will see that the formerly slanted lines of the facade are now parallel. You may take measures directly from the image with AutoCAD that – within the tolerances of the possible exactness – correspond to the measures of the original. For example the width of the upper right-hand side window measures 1.22 m from outer edge to outer edge.

Which accuracy can be reached with this procedure you will learn in section **4.6.2 The Rectification Process** under 'Accuracy of the Result'.

The photo, used in this tutorial, has been taken with a photogrammetric camera and is therefore free of distortions. In contrary, photos, which have been taken with a regular digital camera have, depending on the quality of the lens, more or less distortions. Therefore the photogrammetry tools of the As-Built offer the possibility to determine the distortion and to correct it before the rectification. You will find detailed information regarding the distortion correction in the command reference under →**Rectification according to geometry - Correction of lens distortion**.

4   Image Rectification

After a first overview of the image rectification in the previous sections in this section you will learn which steps belong to a typical image rectification project.

The final result will always be an AutoCAD drawing in which the rectified images are inter-linked. If necessary you can continue working with them in AutoCAD e.g. draw up two-dimensional plans, take measurements, and calculate areas. The rectified images are available as separate files for further processing in other image processing or CAD systems and thus can be opened in each and every image processing program. You may choose between the formats TIFF, JPEG, BMP and PNG.

A typical Project Run

Of course each project will show its special features. Nevertheless one can point out a few typical similarities in the basic procedures during a rectification:

- 1st step: determination and measurement of reference information

- 2nd step: taking photos (and digitalizing them) or scanning maps and plans respectively

- 3rd step: altering the photos into a compatible file format if necessary

- 4th step: rectification of the separate images

- 5th step: evaluation of the rectified images in AutoCAD or another CAD system

As long as the photos were not taken with a quasi distortion free photogrammetric camera, they are generally more or less distorted, depending on the quality of the lens. Therefore they should be corrected during the rectification. You find detailed information regarding the distortion correction in the command reference under →**Rectification according to geometry - Correction of lens distortion.** On page 7-34 is explained, how to determine and correct the lens distortion parallel to the rectification process.

4.1   Photo Rectification according to Control Points

4.1.1   Control Points as Reference Information

The idea of the rectification is to reform a photo so that all angles and proportions of the displayed object plane correspond with the reality. In order to do so the distortion due to the camera position has to be eliminated, which means the image has to appear as if a viewer would look vertically at the object plane from an infinite distance.

Necessary for this are measured reference information from the object. If a surveying instrument (total station) is available one is generally working with **control points**. They are marked on the object to be measured, photographed and registered according to their coordinates. In the photo the corresponding points are picked out and their image coordinates are measured. With the help of at least four of those point assignments the rectification parameters can be calculated.

Determination and Marking the Control Points

The control points have to be marked clearly and numbered on the object. There are two possibilities for the markings: you either stick visible tags to the facade or you select natural points that are rich in contrast and can be identified easily. Clearly suitable are e.g. window corners or décors. In a hand-drawn sketch you will register their position and point number. The points are photographed together with the object to be evaluated.

Measuring the Control Points with a Total station

In order to rectify an image the coordinates of the control points have to be determined. Generally a total station is used for this purpose preferably one with a reflector-less measuring of distances. With such a device you will receive an X-, Y- and Z-coordinate for each point. These are stored as an ASCII-file in a standardized format so they can be read in AutoCAD. Here is an example for such a control point coordinate file:

```
1      95.8471    499.8149    0.72767
2      98.8529    499.8200    0.46680
3     106.4943    567.0582    0.21383
4     103.5116    567.0733    0.22545
5      56.8697    566.3471    1.76136
6      56.8716    554.7248    1.87118
```

In the first column the point numbers are given, in the following three columns are the X-, Y- and Z-coordinates of the points. The order of the columns may be selected at random. If there are any further columns behind them (some instruments store additional information), they will be ignored. Unless you want to store certain control points on different AutoCAD layers. In that case you can read in another column with layer information.

Note: Alternatively there is the possibility to transfer control points directly into your drawing using a total station (As-Built Total Station Interface). Whenever coordinates are expected or you have an option <measure> data can be transferred directly from the total station.

Measuring of Control Points with the Help of a Distance Net

If there is no total station available you may also measure in the control points via a net of distances which you have determined with a hand-held laser (e.g. DISTO). The coordinates resulting from it are two-dimensional referring to the rectification plane. The origin of the local coordinate system has to be determined by you. An example:
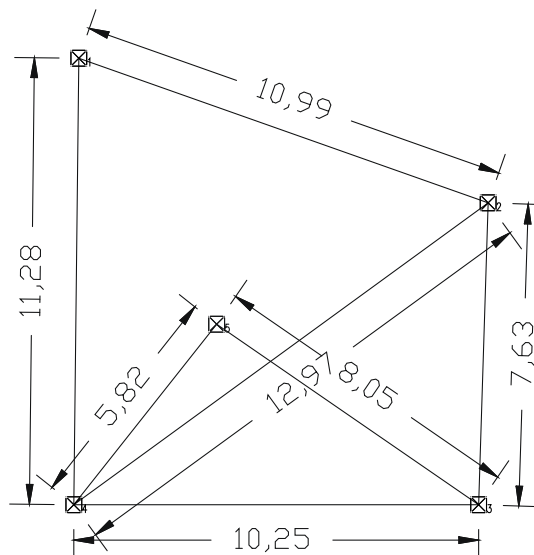
Draw a sketch of your distance net and re-construct it in AutoCAD. To do this use the command →**Control points - Control point via arc intersection**. Move the construction in a way that the point you determined as the origin of the coordinates lies in zero.

You can check the exactness of the control information by an over-determined measuring of your distance net. I.e. that you measure additional control points (e.g. diagonals in a rectangle), and check whether they 'fit together' with the rest of the construction. In this way you may find measuring errors and inaccuracies.

Requirements for the Control Points

1. At least four Control Points are required for each Rectification

In order to carry out the calculation of the rectification unambiguously, at least four control points are required as reference information. In any case you should **consider more points, at least five**. Then there is an over-determination and a least-square adjustment is calculated. This allows for a control of the measured control point coordinates and their assignments, respectively. Errors and inaccuracies can thus be localized.

2. The Control Points for a Rectification have to lie in one Plane

Strictly speaking, an image rectification is only valid for one certain plane, the so-called **rectification plane**. Therefore this method for gaining geometry data is only suited for objects that show a rather plane structure, e.g. facades with relatively smooth walls, paintings, ceilings, floors. Not suited are round buildings, vaults, rock faces or buildings with an especially distinctive depth structure. Here it is better to fall back on other evaluation procedures.

You already have to know during the definition of the control points on which plane you want to rectify. In most cases this will be the facade plane. All the control points must lie on this plane. If you want to rectify on another plane, e.g. a roof plane, at least four additional control points are necessary for it.
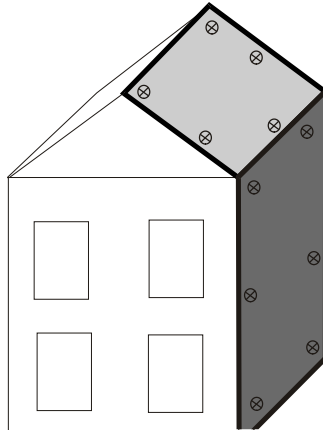
3. The Control Points have to be distributed evenly

The house's facade (Rectification plane) with its control points is situated in three-dimensional space. From our camera position the house's facade was reproduced on the image plane of the camera via central projection. Because of the orientation of the camera the façade appears distorted. This projective distortion now has to be reversed. This is done arithmetically by calculating rectification parameters with the help of control point information.

If possible the control points should be distributed evenly on the edge of the relevant object on the rectification plane. If all control points are close together, small measuring errors in the coordinates will become more noticeable the farther you move away from them. Thus the solution will be more stable with an even distribution of the control points.

A rectification will be completely impossible if all control points are in one line. Such distributions have absolutely to be avoided.
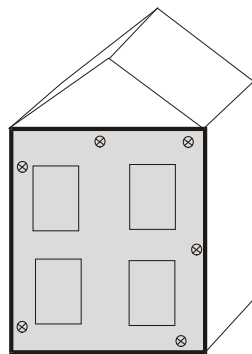
good configuration
of control points
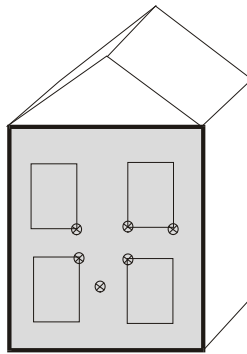
bad configuration
of control points
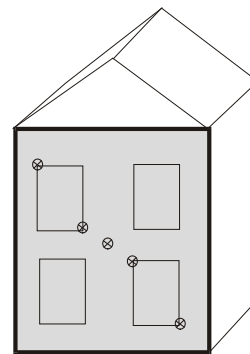
control points in one line
rectification not possible

4. The Exactness of the Control Point Definition and the Exactness of the Rectification should be correlated with each other

This correlation can best be explained with a concrete example:

Suppose you want to take measurements from your image after the rectification with an exactness of 2 cm. Then there are two error sources: the limited exactness of the control point measuring on the object and the control points' assignment in the image (definition of image coordinates). These errors will add up in the evaluation process. For example if the control points on the object are defined with an exactness of 1 cm, 1 cm will be 'left over' for the rectification process. You have to check now whether you will be able to reach this exactness of the image coordinate measuring. That depends on the image resolution and quality as well as the ability to identify the control points. You have to consider this:

You have a facade with a length of 20 m. Your digital image contains 1200 pixels along the facade. 1 pixel then corresponds to a length of 20m/1200 = 1,7 cm in reality. You can measure that accurately in your image, the resolution is thus not quite sufficient. Of course the quality of the control point signalizing and the image quality play an important role as well.

It does not make sense to assign the control points in the image with en exactness of millimetres if your tachymeter has only measured the control points with an exactness of centimetres. On the other hand you don't have to exaggerate the measuring of the control points if you are only able to measure the points in your digital image with an exactness of decimetres due to a low resolution.

4.1.2   The Rectification Process

Depending on the relevant job, you are able to carry out as many rectifications as you like on as many rectification planes as you like in an AutoCAD-drawing. Basically the following steps are necessary:

		Command Name
1.step	**Importing Control Point Information** The control point file in the ASCII-format is selected and integrated into the AutoCAD-drawing in the form of blocks on the layer CONTROL **Alternatively:** Construct control points via distance grid	PCIMPORTCP KUBT_PC_ARCINTERSECTION
2.step	**Define Rectification Plane.** With the help of the control points relevant for the concrete rectification a UCS (User Coordinate System) is defined which correspond to the rectification plane.	KUBT_PC_UCSCP
3.step	**Loading Image.** The image to be rectified is loaded into AutoCAD and positioned freely.	PCLOADIMG
4.step	**Assigning of at least four Control Points to the corresponding Image Points**. Calculating the rectification parameters. With more than four control points an adjustment and error	KUBT_PC_RECTIFY

	calculation is carried out.	
5. Step	**Distortion correction** Only necessary if the image has not been taken with a photogrammetric camera or has not been corrected in advance. By reading in a correction file or determination of the distortion within the image by means of horizontal or vertical straights.	
6.step	**Rectification Process.** The rectified image is calculated with the help of the rectification parameters and stored as a separate file. The rectified image is positioned exactly in AutoCAD.	
Repeat steps 1 to 6 for each single rectification.		
7.step	**Clipping and merging** the separate images to one complete image (if necessary).	OICLIP KUBT_PC_MONTAGE
8.step	**Evaluation of Image.** e.g. setting up a facade plan with AutoCAD-functions	AutoCAD-functions or external software, respectively

The evaluation of the rectified image is almost unlimited. You may use the complete range of the AutoCAD-functionality or import the rectification result in any other CAD system or image processing program.

The further correlations will be explained in a third example. It is a building for which images from more than one facade are to be rectified. The necessary files have not been installed with the setup because of their file size. Please, download them to your machine using following web link (http://service.faro3dsoftware.com/DOWNLOADS/TutorialsVideos/PhoToPlan/PhoToPlan-Tutorial3_en.zip).

The control point coordinates are in the file TUT3_CONTROL.KOO, the distorted original images are present under the following names:

EASTERNFACADE1.TIF
EASTERNFACADE2.TIF
SOUTHERNFACADE1.TIF
SOUTHERNFACADE2.TIF

These images have been taken with a photogrammetric camera, therefore it is not necessary to apply a distortion correction (see command reference page 7-34).

1. Step – Importing the control point information

In the first step you have to import the control point file in your AutoCAD-drawing. In order to do so, open an empty drawing in AutoCAD ('File – New'). Now select the command '**Import control points**'.
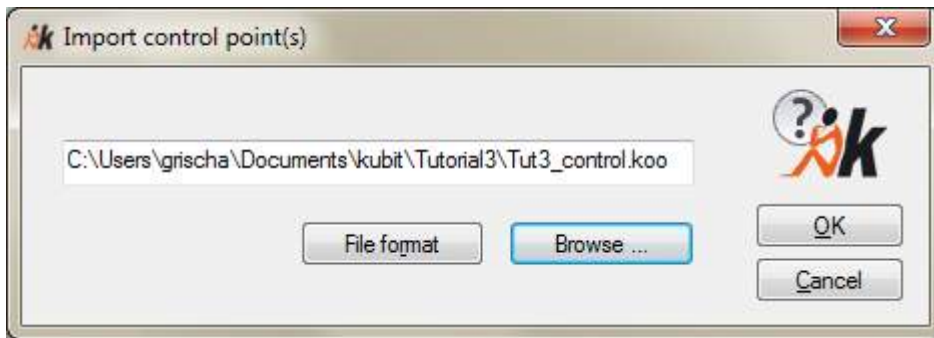
In the corresponding dialogue window click on [**Browse...**] and go to a file selection window. Here you pick out the file Tut3_Papu.koo and click on [**Select**]. Back in the previous dialogue you have to opt for a format to import under [File format].
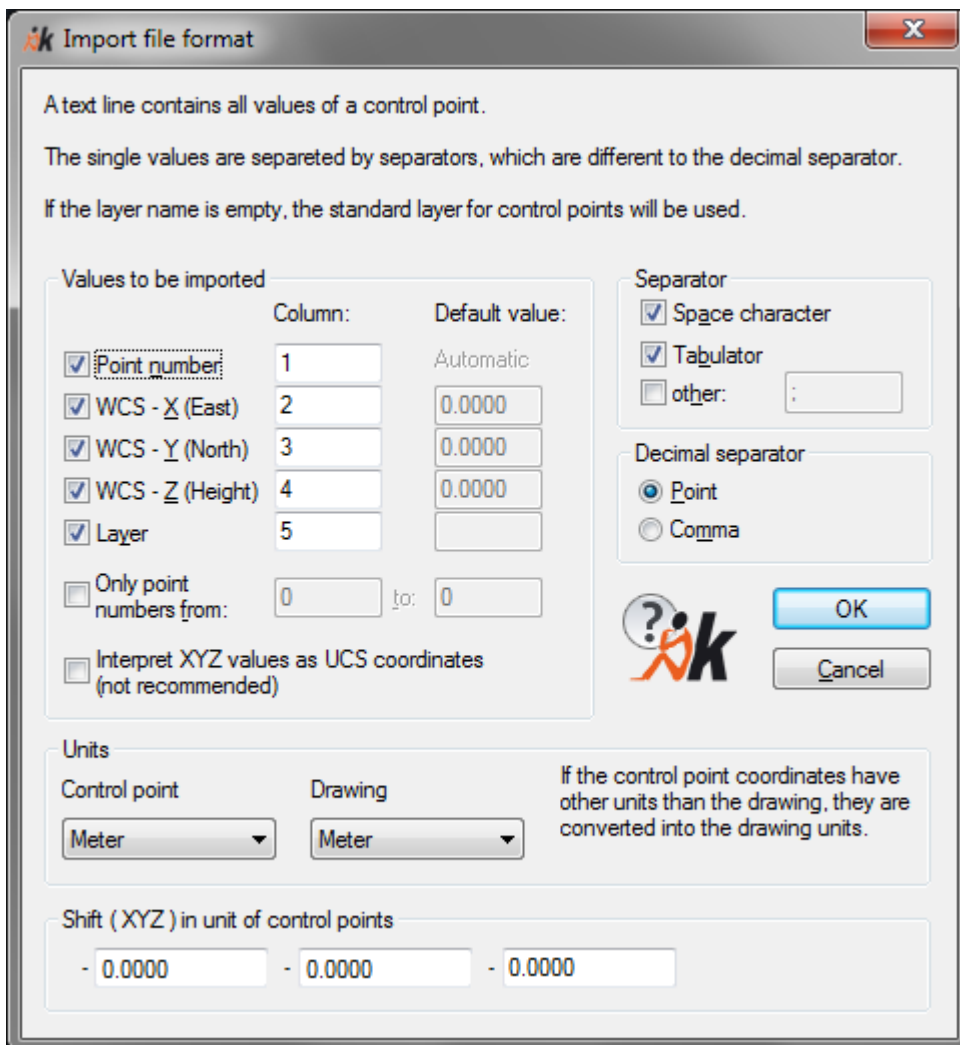
There is the possibility to limit the number of points by entering an interval.

Option "Interpret XYZ values as UCS coordinates (not recommended)" is to be used only by advanced users. You have to secure that coordinates of imported points are conform to your current UCS. Confirm the selection with [**OK**].

        19 Point(s) imported.

appears in the command line. If the points are not yet shown in the window, use the AutoCAD command 'Zoom Extents'. Now the imported points will appear in the

window. As these points are mostly situated on the facades, the approximate outlines of the building can be made out.
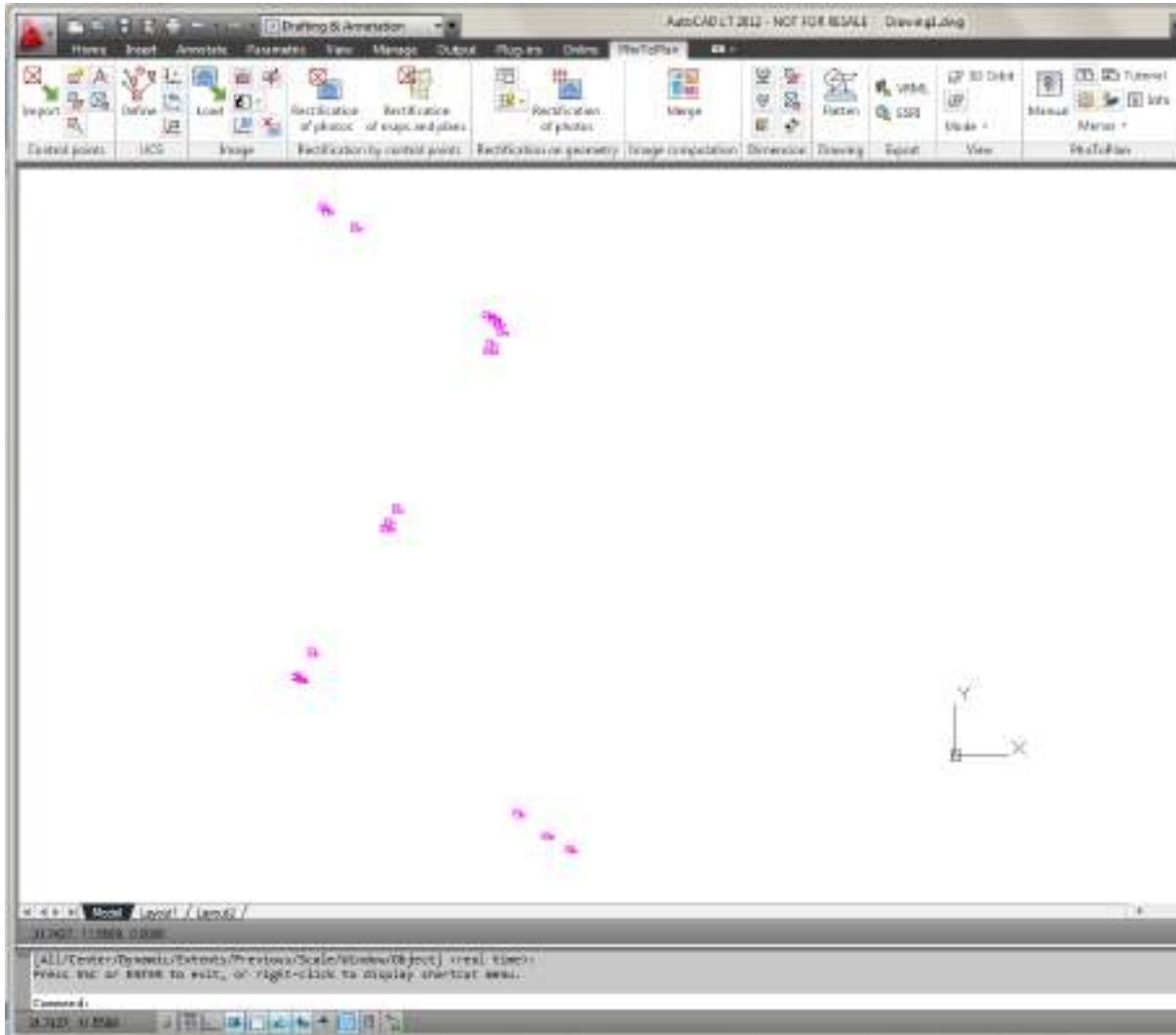
Momentarily you are in the AutoCAD WCS (world coordinate system), and are therefore looking at the XY-plane (outline plane) where the X-axis points to the right and the y-axis straight up. The Z-axis (height above the outline) points towards you. The coordinates of the control points are interpreted as WCS-coordinates.

2. Step – Definition of the Rectification Plane

As mentioned before, a rectification is valid only for one certain plane. It is the one in which the control points relevant for this rectification lie. All parts of the measured object that are situated in this rectification plane are reproduced in scale in the rectified image, everything that is not situated in this plane remains distorted.

The rectification plane is always the XY-plane of the current user coordinate system (UCS). This UCS has to be defined by you. The software always lays the rectified image on the XY-plane of the current UCS. In this example we want to rectify the eastern facade up front at first. Therefore we define a coordinate system (UCS) of which the XY-plane corresponds exactly to this facade plane.

For this there are two possibilities: If you want to rectify a facade that runs strictly vertically use the option "**Rectification plane runs vertically (Vertical UCS)**"'. If the rectification plane is situated freely in space, take "**The rectification plane can take**

an arbitrary position in the space (Free UCS)". Of course it is up to you to use any other AutoCAD command for defining a UCS.

This example employs vertical facade. Select the command "**Define rectification plane (UCS)**" .
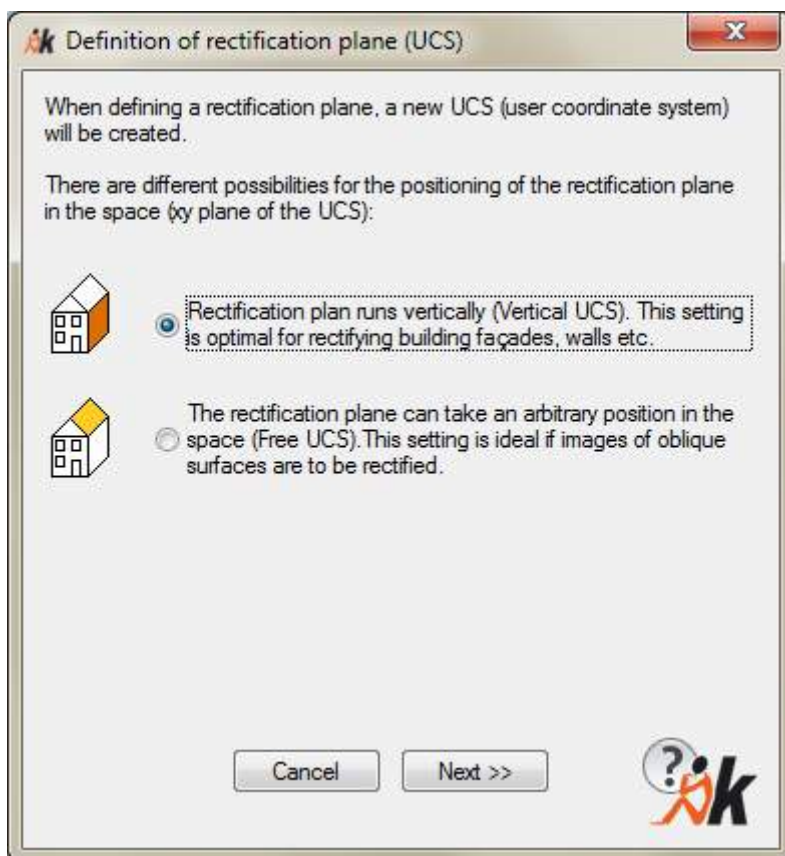
Select the option "Vertical UCS" in the first step and press [**Next. >>**].

For the definition of a vertical plane it is necessary to define at least two points. It is always better to define more control points. For example, select all control points that you want to use for the rectification too or which represent the rectification plane as exact as possible.

The order of the selection of control points also plays a role. The first control point defines the coordinate origin, the second point a point in positive direction of the x-axis of the new UCS. Here you thus determine from which side you look at the plane. First pick a control point that is situated on the left-hand side of the facade, the second control point has to be situated to the right of it. Now the direction of the X-axis is defined, whereas the order of the following control points does not play a role. The UCS is now aligned in a way that you look at the facade from the front.

If you check the option "Take over Height (UCS-Y) from WCS-Z (Shift origin to XY plane of WCS)" you will place the origin of the UCS in the XY plane of the WCS and keep the original height information of the control points.

To select the control points click on [Add]. Following request will prompt in the command line:

   Choose control point or [Number/Measure/Finish] <Finish>:

Now select the control points 15, 16, 84, 83 und 72 consecutively and complete the process with the enter key or the option 'Finish'.

If enough control points have been selected (and are active), a mean vertical plane will be calculated through all indicated (and active) control points. Possible deviations of individual points from this plane will be shown in the column "Deviation".
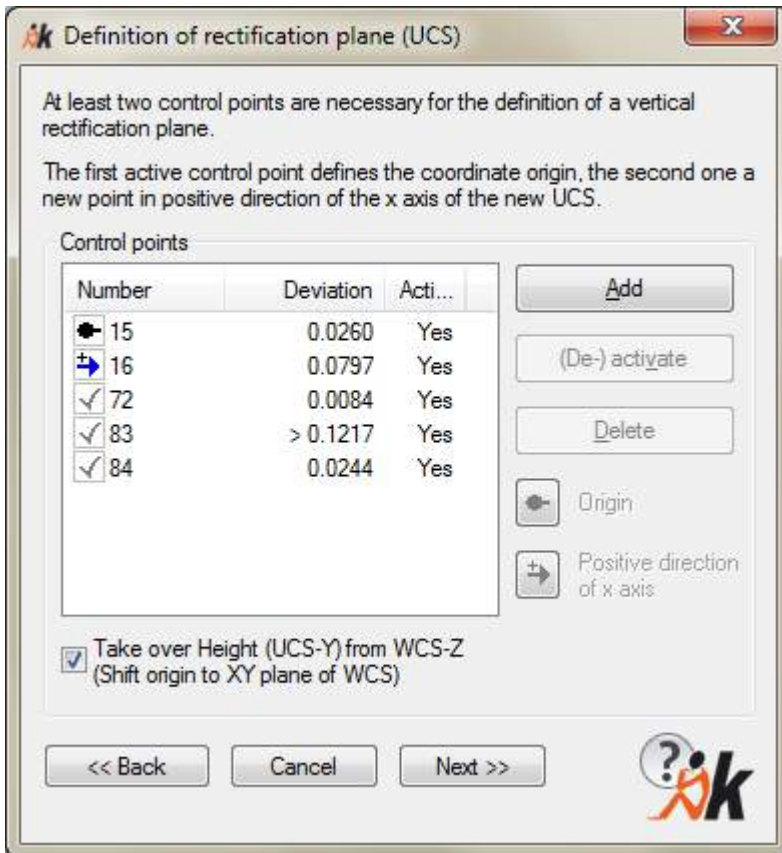
The deviations should be as small as possible. Here you see a point protruding out of the plane. With [**(De-)activate**] you can exclude one or several points from the plane calculation. If you find the individual values satisfactory, click on [**Next >>**].

In the last step you are asked to name the new rectification plane (UCS). This is useful to be able to restore this rectification plane later. In our example please give the name 'East view'. Then click on [**Finish**].
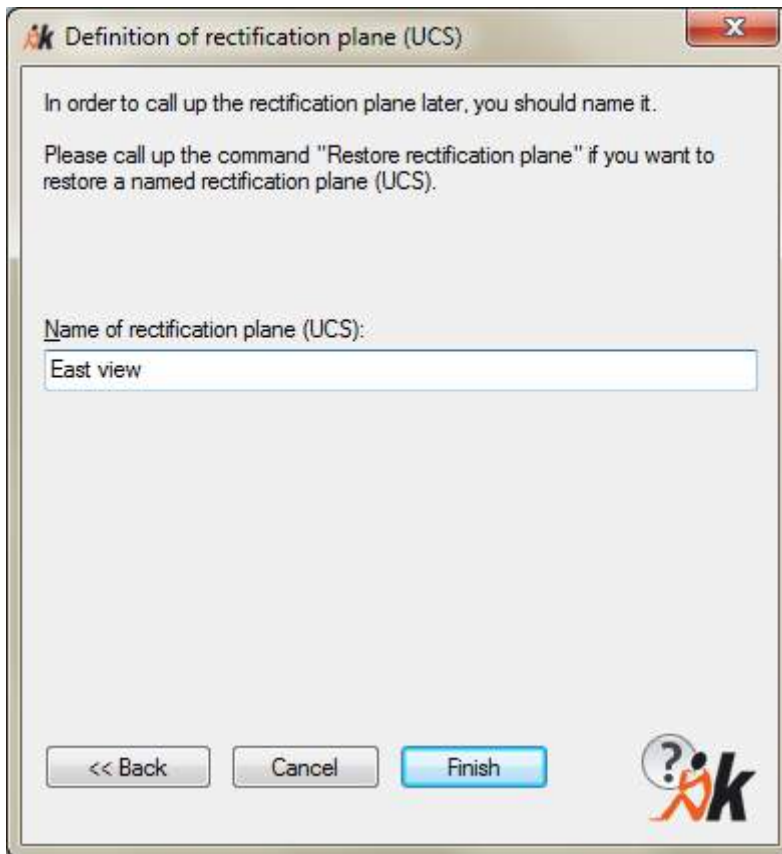
The UCS is now aligned in a way that you view the east facade of the building.

The definition of the rectification plane will be logged in an ASCII file with following naming convention: DRAWINGNAME_UCS_UCSNAME.PRK.

If you call up the command '**Restore rectification plane (UCS)**', you will get to following dialogue:
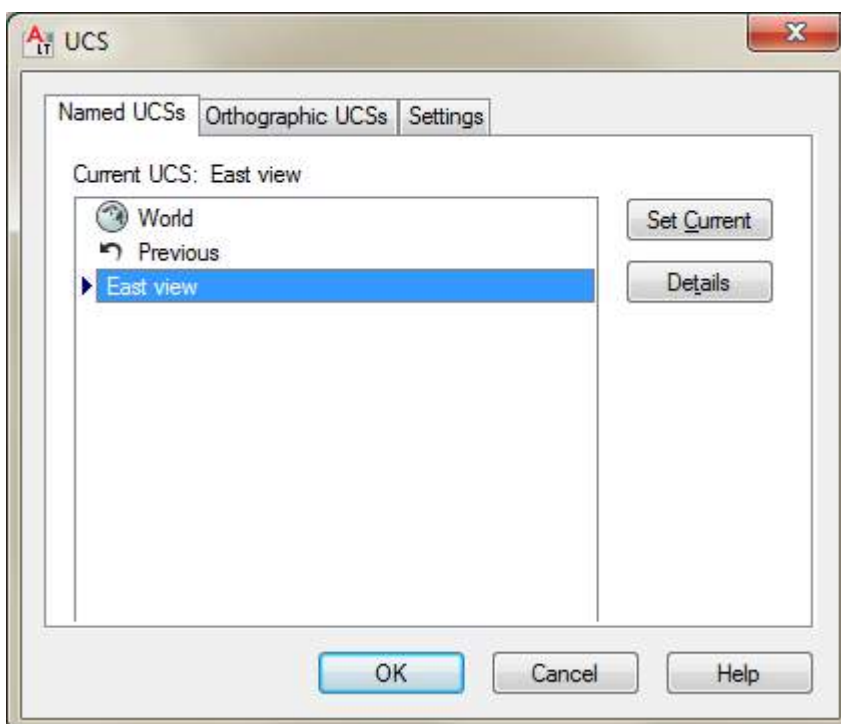
Here you can see all existing user coordinate systems (UCS) of the drawing. You can switch between them with '**Set Current**'. The current UCS is marked with a blue arrow.

3. Step – Loading in the distorted Image

Now select the command '**Image - Load image**'. In the ribbon this command corresponds to this symbol: .

A dialogue for the file selection appears. Go to the directory where you downloaded TUTORIAL3 to and select the distorted image EASTERNFACADE1.TIF. Confirm with **Load**. In the command line the following message will now appear:

> Insert point for image:

Position the lower left-hand side of the image somewhere near the control point cloud. Open a window with the mouse and determine the size of the image with a further click. The positioning and scaling can be carried out completely at random, both have no influence on the result of the rectification.

The image shows the eastern facade of a building.
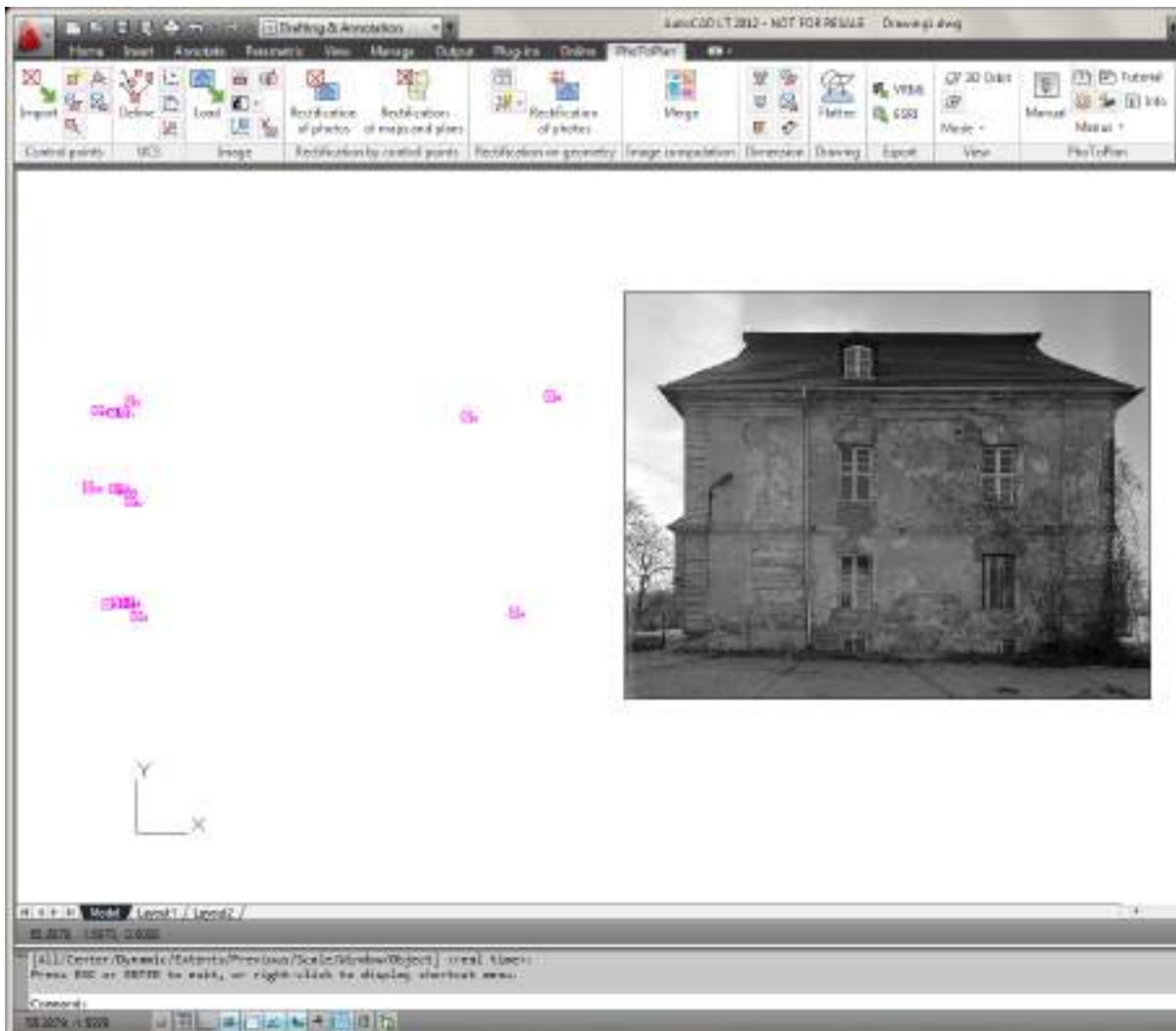
4. Step – Assigning the Image Points

Now assign the control points to their corresponding image points. Do exactly the same as in the Tutorial 1. Remember: You select the command '**Rectification by Control Points - Rectification of Photos**' from the As-Built Photo ribbon. In the dialogue window click on [**New**] and click on the distorted image. With [**Add/Redefine**] you will come back to the drawing and can measure the single control points in the image. Some are marked by tags, some are natural points (window corners, décor corners). Please take the position of the control points from the sketch below.

Point 15:   tag lower left-hand side

Point 16:   tag lower right-hand side

Point 83:   upper right-hand side corner of the upper right-hand side window

Point 72:   lower outer corner of the upper décor stone on the left-hand facade side

Point 84:   upper right-hand side corner of the rectangular décor on the right-hand facade side

eastern facade 1

Here, too, it is possible to select the control points by entering the point number. This is done with the option 'n' <Number>. With the option 'f' <Finish> you cancel the control point assignment and return to the dialogue 'Rectification of photos'.

5. Step – Calculation and Exactness of the Rectification

Now have a look at the error values given in the control point chart. You have measured in five control points. The problem is therefore over-determined and a compensation is carried out. The arithmetical algorithm checks how well the individual points 'fit together' and calculates the best fit for the rectification parameters.

The deviations of the control point coordinates from this medium solution lead to an error value which is given in the last column for each point. With the help of these error values you may check your measurements. Depending on the resolution and the image quality you must decide how exactly you were able to measure in the control points in the image. If the error values exceed your expectations this means an error or inexactness was made during the control point assignment. In this case you should not carry out the rectification but look for the cause of the high error values first.

For the error search the following starting-points are valid:

- A single control point was assigned incorrectly in the image.

  By a systematic de-activation of single points you will find this one easily. Here you will start with the point that has the highest error value.

  In order to do so, mark the relevant point with a click on the point number in the first column. Click then on [**(De)Activate**].

- Control points were switched.

  Deactivate two or more control points at a time in order to find out the switched pair. With only five control points this is actually not possible as with the de-activation of only one point no error values can be calculated anymore (no over-determination). Here you probably have to check all the points in the image once more and if necessary re-assign them.

- The control point coordinate file shows a measuring error.

  Check the coordinate file. If necessary the coordinates have to be measured anew.

If you de-activate more than one point at the same time it may happen that the error values suddenly disappear completely. In this case only four activated points remain. There is no over-determination anymore and a compensation cannot be calculated. An error control is then not possible anymore. The message in the dialogue window below will point this out to you:
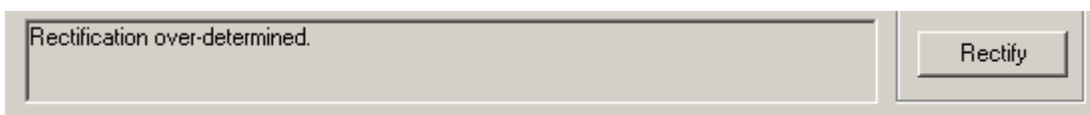
If you deactivate even more points the field button [**Rectify**] becomes inactive and the window will signal:
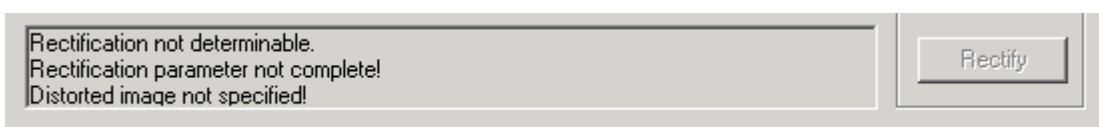
The rectification parameters can now no longer be calculated and a rectification becomes impossible.

Image Rectification and Results

If you are satisfied with the error values (in this example values of a few mm up to 1 cm may be reached) the actual rectification may start. In the lower part of the dialogue you still have to define where and under what name the rectified image is to be stored. With [**...**] you will come to a corresponding file selection window. A detailed description about the three different path options you will find in the command reference under → **Image - Load image**.

With the button [**Further settings**] you can control the properties of the rectified image.

You will be shown the optimal values for the number of pixels, image size and pixel size/resolution. Optimal means that the image to be created contains exactly so many pixels that a maximum of image information is available without wasting memory at the same time. Number of pixels and pixel size in AutoCAD can be adapted to your individual needs, too.

The designations within the frame "**Image size**" are only of interest if you intend to further process the image outside your AutoCAD drawing (e.g. editing and printing to scale in Photoshop or GIMP). For further details on this dialog please refer to the **command reference page 7-37 (**Rectification by control points - Rectification of photos (Projective Transformation)**).**

Image size

Here you see the information on an image in a compressed way:

Image size
in AutoCAD

Number of
pixels

Image size: 24.3253 x 23.3230 (3155 x 3025 Pixel)
approx. 9.1 MB / 2.7 x Distorted Image

Required disc space
(uncompressed) and compared to
the original image
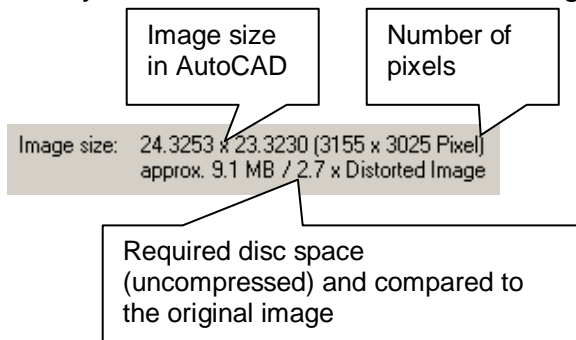
The file size of images of a high projective distortion can increase enormously. In this case you should clip the image before the rectification process and only rectify the relevant area. To do this, use the command "**Image - Clip image**" (see command reference).

Rectification factor

Rectification   2.1 (normal angular shot)
Factor:

The rectification factor specifies the relation of rectified image area and distorted image area at optimal resolution. The higher the projective distortion in the original image, the higher this factor. Usually this factor lies between 1 and 3. Higher values are only to be expected with a very high projective distortion. This factor is intended to help avoid extreme distortions which may require extensive calculations. As a little help, the rectification factor is commented.

After you have checked all these settings and if necessary adapted them, start the process with a click on the button [**Rectify**].

A display of the progress in the status line shows the process. The rectification may take a few minutes depending on the image size and your computer's capacity. In the end the rectified image will lie exactly above the measured control points. The rectification is now complete.

Six files belong to this rectification:

- the AutoCAD-drawing with the rectification

- the distorted image file

- the control point file

- the rectified image file

- a text file with the extension **.ppb** that contains the image position information of the rectified image. Additional information is available in the command reference under '**Rectification by control points - Rectification of photos (Projective Transformation)**'.

- a text file with the extension **.prk** that serves as a protocol file and contains all important information and parameters of the rectification. You can find additional information in the command reference under '**Rectification by control points - Rectification of photos (Projective Transformation)**'.

Multiple rectifications in one drawing.

To show you the possibilities available to you with the AutoCAD platform we will add another rectification into the drawing.

To do so you have to switch back to the outline view as it was after the import of the control points. In order to do so you have switch back to the AutoCAD world coordinate system (WCS).

For AutoCAD beginners: Enter the command "ucs" and select the option "w" (for "world"). Was the UCS symbol shown in 2D mode, in the bottom left-hand side corner you will now see that the coordinate system symbol disappears and a "broken pencil" appears. Was the symbol shown in 3D mode, now 3 axes of WCS appear. Now you still have to switch to the top view. This is done quickly with the AutoCAD-command "plan". With **Enter** you select the default option "Current" (UCS). You now look at the building again from the top and can make out the outline with the help of the control point cloud. The already rectified image is displayed as a line on the corresponding facade.

We now rectify a further facade, a part of the southern facade. This one is connected at an angle of 90° on the left-hand side of the already rectified eastern facade.

complete southern facade

In order to do so repeat the steps just described. As the control points have already been loaded you begin with the definition of a vertical rectification plane. This one lies at an angle of about 90° to the previous rectification plane. Remember: Call up the command **'Define rectification plane (UCS)'** and click on the relevant control points one after another. Which ones are relevant can be learned from the sketch 'complete southern facade' given above.

After that you load the distorted image SOUTHERNFACADE1.TIF from the directory where you downloaded TUTORIAL3 to. This image shows the right-hand side of the

southern facade with the control points 13, 14, 71, 72 and 74. The points 73, 101 and 12 cannot be seen on this image.

After the successful rectification the generated image is directly available on the control points of the facade as well. In order to make clear the position of the two rectifications to each other now look at the building from an angle. With the AutoCAD-command '**3dorbit**' you will come into the 3D-Orbit-Mode where you may turn the object at random in real. Under AutoCAD LT please use Ctrl+left mouse button to activate 3D Orbit (note this works only if activated under Settings→AutoCAD (LT)) or use the Orbit commands from the As-Built Photo ribbon group "View".
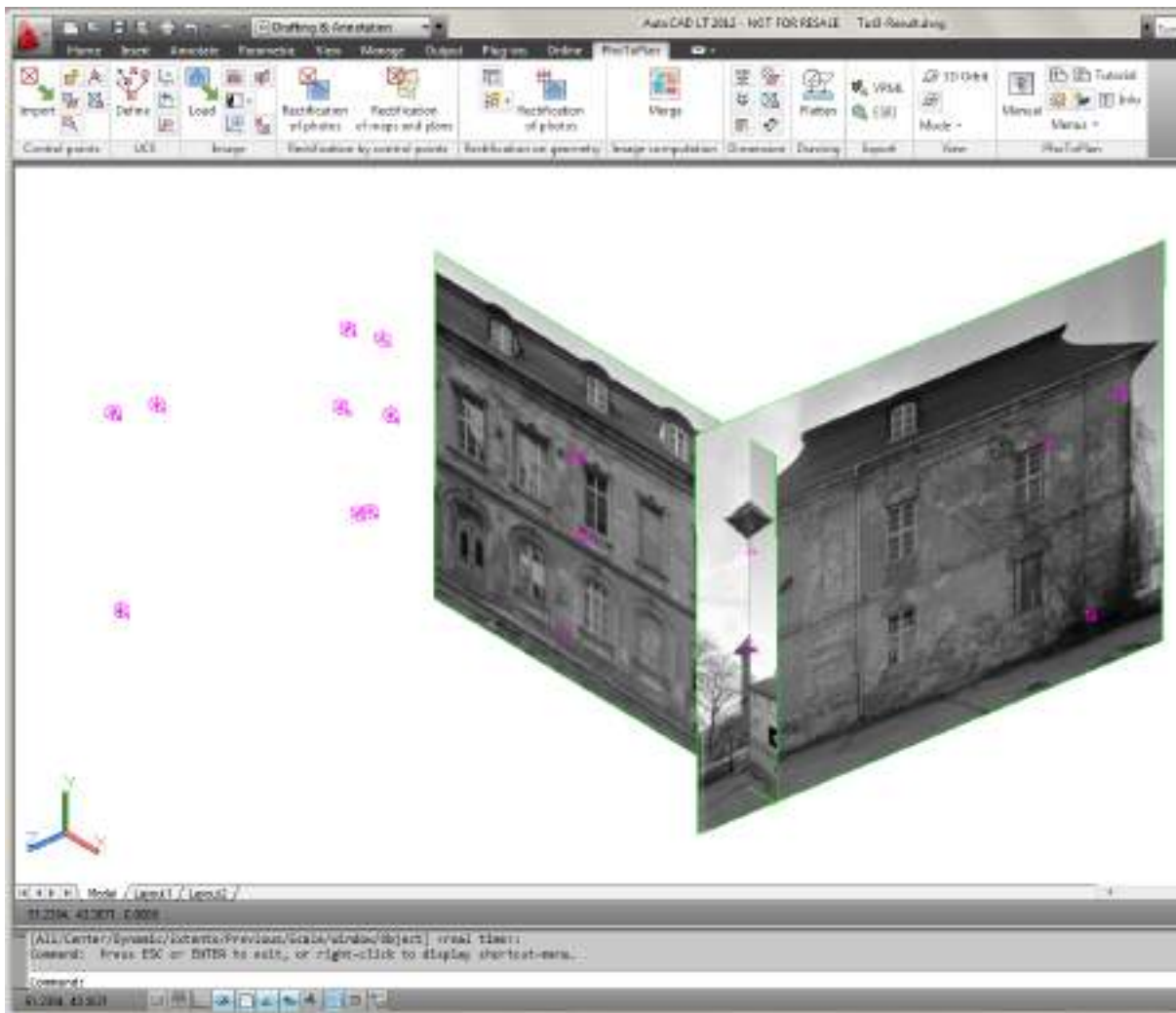
Rectify two more images in the same way:

The southern facade continues further to the left. Therefore you rectify another image onto the same facade plane. Load the image SOUTHERNFACADE2.TIF from the directory you downloaded TUTORIAL3 to. The control points for the rectification may also be taken from the sketch 'complete southern facade" given above. The rectified image overlaps partly with the previously rectified first part of the southern facade. Under **'Tools – Display Order'** in the AutoCAD-menu (enable via MENUBAR=1) you may determine with the help of the commands **'bring to front'** and **'send to back'** which part of the image is to be seen and which one lies in the background.

A typical characteristic of the rectification can be clearly seen: in the sector of the facade plane the two rectified images of the southern facade fit together exactly. In the sector of the roof and the window crosses on the other hand, larger or smaller jumps occur.
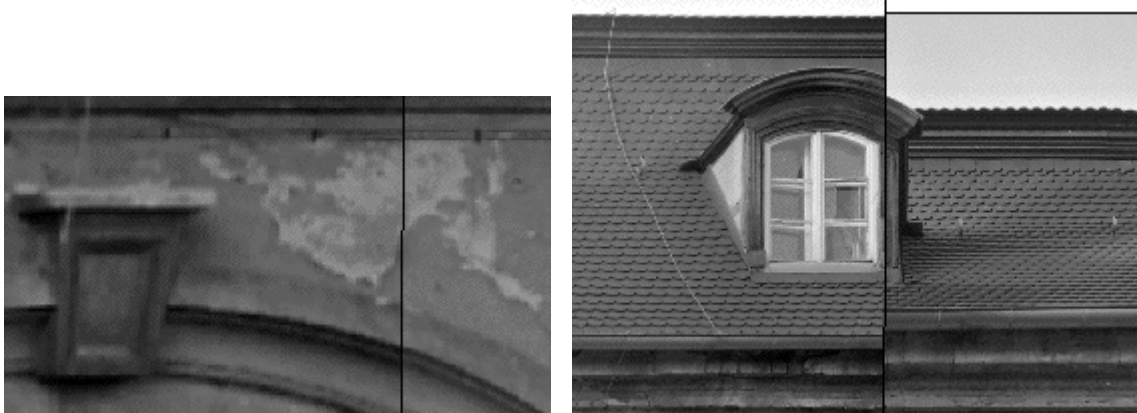
exactly fitting image seams on the facade plane   jumps in the roof sector

The reason for this is that the rectification is only valid for the sector of the rectification grid. All protruding parts or parts that are set back like e.g. the roof or window crosses are not displayed to scale in the rectified image.

Following the southern facade is the second part of the eastern facade. Compared to the first eastern facade this one is set back a few meters. Therefore you now have to define a new rectification plane. The following sketch shows the position of the control points.
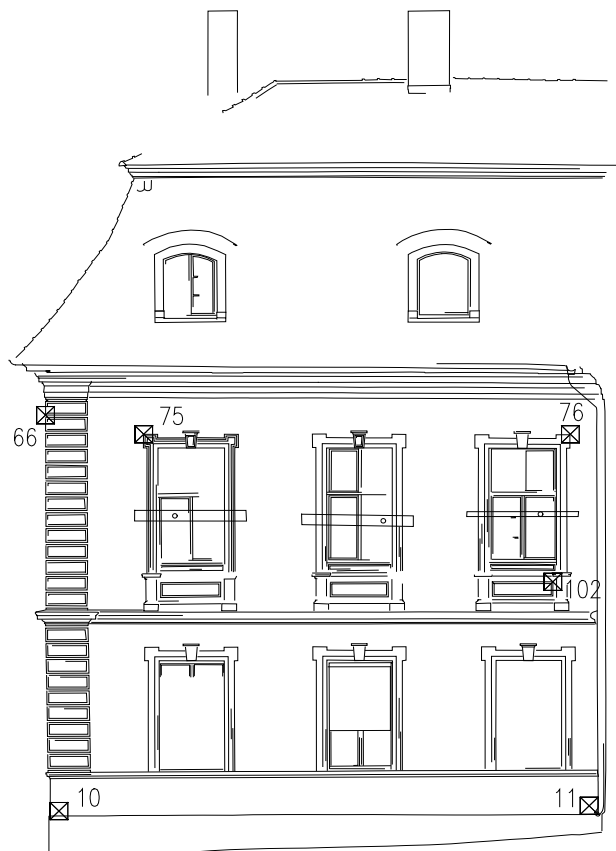
eastern facade 2

As a result you will receive an AutoCAD-drawing that approximately looks like that in a sloping view:
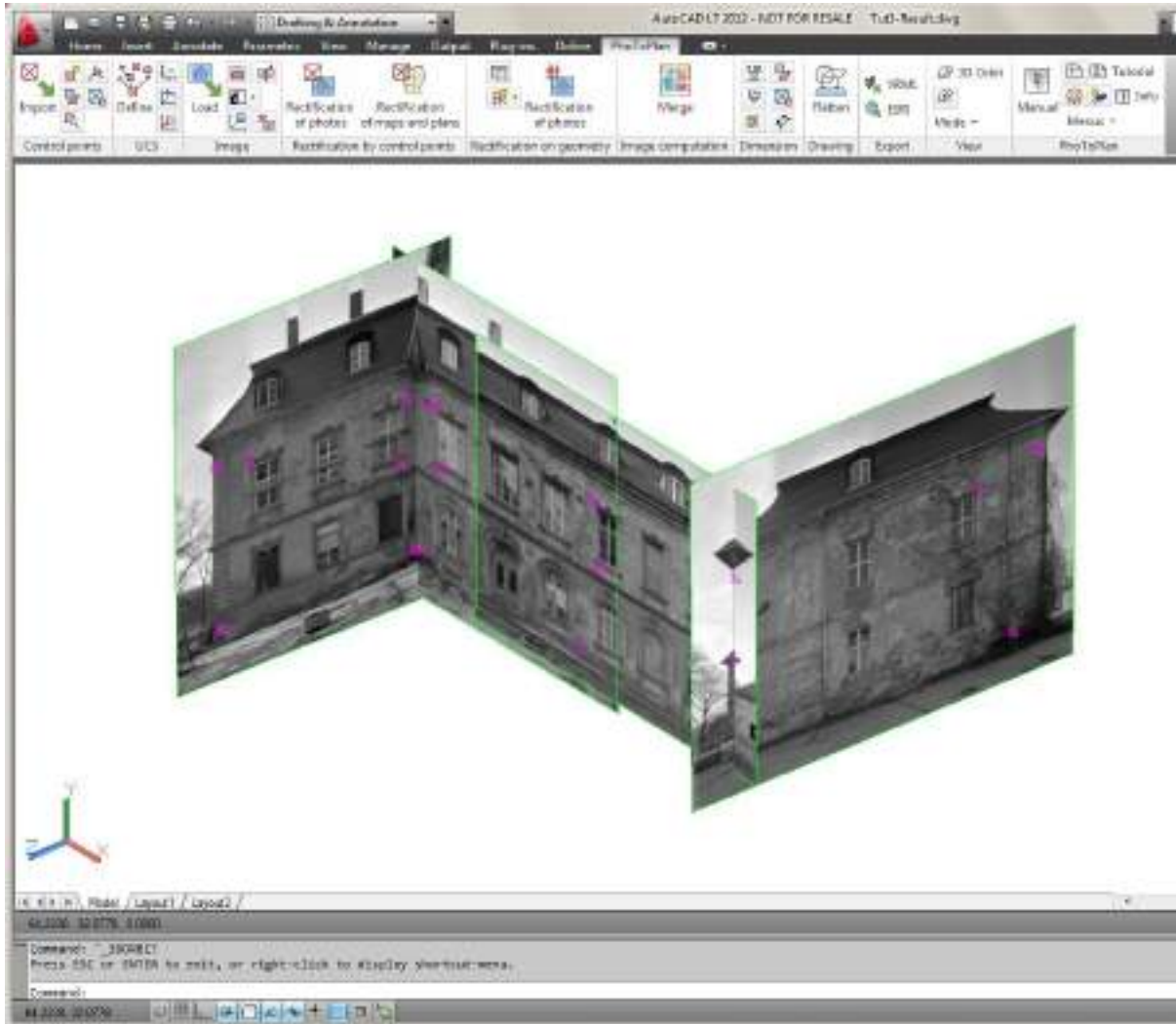
The procedure described above, laying more than one image with various rectification planes into one AutoCAD-drawing is limited to its use in practice. This example was selected to explain the working principle of As-Built Photo.

In order to generate a facade view with the help of the rectified image one would set up an individual drawing for each rectification plane. The rectified image in this case serves only as a constructional help, it is deposited to measure off the geometry from it. On the other hand this procedure offers useful applications for 3D visualizing purposes.

At the end you may overlay the rectified image or the digitized plan with a coordinate grid →**Dimension - Insert coordinate frame.**

4.1.3   Change symbol size (Control points and Image points)

Different projects often differ in facade sizes. The standard setting uses symbol (block) sizes (e.g. Control points and Image point symbols) which are adjusted to facades between 5 – 20 m (AutoCAD units). You can change these settings by using the command '**Control points - Change size of Control points**'.

4.2   Clipping the Images

Before as well as after the rectification process it may make sense to limit the image to a certain sector. In our example we will clip the already rectified images. The two partly overlapping images of the southern facade are to be clipped in a way that the remaining image section reflects the geometry as optimal as possible. In addition to this all non-relevant parts of the image (e.g. background etc.) are to be removed to enable a succeeding merging of the images.

Switch to the UCS of the south view. If you have assigned a name for the rectification plane, you can replace it with ''. If you have not assigned a name for the UCS, you can now repeat the command '**Define rectification plane**' or call up '**Rectification**' - '**Edit**', select the rectified image, answer the question:

Do you want to use the current UCS for rectification?

with 'Yes" and close the dialogue.

For a clipping you will need a boundary. Draw a clip boundary into the right image of the southern view with the help of the AutoCAD command 'PLINE' (**Polyline**). Probably you have to bring the image to the front first. In order to do so, use the AutoCAD command '**Draw Order → Bring to Front**' from the right click menu of the image.
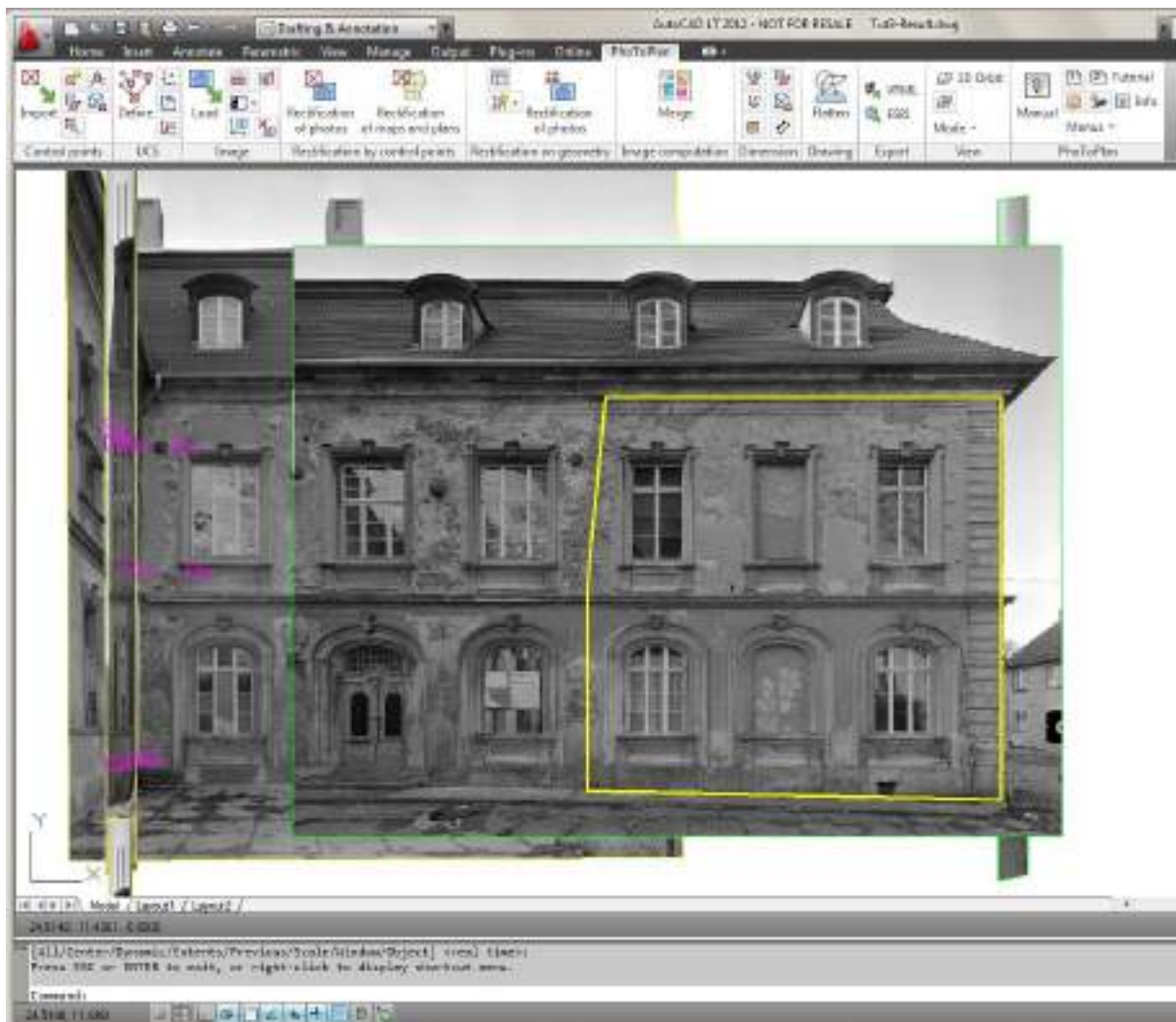
Now call up the command '**Image - Clip image'** from the As-Built Photo ribbon tab
. In the command line the following message will appear:

> Choose image to be clipped:

Now click on the edge of the right-hand side image of the southern facade. After that
you are asked to select the polyline for the boundaries of the image:

> Polyline for boundary or [Points/Further boundary/Delete cut/Back/Finish] <Finish>:

Click this one as well and the following message will appear:

> Polyline for further boundary or [Points/Choose boundary/Delete cut/Back/Finish] <Finish>:

Now you have the possibility to either exit the command with [Return] or to add
additional polylines for the definition of other parts of the image to be clipped. Finally
you will get:
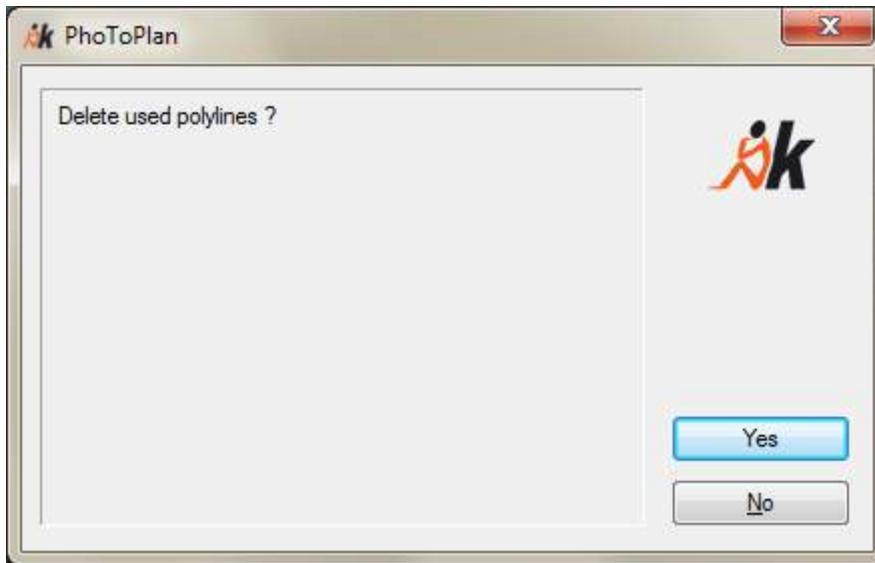
Answer this question with 'No' for the moment in order to see where exactly the
image is clipped. The result is presented as follows:
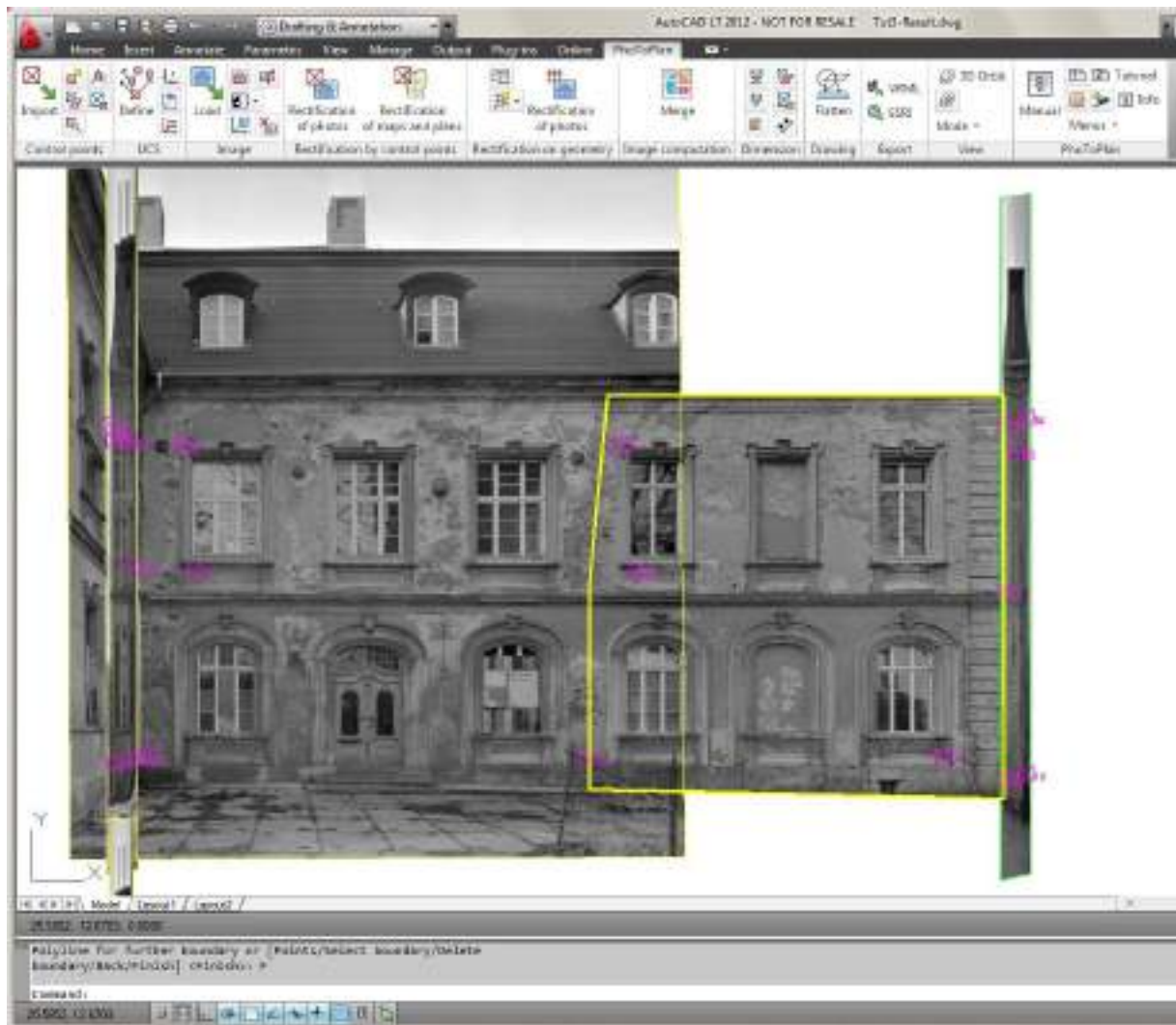
Clip the second image of the southern facade in the same way. Make sure that when you define the boundaries the images still overlap after the clipping. For the further processing of clipped images it's recommended to delete the polylines or displace them to the background by using the AutoCAD command '**Draw Order → Send to Back**' It's now easier to click the image.

The result might look like this:
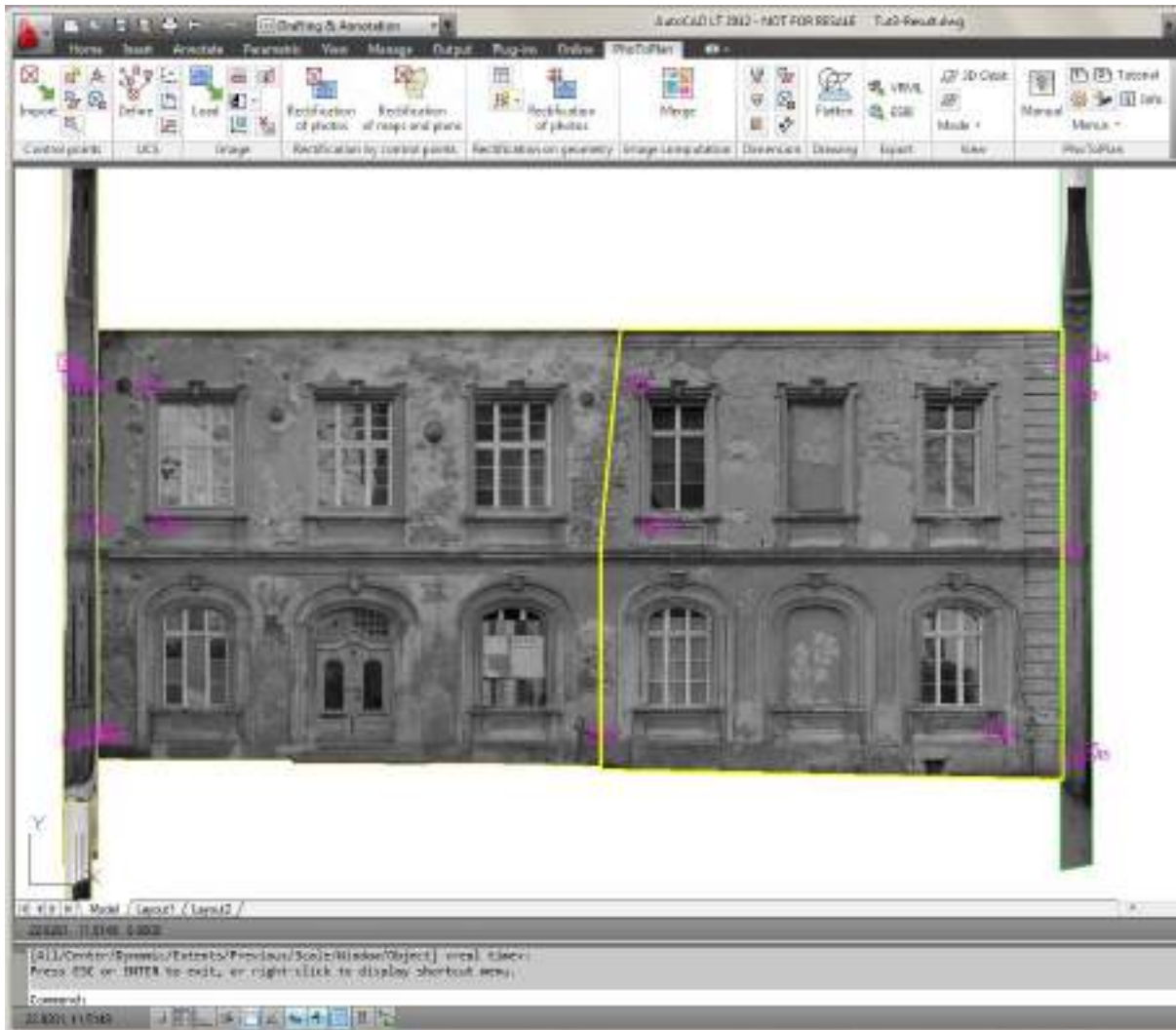
4.3   Merging of Images

If you want import the rectified images into an external image processing program for further processing a problem during the mutual positioning of the separate images will occur. In this case you would have to turn and move the images by eye in a way that the image clippings fit together. This will of course result in a problem concerning the measures. In order to avoid this situation As-Built offers the opportunity to melt more than one image to another (image merging).

To demonstrate this function we will continue with the example above and assemble the two clipped rectified images of the southern facade.

At first make sure that the UCS 'Southern View' is the current one as the images to be assembled are always projected onto the XY-plane of the current UCS. If necessary delete polylines still existing from clipping the images.

Select the command '**Image computations – Merging of images…**' in the As-Built Photo ribbon. In the following dialogue field you will see a list labelled '**source images**'. With **Add** you will come into the drawing and select the images with a click on their boundaries. Now you still have to define which image is to be the one 'on top' in the overlapping sections. This can be done with the arrow keys under '**Drawing**

Order'. Click on the corresponding image in the list and try with the keys '**Move above**' and '**Move below**' in what way the image view changes. Simultaneously the order of the images in the list will be adapted as well.
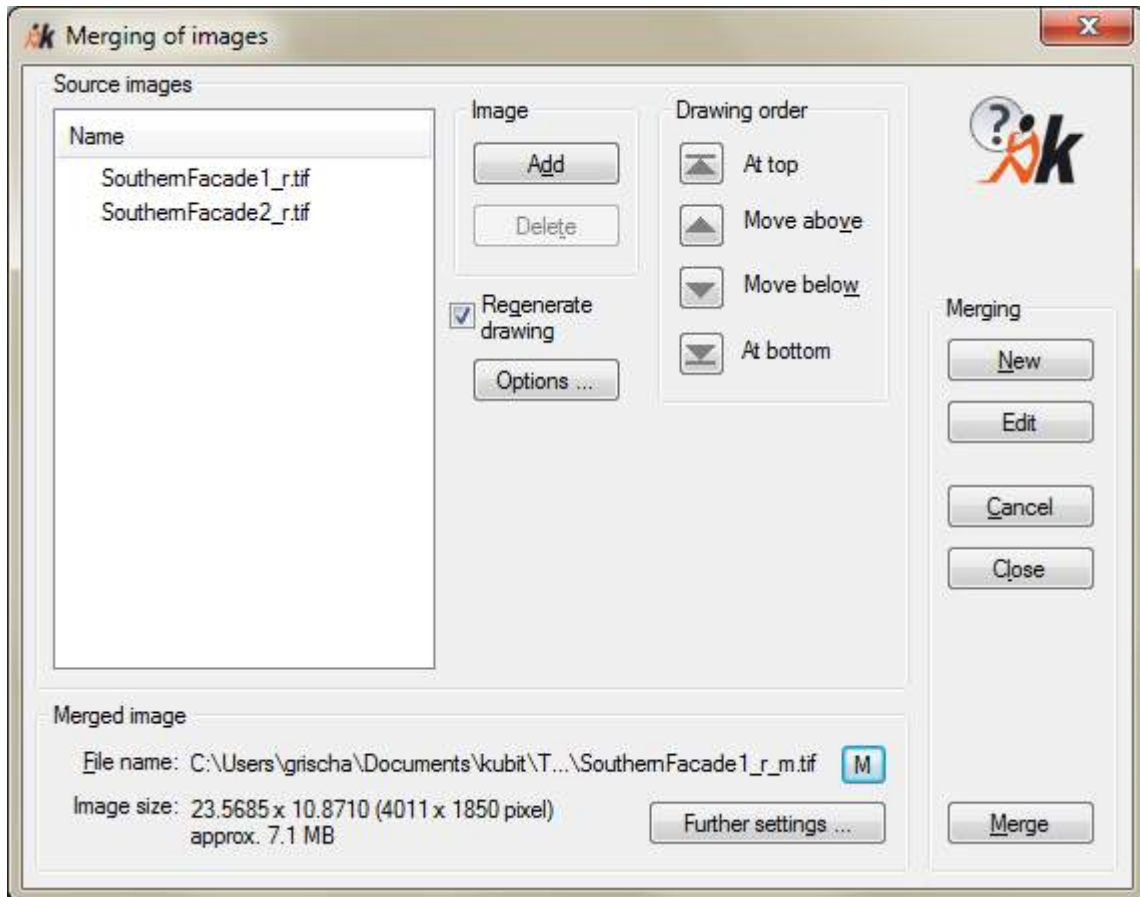
If you are satisfied with the image view you still have to input a few details concerning the assembled image.

Enter a file name for the 'Merged Image'. With '**...**' you will come to the corresponding file selection window. Please choose path and name for the new image. A detailed description about the three different path options you will find in the command reference under → **Image - Load image**.

With the button "**Further settings...**" you can control the properties of the merged image. The dialog is the same as the one in the rectification process. For further details on this dialog please refer to the **command reference page 7-37 (**Rectification by control points - Rectification of photos (Projective Transformation)**)**.

Please ignore the setting options under **"Options"** at the moment. Their functionality will be explained in section **7 Command Reference** under **Image computations – Merging of images…**

With a click on **Merge** you will now start the assembling process. Depending on your computer's capacity a certain waiting time will occur. In the status line of AutoCAD you may see the current processing status.

Below you see a possible result of a merging. The merged image is in the foreground above the rectified separate images. The image is stored under the file name stated in the dialogue window 'Merged image'.
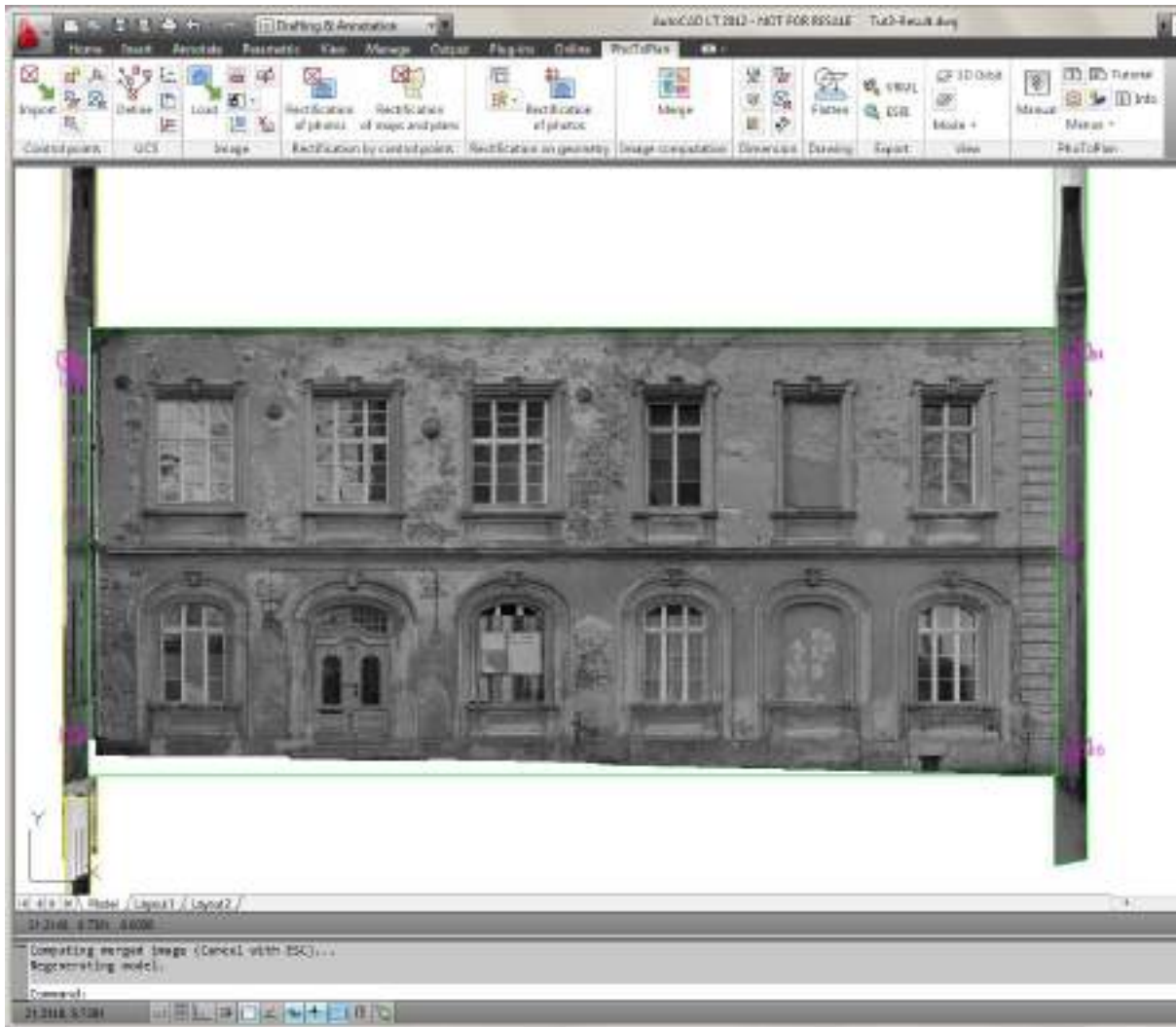
Hint: You may also use the →**Image computations – Merging of images…** command for merging scanned maps and plans. If you have bitonal images (one color and white or transparent background) of plans of different content for the same object – e.g. layout plans from different times or at different conditions – you may superpose these plans by merging them. Please also refer to the information given in chapter **2 Supported Image Formats**.

4.4   Intersection of Images

To create accurate intersection lines in 3D projects the software allows you to intersect images. After selecting two images a theoretical intersection edge is calculated and the images are trimmed to this edge. There are two options to trim or extend an image.

Only images whose image data reaches up to intersection edge can be intersected. After clipping an image, image data of cut off parts are only hidden but not deleted. That means even though the clipped image purely visual does not reach up to intersection edge it will be possible to intersect if image data of the non clipped image reaches up to this edge.

By selecting images which are parallel to each other or lie at same plane no intersection edge can be calculated and an error message appears. A detailed

description of this command and its options you will find in the command reference under **→ Image - Intersect image boundaries.**

4.5   Map Rectification according to Control Points

Old plans and maps on paper lose their scale over the years even under best storage conditions. The underlay material loses its shape through environmental influences or even through its own weight when it is stored hanging. Our software can compensate these global deformations. However, strong local deformations, e.g. creases, cannot be compensated.

You can generate the necessary reference information (control points) out of the grid or you are provided with separate control point coordinates which are identifiable on the map. It is important that you define a large number of control points that should be equally distributed on the map.

The polynomial that is to be used for map rectification depends on the specific case you are working on. A first degree polynomial can only describe affine transformations (rotation, scaling, shear) but is of advantage since it carries on linearly outside the set of control points.
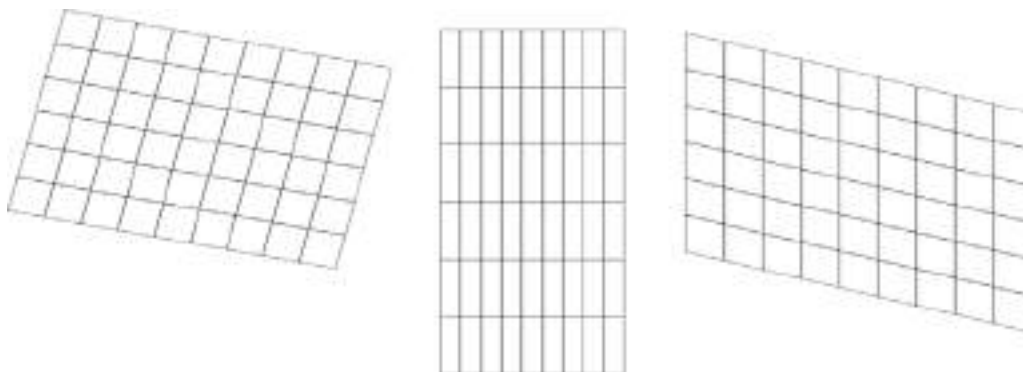
These rectifications can be described by a first degree polynomial (affine transformation).

Higher degree polynomials can already compensate crooked lines but they are not defined outside the set of control points. Thus the map must be clipped close to the area which is described by control points.
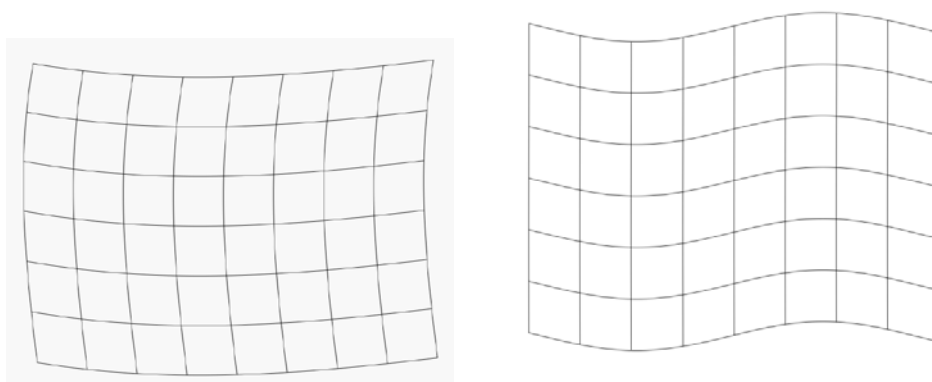
To compensate rectifications as shown above, you have to work with second or third degree polynomials.

The rectification process is run analogous to the photo rectification according to control points.

4.6   Photo Rectification according to Reference Measurements and Object Geometry

4.6.1   Lines and Measures as Reference Information

If there is no total station available for measuring in the control points, you will have to work with reference measures. For the rectification of an image at least two, better three, reference measures are required. Certain conditions are attached to the selection of the measures distances. These have to be followed unconditionally in order to achieve a good result.

The measurements are later assigned in the image with a statement concerning their real length. With the help of the rectification grid which is adapted to the distorted image at clear-cut edges standing perpendicular to each other it is stated how strong the projective distortion in the image is and in which direction it runs. In the Tutorial 2 you were already able to get a short idea of this procedure.

Determining and Measuring the Reference Measures

The reference measures have to be measurable unambiguously. They also have to be identifiable unambiguously in the photo. Edges, window and décor corners that are rich in contrast are especially suited. For additional support you may also mark the final points of the measures with stickers or chalk marks. Note the position and the lengths of the measures in a hand-made sketch.

Tape measures or hand-held lasers (e.g. DISTO) are suited for measuring the reference measures

Requirements to the Reference Measures

You will need at least two, better three, reference measures for each photo to be rectified. Certain conditions are attached to the course and the length of the measures. These have to be followed unconditionally in order to achieve a good result.

1. **The first and the second reference measure have to stand rectangular to each other and have to run along the directions of the grid lines of the rectification grid.**

   With the help of the first two reference measures the relation of height and width to each other in the rectified image is calculated. Therefore it is important that the measures run orthogonally to each other and parallel to the lines of the rectification grid. For example the height and width of a window are suited if one can assume that the window is 'straight" in the wall. On some objects it is difficult to find suited measures. Then one can make do with plumb lines and a horizontal scale attached directly to the object to be measured. These will then serve as reference measures.
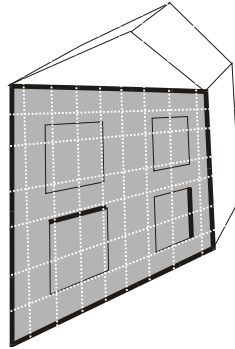
In principle it is better to select reference measurements that are as long as possible in order to obtain a good result. But very often shorter distances like width or length of a window are easier to measure than e.g. the complete width or height of a facade. Therefore the measuring of a third reference measurement is recommended.

2. The (optional) third reference measure should be long enough to represent the dimension of the object.

If you have selected relatively short distances for the first and the second reference measurements it is recommended to measure a third, longer distance. Its alignment can be chosen at random it thus may also run diagonally across the facade. With the help of the third distance the scale of the rectified image is calculated. The longer this distance is the more accurate is the calculated scale.

3. All reference measures have to lie in one plane.

Strictly seen an image rectification is only valid for one certain plane, the so-called **rectification plane**. Therefore this method for gaining geometry data is only suited for objects that show a rather flat structure, e.g. facades with relatively smooth walls, paintings, ceilings, floors. Not suited are round buildings, vaults, rock faces or buildings with an especially distinctive depth structure. Here you have to fall back on other evaluation procedures.

You must already have to know, during the definition and measuring of the reference measurements, on which plane you want to rectify. In most cases this will be the facade plane. All the reference measurements have to lie on this plane. If you want to rectify on another plane, e.g. a sloping roof plane, another complete set of reference measurements is necessary.
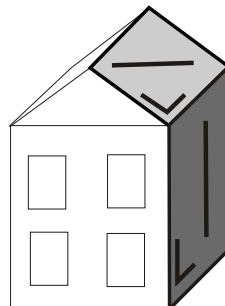
4. The Exactness of the Reference Measurements and the Exactness of the Rectification should be correlated with each other.

This correlation can best be explained with a concrete example:

Suppose you want to take measurements from your image after the rectification with an exactness of 5 cm. Then there are two error sources: the limited exactness of the

reference measurements on the object and the reference measurements' assignment in the image (definition of image coordinates). These errors will add up in the evaluation process. That means if you were able to measure the reference distances on the object with an exactness of 3 cm, 2 cm will be 'left over' for the rectification process. You have to check now whether you will be able to reach this exactness for the assignment of the measure in the object. That depends on the image resolution and quality as well as the ability to identify the reference distance measurements. You have to consider this:

You have a facade with a length of 20 m. Your digital image contains 1200 pixels along the facade. 1 pixel then corresponds to a length of 20m/1200 = 1,7 cm in reality. You can measure that accurately in your image, the resolution is thus sufficient. A precondition is that the final points of the reference measures can be identified unambiguously. If necessary you will have to mark the measures with chalk or tags before taking the photo.

Of course the question as to how well the rectification grid was adapted to the object geometry plays an important role as well for the exactness of the rectified image.

4.6.2   The Rectification Process

The principle run of rectification according to geometry is as follows:

1. step	**Loading the distorted image** The image to be rectified is loaded in AutoCAD and positioned at random.
2. step	**Distortion correction** Only necessary if the image has not been taken with a photogrammetric camera or has not been corrected in advance. By reading in a correction file or determination of the distortion within the image by means of horizontal or vertical straights.
3. step	**Adding on the rectification grid** The rectification grid is assigned to the image.
4. step	**Adapting the rectification grid** By pulling on the four main grid points the grid is adapted to the horizontal and vertical lines in the image.
5. step	**Assigning the reference measures** Call up the rectification dialogue. Enter the measured values for the reference measures and assign their position in the image → the rectification parameters may be calculated.
6. step	**Rectification process** As-Built calculates the rectified image with the help of the rectification parameters and stores it under the stated name. The rectified image is exactly positioned in AutoCAD.
7. step	**Image evaluation** e.g. setting up a facade plan with the help of the AutoCAD functionality.

The evaluation of the rectified image is almost unlimited. You may use the complete range of the AutoCAD functionality or import the rectification result in any other CAD system or image processing program capable of half-tone pictures.

The single steps of the rectification process are described in detail as follows.

1. Step – Loading the Distorted Image

Select the command '**Image - Load image**'. In the ribbon you will find it under the symbol ![symbol].

A dialogue for selecting the file appears. Pick out the image file and confirm with Load. In the command line you are asked for an insertion point and may open up a rectangle for the image size. The positioning and scaling can be selected at random they do not have any influence on the rectification result.

2. Step – Distortion correction

Photos, which have been taken with a regular digital camera have, depending of the quality of the lens, more or less distortions. Therefore our software offers the possibility to determine the distortion and to correct it before the rectification. The according command is →Rectification according to geometry - Correction of lens distortion ![symbol]. By reading in a correction file or by determination of the distortion within the image (by horizontal or vertical straights) the aberration, which occurs due to the distortion, can be eliminated.

3. Step – Adding on the Rectification Grid

In order to determine the degree of the distortion in the image you will have to mark two directions in the image which are at right angles to each other. A variable grid that is put over the image serves for that purpose.

The command '**Rectification according to geometry - Attach rectification grid**' or ![symbol] serves for inserting the grid. After the start of the command you are asked to select a distorted image. Click on the periphery of the previously loaded image. In the dialogue box which now appears you may state how many horizontal and vertical auxiliary lines the grid is supposed to have. Determine this number so, that all well visible horizontal and vertical edges in the image may be used for the adaptation of the grid. A maximum of 20 grid lines for each direction is possible. The grid is now positioned automatically above the image. It will appear in the current layer and assumes its colour. Each image can have only one rectification grid.

The rectification grid is a special As-Built object. If you want to carry out any alterations, e.g. moving, turning or scaling, this can only be done with image and grid together. The grid itself – with the exception of layer and type of lines - cannot be processed with AutoCAD-commands.

4. Step – Adapting the Rectification Grid

In the next step the grid has to be adapted in a way that the horizontal and vertical grid lines are congruent with two direction in the image that are at right angles to each other. Generally these will be horizontal and vertical edges on facades e.g. sides of buildings, upper and lower edges of buildings, window frames, ledges or décor lines. In order to do so the grid is marked with a click. At the main grid points (marked by circles) as well as at the auxiliary grid lines the 'handles' typical for AutoCAD will appear. With a click on one of the handles and 'pulling" with the mouse you may alter the grid.

With the main grid points you alter the grid's geometry. Try to adapt the grid as exactly as possible to the edges in the image in that way. This will be an iterative process, approach a constellation as optimal as possible in more than one run.

To control the adaptation you can use the auxiliary gridlines. They may be moved in parallel with the help of the handles. Position the auxiliary lines in a way that they lie on the clear-cut edges in the image. The rectification itself is not altered by this, the auxiliary lines really only serve as an aid for a better visualization on the screen. With the commands **'add horizontal auxiliary line'** , **'add vertical auxiliary line'** and **'delete auxiliary line'** you may adapt the number of auxiliary lines in both grid directions to your special requirements.
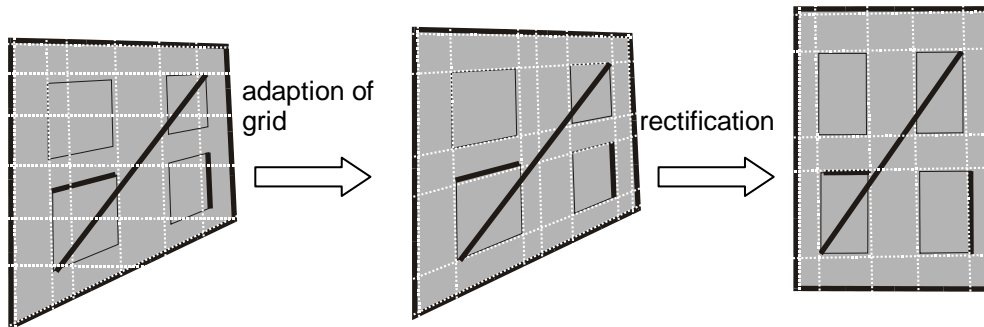
It is important that the edges that you use for the grid adaptation stand at right angles to each other in reality and that they lie in the rectification plane or parallel to it, respectively. The rectification plane is the one in which you measured your reference measures.

Of course you always have to make assumptions that cannot or only hardly be checked. You have to evaluate according to the building's structure whether or not you may 'trust" the building's geometry. At an old slanted half-timbered house e.g. one cannot assume that the props and crossbeams stand rectangular to each other. A rectification is possible anyway but you have to bear in mind that the result cannot be precise. In a modern framework construction on the other hand one can assume right angles in most cases.

5. Step – Assigning the Reference Measurements in the Image

When you have finished the grid adaptation call up the command '**Rectification according to geometry - Rectification of photos according to geometry (Projective transformation)'** .

In the rectification dialogue which appears go to **Rectification –** [**New**] and select the image to be rectified in the drawing. In the dialogue you will now see red question marks in all the places where you have to enter values.

Now assign the reference distances measured on the object to the distorted image. This procedure was already explained thoroughly in the Tutorial1.

Remember: After clicking the buttons

Width measurement (red)

Height measurement (green)

Large reference measurement (magenta)

you will come to the drawing where you state the start and end point of the distances. In the input fields 'length' you enter the corresponding measured values. The question marks are then replaced by green hooks.

You may edit the reference measurements' values and the image assignments as often as you want to. It is only important that in the end all entries are marked by a green hook.

6. Step – Image Rectification and Result

At this point the software has enough information to calculate the rectification parameters. Before starting the rectification process a few statements concerning the rectified image have to be made.

▪ **Alignment**

Here a line may be given optionally to which the rectified image is to be aligned. If the default 'according to UCS" is accepted the rectified image will be aligned according to the current user coordinate system (UCS). The alignment of the user coordinate system can be recognized by the XY symbol on the bottom left-hand side in the AutoCAD system.

or
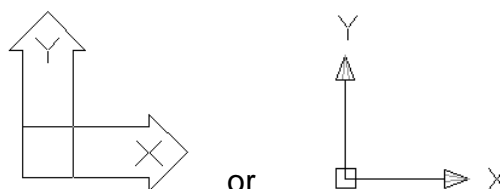
• **Insertion Point**

The definition of an insertion point for the rectified image is optional. A reference point in the source image is assigned to a randomly selected other point in the drawing at which the corresponding point of the rectified image will then be placed. If no insertion point is defined, the rectified image is automatically placed right of the distorted image.

• **File Name**

Here a path and a file name for the rectified image have to be given. With '**…**' you will come to a corresponding file selection window. You may choose between the image formats TIFF, JPEG, BMP and PNG. A detailed description about the three different path options you will find in the command reference under → **Image - Load image**.

With the button [Further settings] you can control the properties of the rectified image. For further details on this dialog please refer to the **command reference page 7-37.**

- **Image size**

  Here you see the information of an image in a compressed way:

  Image size in AutoCAD | Number of pixels

  Image size: 24.3253 x 23.3230 (3155 x 3025 Pixel)
               approx. 9.1 MB / 2.7 x Distorted Image

  Required disc space (uncompressed) and compared to the original image
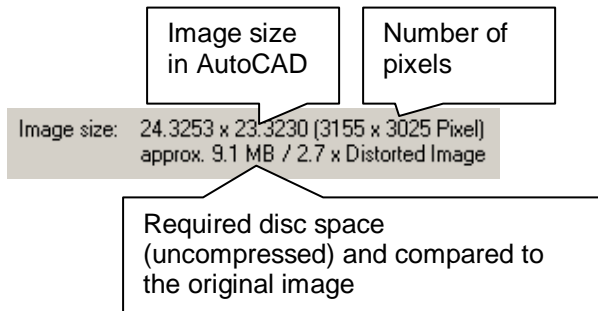
  Rectifying images with a huge projective distortion the file size of the resulting image may become immense. In that case it is recommendable to clip the image prior to rectification. This way only the relevant parts are rectified. The command '**Image - Clip image**' (refer to the command reference) serves this.

- **Rectification factor**

  Rectification 2.1 (normal angular shot)
  Factor:

  The rectification factor specifies the relation of rectified image area and distorted image area at optimal resolution. The higher the projective distortion in the original image, the higher is this factor. Usually this factor lies between 1 and 3. Higher values are only to be expected with a very high projective distortion. This factor is intended to help avoid extreme distortions which may require extensive calculations. As a little help, the rectification factor is commented.

When you have checked all these statements and if necessary adapted them then start the process with a click on the button [**Rectify**]. A display of the progress in the status line shows the process. The rectification may take a few minutes depending on the image size and your computer's capacity. The rectified image will be positioned at the point defined by the insertion point. The rectification is now complete.

Five files belong to each rectification:

- the AutoCAD drawing with the rectification

- the distorted image

- the rectified image

- a text file with the extension **.ppb** that contains the image position information of the rectified image. You will find more information concerning this in the command reference under '**Image rectification according to Geometry**'.

- a text file with the extension **.prk**, that serves as a protocol file and contains all important data of the rectification for you to read. You can find more information concerning this in the command reference under '**Image rectification according to geometry**'.

Accuracy of the Result

When you compare the two rectified images of Tutorial 1 and Tutorial 2 you will notice that they are not exactly congruent. There are differences in scale and geometry of a few centimetres.

The result of a rectification according to geometry cannot be as exact as the result of a rectification according to control points. These may be the reasons:

- The process is based on assumptions. During the adaptation of the rectification grid one has to assume that certain lines in the image run orthogonal or parallel, respectively, to each other. It depends on the building's type and structure whether or not one can make these assumptions. Old slanted beam and crossbeam constructions or extremely dilapidated facades may not show their original geometry anymore.

- The exactness of the entered reference values decisively determines the quality of the result. A previous calculation error as described in **4.6.1 Lines and Measures as Reference Information** is recommended. The better the measured reference values fulfil the requirements explained there the more precise the result will be.

- The procedure works without an over-determination. That means only a minimal set of information is available for calculating the rectification parameters. Thus an error control is not possible. A probable inexactness or an error when taking down the reference measures is not noticed.

If measuring equipment is at your disposal you should thus always prefer the rectification according to control points to the rectification according to geometry.

4.7   Photos – Shooting and Digitizing

There are various possibilities and ways of acquiring the digital source images. The question as to which camera is best suited plays a role, as well as image resolution and image format.

Camera

For taking the photos you may either use a digital or a conventional analogue camera. In the latter case the photo still has to be digitalized. There are advantages and disadvantages to both methods, the ideal solution depends on each individual situation.

Crucial for the quality of a camera is the quality of its lens (distortion qualities, resolution, colour clarity, correction of image plane) as well as the quality of the CCD matrix or the film (resolution, colour / brightness)

As the objects to be measured are mostly facades, wide angle images seem to be suited best in order to make do with as few images as possible. But be careful: the more wide angled an object lens is, the stronger the cushion or barrel shaped **distortions** due to the geometry of the lens will appear on the edge of the image.
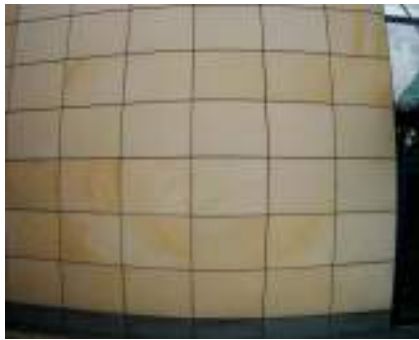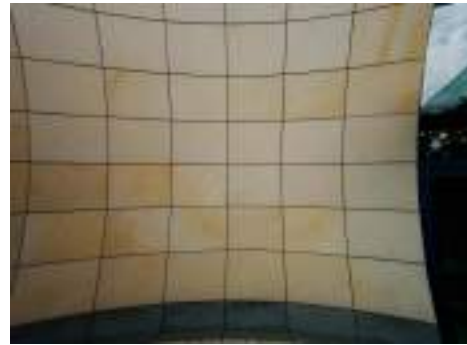
barrel shaped distortion   cushion shaped distortion

These distortions can be eliminated up to a certain degree. Please refer to section '**Correction of lens distortion**' in the command reference. It is recommended to use a high quality object lens with distortion correction. With the help of special additional lenses these cameras try to reduce the distortion as far as possible.

Hints: Extremely wide angled object lenses are not suited for measuring distances in images since their distortions cannot always be fully eliminated.

A <u>fixed</u> lens is advisable. **No zoom** is to be used for the photos. Turn off the autofocus. Either zoom out completely or not at all. It is possible to fix the focus by the help of sticky tape. Or simply use cameras without zoom lenses.

Resolution

In most cases analogue images and a good digitalization will lead to a higher resolution as images taken with digital cameras.

The decision on which camera you use should depend on how much you have to be able to recognize on the image in order to carry out a concrete task. As a basis you should not use a resolution as high as possible but only as high as necessary. In the source image for the rectification you have to be able to clearly make out all the details that you want to capture. A rectification just 'lines up' the image 'in a straight row' but does not add information. A too high resolution on the other hand takes up too much storage capacity and slows down the image processing functions of the computer.

From our own experience only digital cameras with an image size of at least 3 million pixels (which equals an image format of about 1500x2000 pixels) are suited for taking images of facades. With an easy calculation you may find out whether or not you camera is sufficient for the concrete task.

In order to do so you have to know the number of pixels N and the focal length f (with reference to the 35 mm film format) of your camera as well as the typical distance when taking the pictures E on the object. The following formula will then give you the size n_o of a pixel on the object:

$$n_o = \frac{0,024m \cdot E}{\sqrt{\frac{N}{1,5}} \cdot f}$$

Common digital cameras usually have a minimum focal length $f = 35$ mm. The following chart tells you how the number of pixels of your camera and the size of the pixel on the object depend on each other for various distances.

f = 35 mm		Distance when taking the pictures E in m				
Number of pixels N in the camera		5	10	25	50	100
	1.5 million	3.4 mm	6.9 mm	17 mm	34 mm	69 mm
	2 million	3.0 mm	5.9 mm	15 mm	30 mm	59 mm
	3 million	2.4 mm	4.8 mm	12 mm	24 mm	49 mm
	4 million	2.1 mm	4.2 mm	11 mm	21 mm	42 mm
	6 million	1.7 mm	3.4 mm	8.6 mm	17 mm	34 mm

This data give the best possible value of exactness with which you can measure in the digital image. Image quality and the ability to identify the reference measurements on the image will increase this value more or less.

Image Exposure

Consistent exposure, coverage and illumination of the object is required. Beware deep dark shadows. Plan for the best time of day (position of the sun, overcast weather). Use a tripod and cable release or remote control to get sharp images.

Digitalization and File Format

With photographs there is furthermore the question of the digitalization. For this there are various possibilities. An obvious solution would be a flat bed scanner to scan in the printed images. A disadvantage is that the scanned image is additionally distorted if the paper image is not put plan into the scanner. Also the image quality (contrast and amount of tone values) will decrease. Especially for tasks that require a high exactness this method is not recommended. As an alternative you may scan in slides or negatives directly. There are special devices for this which are relatively expensive. The simplest method is to develop a film on CD ROM (e.g. Kodak Photo CD). Many photo laboratories offer this service at relatively low costs. Thus at a standard level you will obtain about 6 million pixels from a 35 mm film negative and you do not have to carry out the additional steps of work.

You may choose between TIFF, JPEG, BMP and PNG as a file format for the images. If the images are available in another format they must to be converted into one of these formats.

4.8   The camera parameter file (VP2)

The camera parameter file (*.VP2) is a text file, used in order to repeatedly use certain parameters and the calibration data of the used camera (inner orientation), which have already been determined for the →**Correction of lens distortion** and the →**Image orientation**. That way it is possible to save time with the photogrammetric processes.

By doing so, it is not necessary, to determine the distortion and the remaining camera parameters again, for photos, taken with the same camera, the same focal length and format.

If several cameras have been used, it is reasonable to establish a library of VP2 files.

In our software the VP2 file is either generated and saved via the → **Correction of lens distortion** or the →**Image orientation** command.

The format of the file looks as follows:

```
 1    Name                   DSC_0027
 2    ImageWidth             4288
 3    ImageHeight            2848
 4    BHPx                   2144.0000000
 5    BHPy                   1424.0000000
 6    R0                     1607.4430586
 7    K1                     -1.6073702473e-008
 8    K2                     1.0027871993e-015
 9    P1                     1.1694952768e-006
10    P2                     1.6846092649e-007
11    LensLength_MM          5.0000000000e+001
12    SensorElementSizeX_MM  1.5534979113e-002
13    SensorElementSizeY_MM  1.5534979113e-002
```

The first line contains the name of the image file, with the help of which the distortion and the camera parameter have been determined. The next lines contain the image width (sensor size in x) and the image height in pixels (sensor size in y).

BHPx and BHPy are the coordinates of the principal point, stated in pixels. R0, K1, K2, P1 and P2 are the distortion parameters without units. R0 is the zero radius of the distortion curve. K1 and K2 are the parameters of the radial-symmetric distortion, P1 and P2 the parameters of the radial-asymmetric distortion.

In lines 11 to 13 follow the focal length and the senor element measures in millimetres.

If a calibration protocol from a camera check outside of our software is available for the camera, it may be used in order to generate a VP2-file. For Rollei Metric cameras we have prepared an Excel sheet that helps you to create a VP2 file from the data of the calibration protocol of your camera. You find it in the Box for AutoCAD installation folder under "Tools\Photo".

The following shows the connections between the sizes within the calibration protocol of a Rollei-Metric camera and the information of the VP2 file from FARO:

The auxiliary quantity f is used in formulas further down:

$$f = 1.0 / PixelSize\_MM$$

Image size in pixels:

$$VP2.ImageWidth = SensorSize\_Pixel\_X$$

$$VP2.ImageHeight = SensorSize\_Pixel\_Y$$

Radial-symmetric distortion:

$$VP2.K1 = A1\_MM / f^2$$

$$VP2.K2 = A2\_MM / f^4$$

Radial-asymmetric distortion:

VP2.P1 = B1_MM / f

VP2.P2 = B2_MM / f

Principal point in pixels:

VP2.BHPx = f * XH_MM + SensorSize_Pixel_X / 2

VP2.BHPy = SensorSize_Pixel_Y / 2 - f * YH_MM

Zero radius without unit:

VP2.R0 = f * R0_MM

Focal length in millimetres:

VP2.LensLength_MM = | CK_MM |

Sensor element size in millimetres:

VP2.SensorElementSizeX_MM = PixelSize_MM

VP2.SensorElementSizeY_MM = PixelSize_MM

A numerical example:

Protocol data of the camera check:

Focal length in millimetres:

CK_MM = -24,409 mm

Principal point in millimetres:

XH_MM = 0,073 mm

YH_MM = -0,084 mm

Radial-symmetric distortion in millimetres:

A1_MM = -1,482e-04

A2_MM = 2,177e-07

Radial-asymmetric distortion in millimetres:

B1_MM = 1,445e-05

B2_MM = -5,276e-06

Zero radius in millimetres:

R0_MM = 0,0 mm

Information regarding the sensor:

SensorSize_Pixel_X = 4256

SensorSize_Pixel_Y = 2832

PixelSize_MM = 0,0085 mm

Calculation of the parameters for the VP2 file:

f = 117,64705882352941176470588235294

VP2.ImageWidth = 4256

VP2.ImageHeight = 2832

VP2.K1 = -1,070745e-8

VP2.K2 = 1,13640760625e-15

VP2.P1 = 1,22825e-7

VP2.P2 = -4,4846e-8

VP2.BHPx = 2136,6

VP2.BHPy = 1425,9

VP2.R0 = 0,0

VP2.LensLength_MM = 24,409

VP2.SensorElementSizeX_MM = 0,0085

VP2.SensorElementSizeY_MM = 0,0085

4.9   Maps and Plans – Digitizing

In contrast to scanning 35 mm film negatives or printed photos, digitalizing maps and plans does not require such a high resolution. Normally, a resolution between 100 and 300 DPI will suffice. If you want to digitalize paper plans or drawings (e.g. plans of buildings), creating a black and white image is sufficient. This saves memory and contrasts are higher than in grey scale or colour scans.

4.10 Handing on the results

AutoCAD drawings created with our software mostly contain one or more images or photos. If these data (drawing and the according images) shall be handed on to other editors or customers, it makes sense to load or save the original distorted image as well as the rectified image with the appropriate settings for the path. Detailed explanations on the possible path setting are to be found in the command reference under →**Image - Load image**.

A simpler way to ensure that all files linked with a drawing are handed on is provided by the AutoCAD command '**eTransmit**'. This command offers a wizard that helps to assemble all data that you want to forward to other people. For a detailed description of the command '**eTransmit**' please refer to the AutoCAD help.

4.11 Processing of output images in external software programs

Images that have been rectified or merged with our software can be further processed outside of AutoCAD using image processing software like Photoshop or GIMP. In order to obtain the desired scale certain settings for the correct image size have to be done. As-Built provides this information in the 'Further settings' dialogue, that can be opened during the rectification or merging process. Just click on the Button 'Further Settings'

Also refer to the command reference →Rectification by control points - Rectification of photos (Projective Transformation), →Rectification according to geometry - Rectification of photos according to geometry (Projective transformation), →Image computations – Merging of images…

To scale an image outside of AutoCAD

The following example shows the proceeding for obtaining the desired image scale outside of AutoCAD.
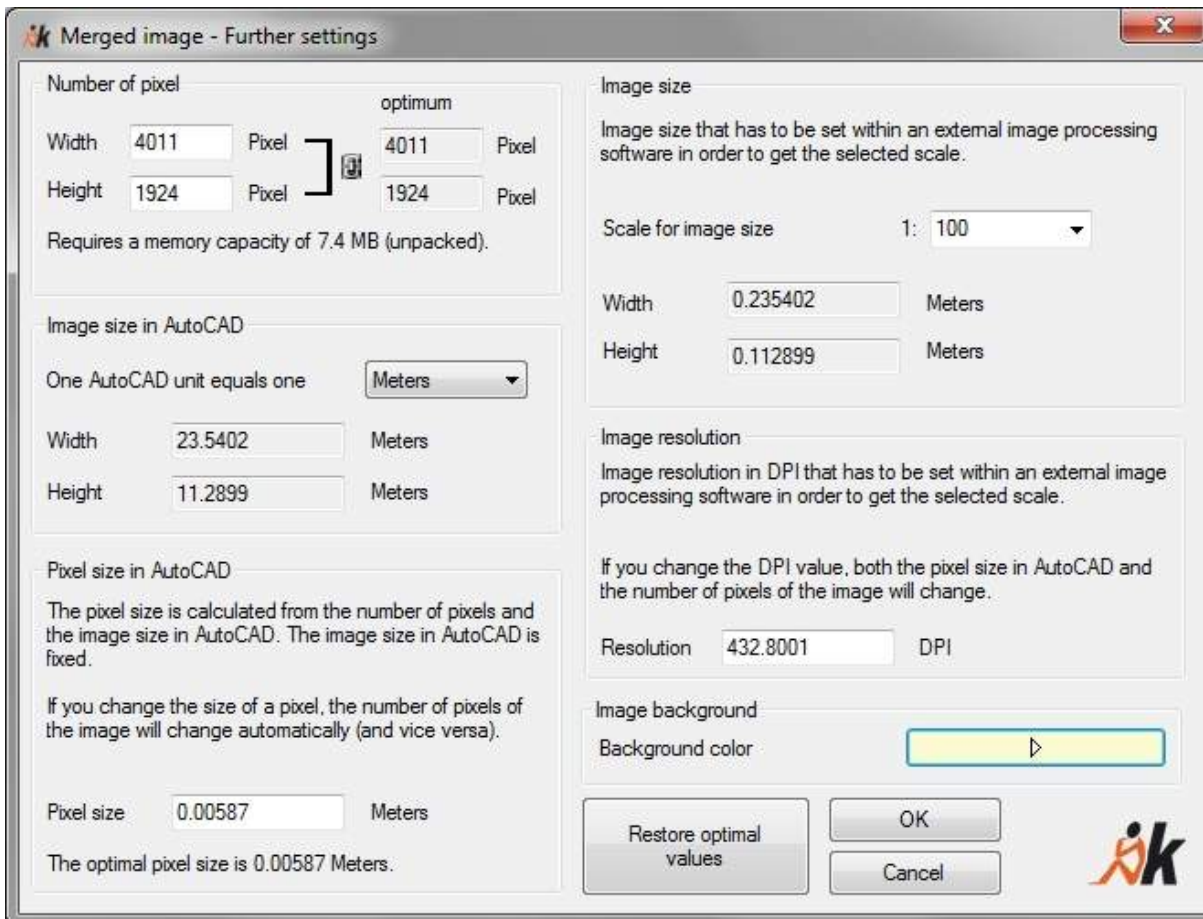
On the right hand side of the window 'Further settings' select the scale you want to obtain within the external image processing software. The width and the height of the image are now shown directly below the scale. The units correspond with those set in the left part of the dialogue. You should note down these values as well as the image resolution and the number of pixels for the width and the height, since you will need them later.

After rectification/merging in our software you open the resulting image in the external program. Every image processing software has a command for image size settings. Mostly it is named ''image size' or 'print size' or similar in the menu. In these settings you have to type in the image width and height you wrote down. In some programs alternatively the DPI value can be entered.

Important advices:

- Please observe the unit of the values. You need to set the same unit that was used in As-Built.

- The proportion of the image must be preserved. That means the ratio of image length and width must not be changed.

- You must not resample the image. That means the number of pixels in width and height must not be changed.

- The software must not round the values for image width and height. Rounded values will adulterate the image scale.

Image processing programs that cannot provide this functionality are not suitable for true to scale tasks.

Image merging outside AutoCAD

If you want to rework and merge the rectified images with an external program, the As-Built merge option 'create separate images' may be helpful. For further details about the handling of this option please read the command reference under →**Image computations – Merging of images…**
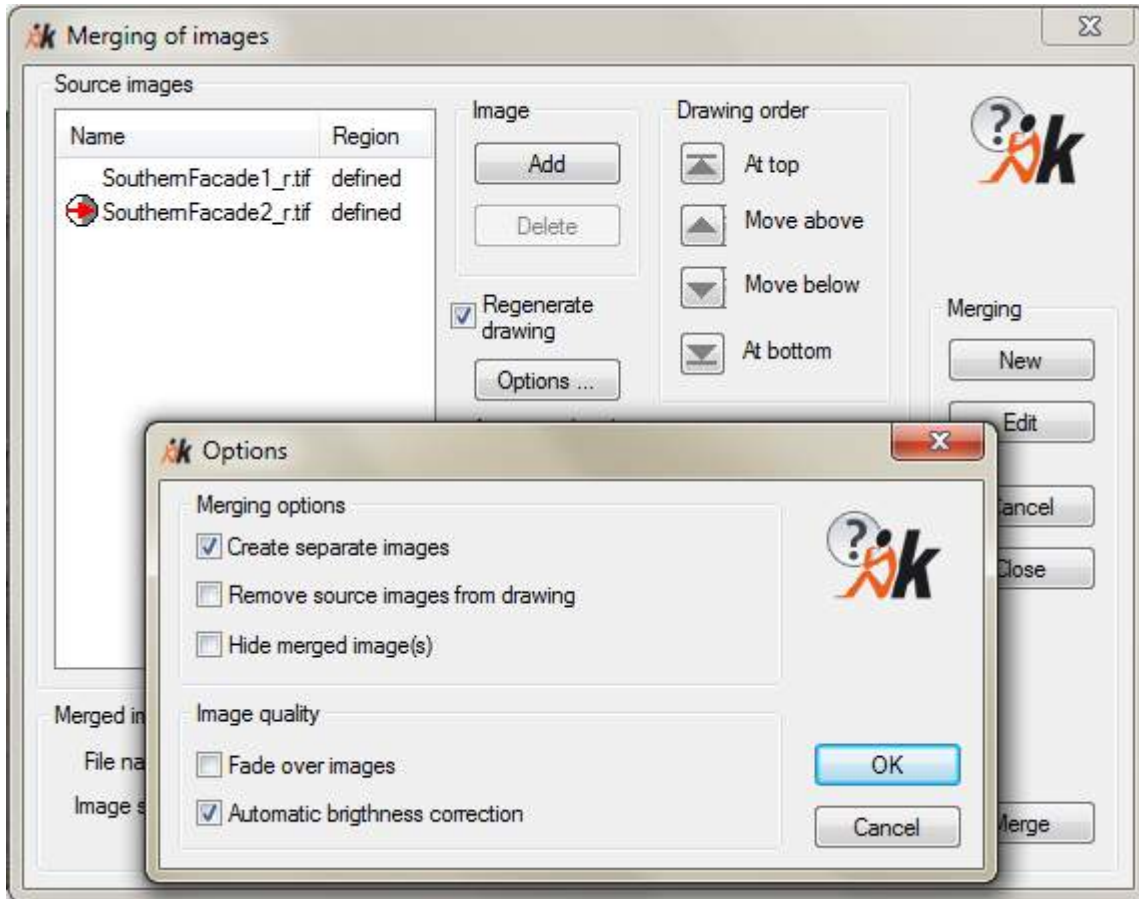
If you activate this option, As-Built generates one separate image for each source image. The created images all have the size of the complete montage.

In the external image processing software you may overlay these separate images as layers and design the cutting edges and transitions by hand.

In the following this process is described roughly. Surely there will be differences in detail between the several programs.

Please open the separate merged images that were generated by As-Built. Create a new empty image that has the same size than the merged images (width, height). Please observe the image scale settings (described above). Create as much new layers as the number of merged images in this empty file. In the next step insert the separate merged images (they have all the same size) into the empty file, each on one layer.
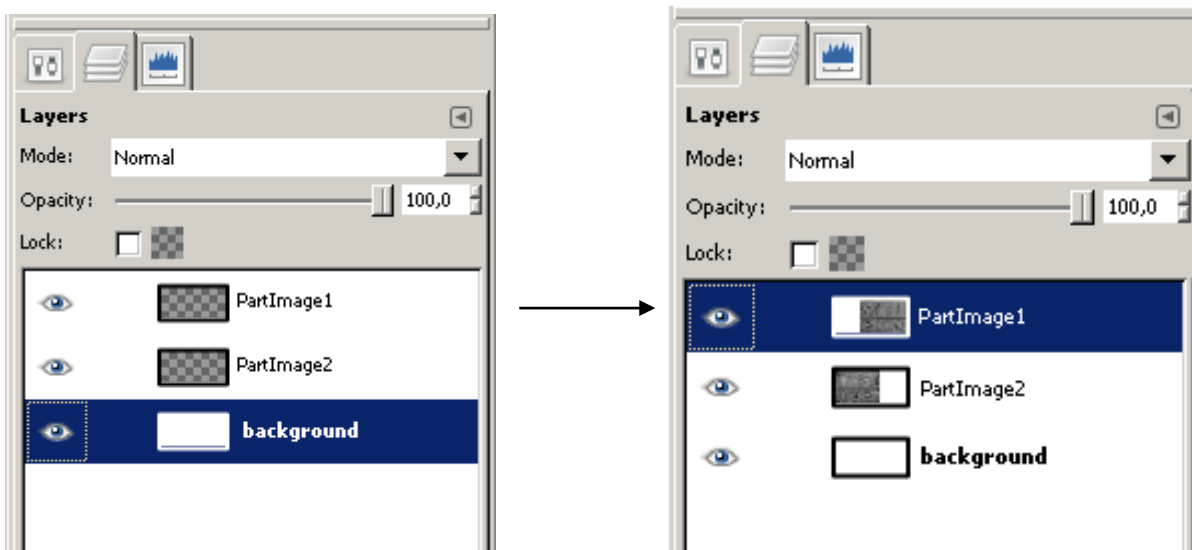
Now use the tools of the programs to cut and finish part images. The result of the merged images could kook similar to this:

5   Working with Oriented Images

After you have gained knowledge about the image rectification in the preceding sections you will, in this chapter, learn about working with oriented images. Requirements for the three-dimensional evaluation of photos are information about the position and orientation of the images of the object to be measured and displayed. The first part of this chapter will therefore introduce you to the image orientation. Furthermore you will get to know the methods of the photogrammetric evaluation of oriented images within AutoCAD.

5.1   Image orientation
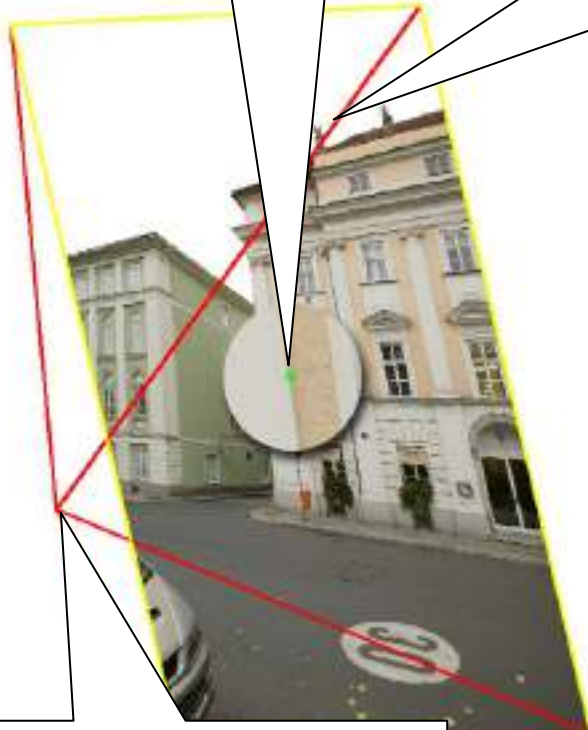
As-Built defines a new class of pixel images inside AutoCAD – the oriented images. These are the result of the image orientation process. You may immediately work with them in As-Built, for example generate 3D models, take measures, calculate surfaces and volumes. The oriented images will be saved as separate file for the processing within other AutoCAD drawings. You may choose between TIFF, JPEG, BMP or PNG as file format.

Oriented images know their inner and outer orientation parameters.

Principal of an image
Foot of perpendicular from the center of projection to the image, normally the center of the image

Reference lines from the image corners to the center of projection.
They help with the 3D navigation, for a better capturing of the position of the image within space. They can be switched off if necessary (→ **3D Images – Show/hide auxiliary lines**)

Layer	KUBITORIIMAGE
Linetype	——— ByLayer
LinetypeScale	1
PlotStyleName	ByColor
Lineweight	——— ByLayer
Hyperlinks	Hyperlinks
Material	ByLayer
Image Properties	▲
Name	DSC_0019_orien...
Path	K:\kubit\Projekt...
Width (Pixel)	4288
Height (Pixel)	2848
Transparency	0
Scale	20
Show 3D graphics	Off
Locked	Yes
Image Adjust	▲
Brightness	50
Contrast	50
Fade	0
Interior orientation	▲
Focal length	0.05
Sensor element width	0.000015324
Sensor element height	0.000015324
Exterior orientation	▲
Camera center point X (WCS)	-11.1967
Camera center point Y (WCS)	-8.4931
Camera center point Z (WCS)	11.951
Vertical angle	22
Horizontal angle	218
Twist	269

Center of projection
Is equivalent to the focal point of the camera.

Display size of the oriented image

By default, the oriented image is displayed with the setting "small". Via the AutoCAD properties window of the oriented image you may call up scale, which has been set to 20 for the default setting. This scale refers to the distance of the center of projection to the image plane. That means, that the image will be displayed with the 20-fold focal length and therefore in most cases will be comfortably visible within the drawing. There are two ways to change the display size:

- You may customize the display size of the oriented image flexibly by changing the scale factor within the properties window.

- Two default sizes are offered by the command →**Oriented Images – Set size** – "small" and "large". "Large" means, that the image will be enlarged and it will be placed behind all AutoCAD graphics that are visible within the current view. That is important for the further work with the image, so it will not cover the graphic. If the drawing does not contain a graphic which could be covered, the command doesn't have any effect.

But how to generate oriented images?

A typical course of a project

Certainly, every project has its distinctive features. But there are essential similarities for the basic procedure when orienting images:

1. step: set and measure control points

2. step: taking photos (and digitizing them)

3. step: transforming images into a compatible file format where applicable

4. step: distortion correction where applicable

5. step: orienting the individual images with As-Built or automatic orientation with an external software (e.g. Agisoft PhotoScan, Recap Photo) and import in As-Built.

6. step: evaluation of the oriented images within AutoCAD .

5.1.1   Control points as reference information

Every photo has a certain spatial position and alignment at the time of the shooting. In photogrammetry we speak of the inner and outer orientation. The purpose of the image orientation is the determination of the inner and outer orientation parameters. The inner orientation parameters are:

- The position of the principal point of the image.

- The focal length of the camera.

- The dimensions of a pixel.

The outer orientation is a fixed transformation of the coordinate system of the camera into the world coordinate system. This transformation contains the position of the focal point and the spatial orientation of the camera.

In order to determine these parameters control points are used. Those are marked at the measurement object, photographed and measured with the help of a total station. The control points are assigned to the corresponding points within the photo. On the basis of this point assignment the software calculates the orientation of the image.

The number of needed control points depends on the fact, if information regarding the distortion and the parameters of the camera are already available or if these have to be calculated as well.

Determining and marking the control points

At the object the control points have to be clearly marked and a number has to be assigned. There are two ways of marking. You either put clearly visible stickers on the façade (advantage: enough contrast) or you select natural points, which are rich in contrast and clearly identifiable. Joints or decors are suitable. A control point should be as even as possible, so there won't be any mistakes when measuring with the total station. This is, because of the lacking bundling of the laser beam, the case when measuring corners. You record the position and point number in a sketch. The control points are photographed together with the object to be evaluated.

Note: Instead of using a sketch you may also print a photo in an adequate resolution in order to mark the control points there.

Measuring the Control Points with a Total station

In order to orientate an image the coordinates of the control points have to be determined. Generally this is done with a total station preferably one with a reflector-less distances measurement. With such equipment you get X-, Y- and Z-coordinates for each point. These are stored as an ASCII-file in a consistent format so they can be imported into AutoCAD. Here is an example for such a control point coordinate file:

```
1     95.8471   499.8149   0.72767
2     98.8529   499.8200   0.46680
3    106.4943   567.0582   0.21383
4    103.5116   567.0733   0.22545
5     56.8697   566.3471   1.76136
6     56.8716   554.7248   1.87118
```

The point number are in the first column, followed by three columns with the X, Y, Z coordinates of the points. The order of the columns can be selected at will. If there should be additional columns (some instruments save additional information) these will be ignored. Unless you want to place certain control points on different AutoCAD layers. In that case you can import another column with the layer information.

Note: Alternatively As-Built offers the possibility to transfer control points directly into your drawing using a total station (As-Built Total Station Interface). Whenever coordinates are expected or you have an option <measure> data can be transferred directly from the total station to the AutoCAD drawing.

Requirements to the control points

1. At least nine control points are necessary for every image.

In order to be able to calculate the orientation definitely, you will need at least nine control points as reference information. You should always use **more points** though. Then there is an over-determination and a statistical adjustment is calculated. This allows checking the measured control point coordinates respectively their assignment. This way mistakes or imprecision can be pinpointed.

The **needed number** of control points will be **reduced to six**, when the distortion does not have to be calculated automatically, since the image to be oriented has already been corrected or when the parameters of the distortion are already known.

If, in addition, the focal length of the camera and the size of the sensor elements (pixel) are known, you need **only at least 4 control points** for the image orientation.

2. The spatial distribution of the control points for the image orientation has to be even

The better the spatial distribution of the control points, the more stable is the algorithms calculation for the inner and outer orientation parameters of the photo. All control points should be pictured within the photo and be clearly identifiable. They should be spread evenly across the complete image. The control points **must not** be **in one plane** but should be spread as evenly as possible across space. That means they should be in different depths within the image. The control points should not in corners or on edges to ensure higher accuracy during the measurement with the total station (distance measurement).

3. The accuracy of the control point determination and the orientation accuracy should be coordinated

It does not make sense to assign the control points within the image accurate to the millimetre for example, when the total station has measured the control points only accurate to the centimetre. On the other hand you do not have to be too accurate when measuring the control points, if you can only measure the control points within your image accurate to the decimetre, due to the low resolution of your digital image and the lacking identifiability of the points.

5.1.2   Information regarding the photo planning for the multi image evaluation

For **large-scale evaluations** it is recommended, to take a "ring" of photos around the object, with an overlap of the photos of greater than 50%. If possible, the photos should be taken from a height about half way up the object. In order to be able to connect the photos it is recommended, to include the context or setting (ground line and/or skyline). There should be a photo of every object edge which also shows the two adjacent sides. If possible, the roof should also be visible within the photos. Important: no image should lack overlap to the next photo and every photo should contain enough visible control points (see section 5.1.1). For an overview rectangular photos of the complete façade are helpful.

For **detail evaluations** stereo image pairs should be taken. In a normal case a base-distance-ratio (ratio between the distance of the two camera positions and their distance to the object) of 1:4 to 1:5 is recommendable. For the convergent case the base-distance-ratio may lie between 1:10 and 1:15. The divergent case, that is, the basis between the shooting position is larger than the distance to the object, should implicitly be avoided. Add close-up squares on stereo-pairs for detail and measure control distances or place a scale bar in the view. The overlap of photography has to be checked. If in doubt add more shots and measured distances for any potentially obscured areas. It is important, that enough control points (at least four) are visible in the stereo image area.

A fixed optics are recommended. **No zoom** is to be used for the photos. Disable the auto-focus. Either zoom out completely or not at all. It is possible to fix the

focus using adhesive tape. Disable auto-focus. Or simply use cameras without zoom optics.

Use a fixed focal length for ring shootings and a second fixed focal length for details. Please note also the information in chapter 4.7 Photos – Shooting and Digitizing.

If you are using third party software such as Agisoft PhotoScan or Autodesk ReCap Photo for a fast and **automatic** image orientation, we highly recommend to observe the manufacturer's instructions for image capture in order to get good quality orientation results!

5.1.3   The image orientation process

Depending on the particular task, any number of images may be oriented within an AutoCAD drawing. The result of the image orientation is a new image as well as the corresponding file with the orientation data (extension: .ORI) and a protocol file (.PRK). From that file you can get the data of the inner and outer orientation, the used control points and the remaining errors and deviations of the calculation.

The calculated camera and distortion parameters can be saved to an appropriate file with the extension .VP2. That way this information is available for the orientation of other photos, taken with the same camera. In such a case you need less control points.

The necessary steps are described in the following.

You may try the described on your own using the data of TUTORIAL 4. Photos have been taken of two façades of a building. These photos can be orientated using the measured control points. The files of Tutorial 4 have not been installed with the setup because of their file size. Please, download them to your machine using following web link

(http://service.faro3dsoftware.com/DOWNLOADS/TutorialsVideos/PointSenseAutoCAD/Tutorial_Oriented_Images_en.zip).

As starting point for the exercise you only need an empty AutoCAD drawing and following files of tutorial 4:

- CONTROLPOINTS.KOO (control point coordinates)

- DSC_0027.JPG and DSC_0028.JPG (images to be orientated),

- as well as the digital control point sketch (TUTORIAL4_CONTROLSKETCH_IMAGEPOINTS.DWG).

The drawing TUTORIAL4_ORIENTEDIMAGES.DWG shows the result of the exercise.

Hint: Please, open the drawing with the control point sketch in a separate AutoCAD session, since newer versions of AutoCAD do no longer support switching between DWG files while a command is running.

1. At first the control points are imported into the drawing. They may be loaded from a text file IMPORTCP (→**Control points - Import control points**) or inserted via the NEWCP command **(→Control points - Define control points**). They may also be measured directly with a total station (As-Built Total Station Interface). For the tutorial run the →**Control points - Import control points** command and

select the CONTROLPOINTS.KOO file for import. Ensure the settings of the file format dialog correspond with the format of your control point file.

2. As the next step the drawing is rotated with the help of the 3D orbit (3DORBIT), so you approximately look at it like form the camera position. All control points contained in the image should be clearly visible.

3. Via the command PCSETUCS (→**UCS - UCS from current view**) a local UCS is defined. Its XY plane matches the current screen view exactly. When doing so, the control point symbols are rotated automatically, so the numbers can be read.

4. Now the image to be orientated is inserted with the command →**Image - Load image**. It is placed freely next to the control points. Note, you may have to enter a rotation in the dialog.
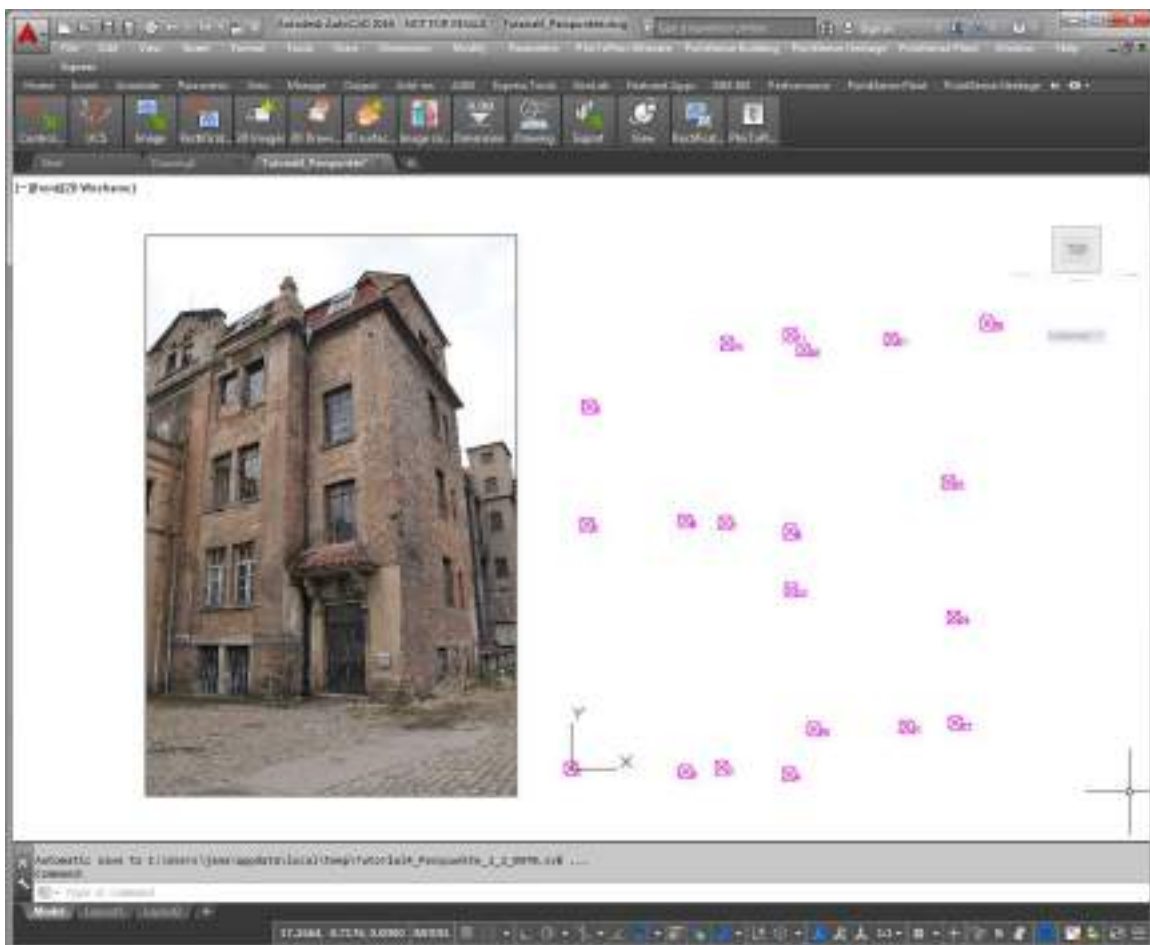
5. Now you will start the actual image orientation with the command PCIMGORI (→**Oriented Images – Image orientation**). In the dialog that opens click the [New] button and then select the image to be orientated. When you are back in the dialog, you have to click on [Add / Redefine] in order to be able to assign the corresponding points within the image to the control points. As-Built then calculates the parameters of the inner and outer orientation for the image. The remaining errors and deviations of the calculation are reported in the control point list. By (de)activating particular points you may influence the quality of the calculation. You may extend the image orientation dialog by using the button [Camera parameter >>], in order to adjust the following settings. If you have adjusted them you might be able to reduce the number of needed control points:

- Is the distortion correction for the image to be calculated simultaneously or are there already information regarding this?
- Are camera paramters already known? (From the calibration or from a previous orientation of an image which was shot with the same camera)

In order to be able to view and then to save the results of the orientation into a parameter file (VP2) ([Save camera parameters] button) use the [Details + Save…] button.

For further information regarding these options please refer to the command reference (→**Oriented Images – Image orientation**).

If there are no parameters known you need to assign at least nine control points. For the tutorial you find a control point sketch in TUTORIAL4_CONTROLSKETCH_IMAGEPOINTS.DWG. Please open this sketch in a separate AutoCAD session.
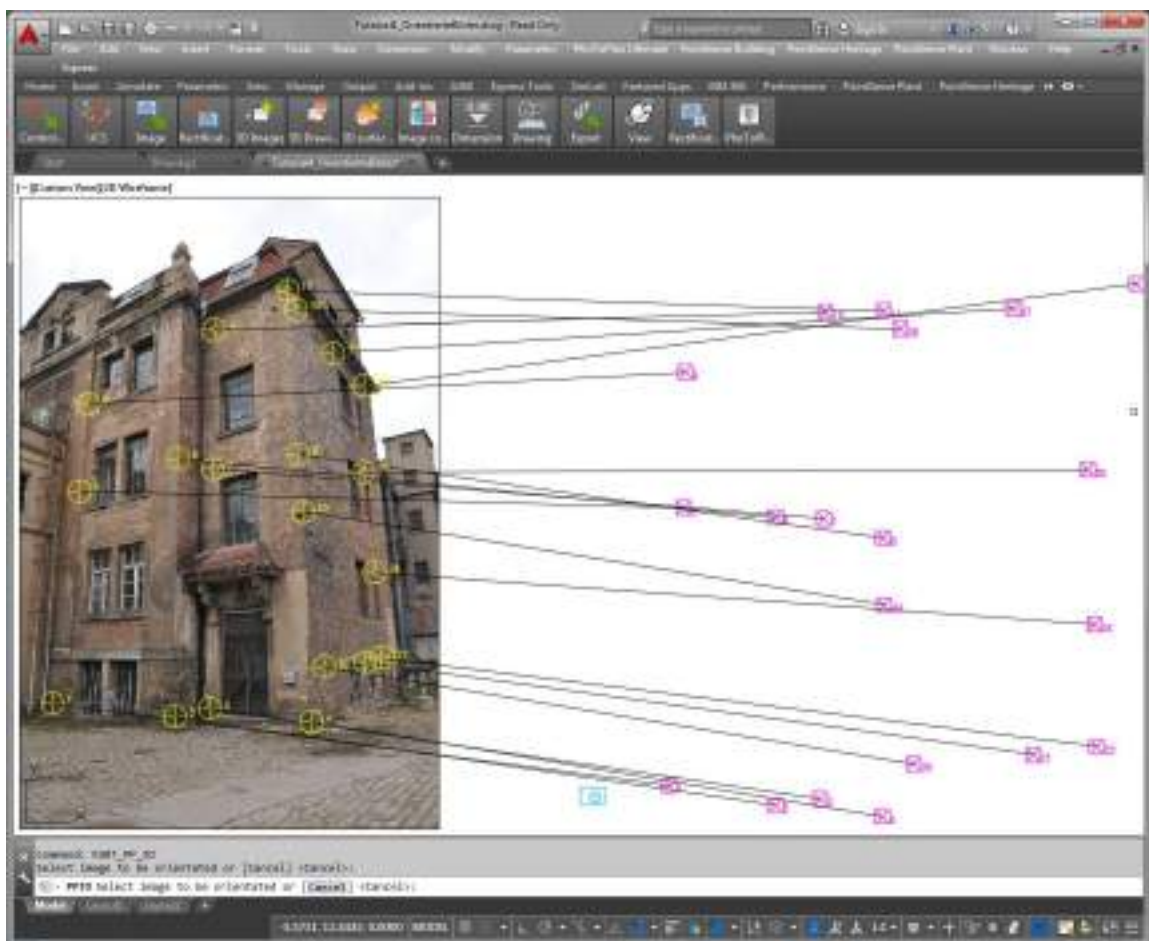
6. As result, the image is displayed as oriented image in the drawing. It is lying –
    within the calculation accuracy – exactly behind the used control points, so these
    are displayed congruent with the image. At the same time, As-Built switches to
    the camera navigation mode for the image (see →**Oriented Images – CamNav
    on**).

With the generated oriented image you may now model spatially, when adding surface information or a second image. For more information please read the following sections and pay special attention to the entries about 3D drawing within the command reference. You can find a detailed description of the format of images oriented with As-Built under →**Oriented Images – Load oriented image (kubit ORI format)**(page 7-59).

Note

You have taken a large number of photos of your object and want to orientate them fast and automated for later processing or modeling in As-Built? Then you may use the Autodesk ReCap Photo web service for image orientation and afterwards import the orientated photos to As-Built using the command →**Oriented Images – Import ReCap Photo project**.

Instead of the web service you may also use Agisoft PhotoScan for fast automated image orientation and then import the PhotoScan project with →**Oriented Images – Import Agisoft PhotoScan project** in FARO As-Built for AutoCAD.

For further detail please refer to the command reference for further detail.

5.2   Optimizing the image display in AutoCAD

When working with oriented images in the camera navigation mode often problems occur regarding the image display, e.g.:

- The image "jumps" when zooming or it is placed slightly shifted in space.

- The cursor does not respond correctly.

- The image is not visible although it has been loaded.

- The graphic is covered by the image, even though the image has been placed "behind" these elements.

The reason for this is that, when being in the camera navigation mode, AutoCAD is switched to the perspective mode (perspective projection). Then graphic elements and oriented image can be displayed congruently. Unfortunately AutoCAD has some lacks of performance for the image display, they can for the most part be eliminated by certain settings though. The used graphic board has also an influence on this.

Test the following settings:

Enter the command "3DCONFIG" or "GRAPHICSCONFIG" into the command line to check on graphics performance.

Enable the hardware acceleration.

AutoCAD is automatically searching for graphic cards updates.

Graphics Performance

Hardware Setup

Video Card: NVIDIA NVS 4200M

Driver Version: 9.18.13.1269   Virtual Device: DirectX 11

Effects Settings

Hardware Acceleration   On

Disable hardware acceleration only if you are experiencing
graphics issues or have an incompatible video card.

☑ **High quality geometry (for capable devices)**
    Renders curves and lineweights in high quality and improves anti-aliasing
    performance in 2D wireframe.

☑ **Smooth line display**
    Removes the jagged effect on the display of diagonal lines and curved
    edges in 2D wireframe.

☑ **Advanced material effects**
    Increases details and realism of certain materials applied to 3D surfaces.

☑ **Full shadow display**
    Displays 3D object shadows in the viewport.

☑ **Per-pixel lighting (Phong)**
    Increases details and realism when working with 3D objects and lighting
    effects.

☑ **Uncompressed textures**
    Uses more video memory to display better quality textures.

Restore Defaults   Tuner Log   OK   Cancel   Help

5.3   3D drawing with two and more oriented images

If you have at least two oriented images it is, with their help, possible to generate exactly positioned 3D drawing objects in AutoCAD. The needed commands are provided by As-Built within its ribbon.
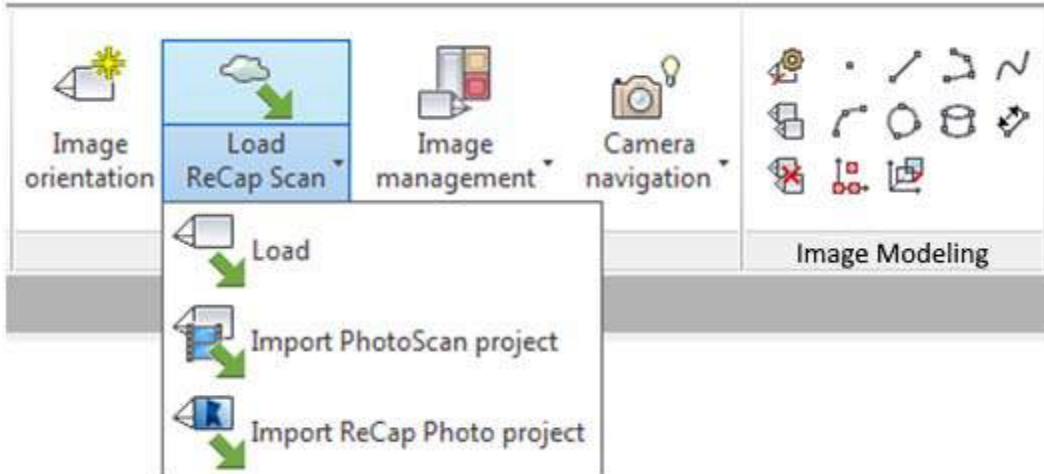
In order to be able to use these functions, proceed as follows:

1. At first load at least two oriented images into the drawing. To do so use the command →**Oriented Images – Load oriented image (kubit ORI format)**. You can find further information on this command in the command reference starting from page 7-59. Section 5.1 Image orientation describes how to generate oriented images. For the quality of the multiple image evaluation it is **important** that the angle between the images used is not too small and yet there have to be enough common points visible in the photos. In section 5.1.2 you find detailed information on planning the photo shooting.
   If you took many photos of your object and used Agisoft PhotoScan or Autodesk ReCap Photo for an automated orientation, you may import the oriented images into As-Built by using the commands:
   →**Oriented Images – Import Agisoft PhotoScan project**
   →**Oriented Images – Import ReCap Photo project**.

2. Following you have to open the Image management (→**Oriented Images – Image management**) and define at least two viewports, which - according to your screen format - are aligned side by side or one above the other.
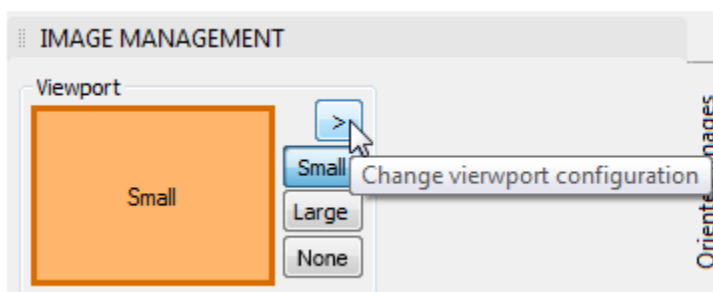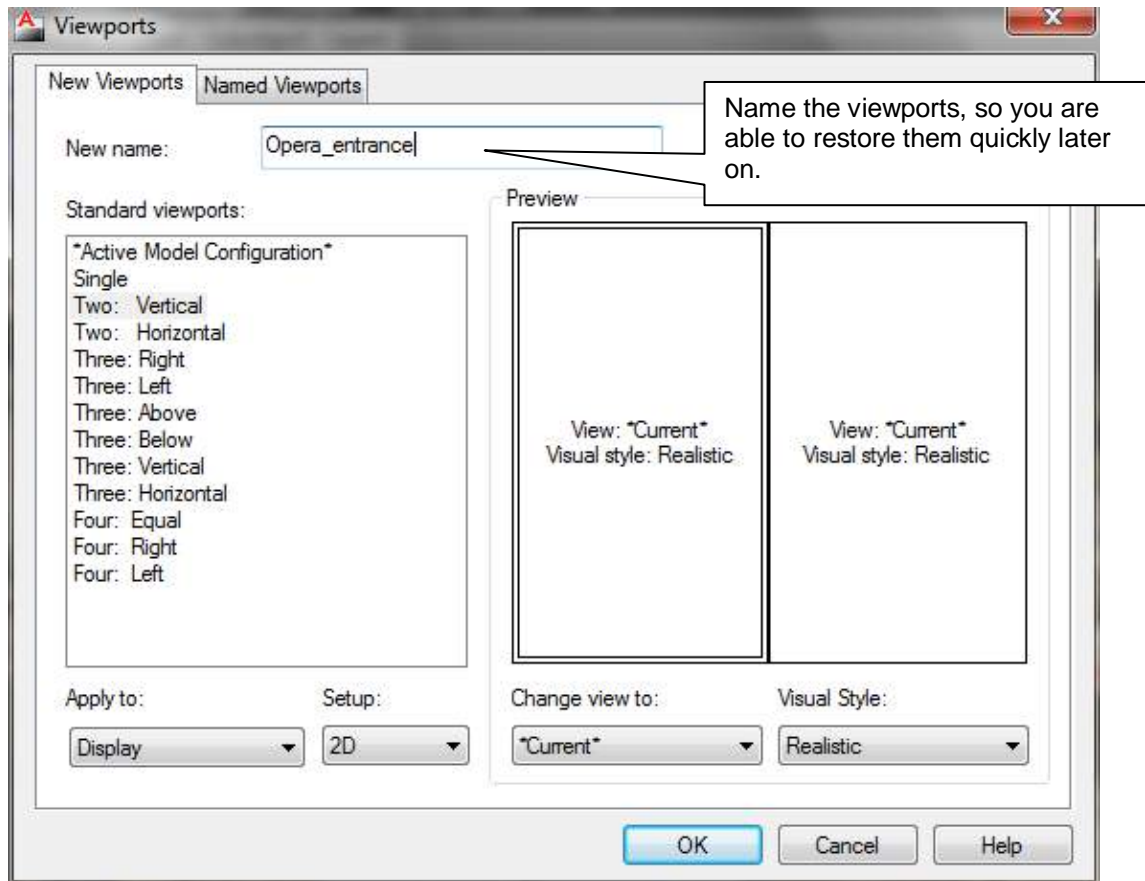
With two viewports it is possible to work so that in one of them the oriented images can be swapped and in the other the created geometry can be checked. If you only have two or three oriented images y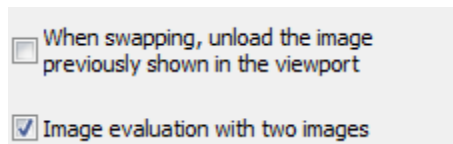ou can create three or four viewports two or three for the oriented images and one for checking the geometry. If you want to work with only two images, activate the settings in image management, on the tab "Settings" as follows:
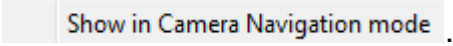
3. The current split of your drawing in the viewports is displayed in the thumbnail of the image management window. The current viewport has a thick border. To change the current viewport, either click in the viewport itself or on its thumbnail.
A small text and coloured highlighting shows how the oriented images in this viewport are displayed in the camera navigation mode:
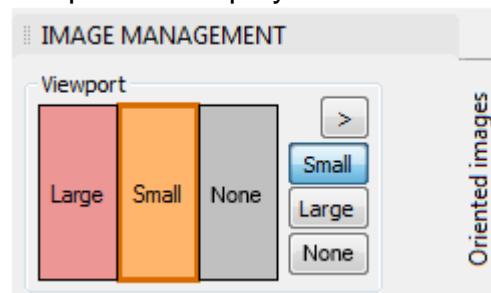
To simplify assigning of the homologous point pairs you must switch on the camera navigation in at least one viewport. Camera navigation means that in selected viewport just *one* image will be perspectively displayed from the camera

position. In a further viewport the geometry will be displayed for checking without the images. The viewport is configured by the buttons [Large], [Small] and [None]:

- Small (orange) – The image lies in front of the drawing geometry – it hides them.
- Large (red) – The image lies behind the drawing geometry – the geometry is visible in front of the image. This automatic scaling happens only if there is already is some geometry in the drawing. When you have later created some geometry, simply click again on the [Large] button for this viewport. The view is then refreshed.
- None (grey) – no oriented images are displayed in this viewport. The geometry is displayed in 2D mode.

To display an image in camera navigation mode in the selected viewport, double click on the chosen image in the image list or select the appropriate entry in the right click context menu of the image   Show in Camera Navigation mode .

Ensure that a different oriented image is displayed in each viewport. Only set camera navigation mode in one viewport to "Large", otherwise the images will, because of their overlaps, hide each other. More information to image management and camera navigation can be found in the Command Reference:
→**Oriented Images – Image management**
→**Oriented Images – CamNav on**.

Please pay special attention to the information regarding the improvement of the image display in section 5.2.
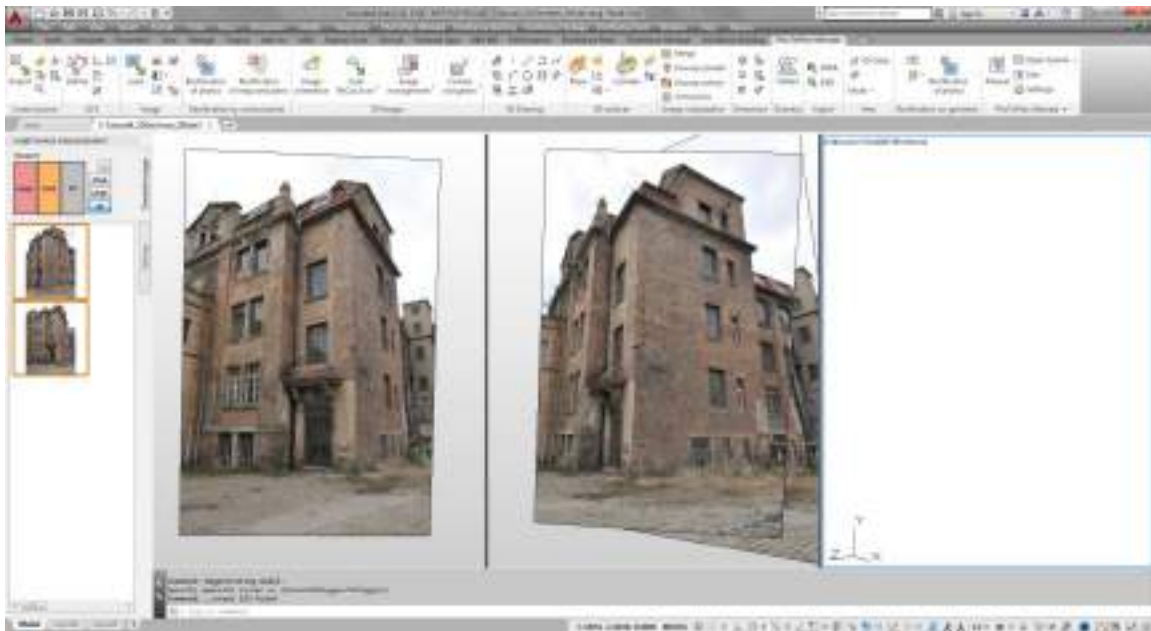
As well as the quick methods of scaling images in the camera navigation mode mentioned above there are further possibilities to adjust the image size of each oriented image:

- flexibly in the AutoCAD properties window for that image by setting the size factor, so that the image is displayed behind all of the geometry
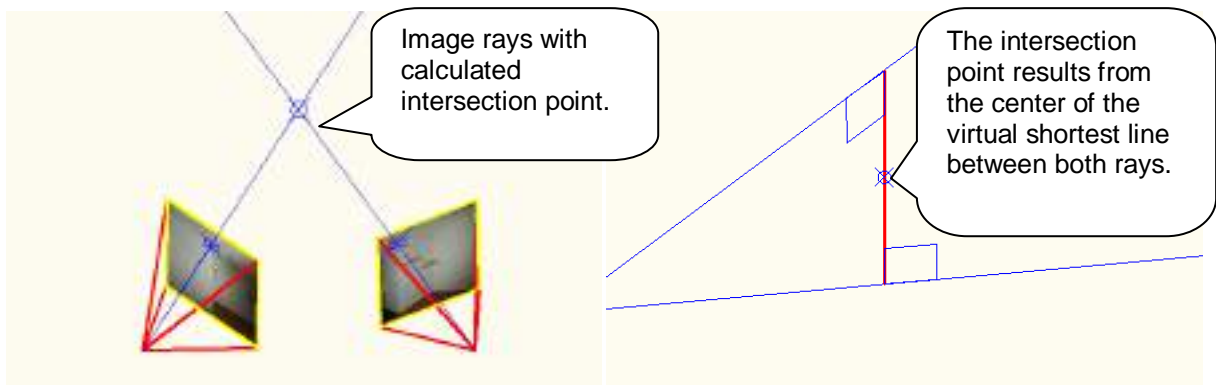- very flexibly and intuitively by Ctrl+turning the scroll wheel

4. After these preparations you may draw, with help of the following commands:
    →**Image Modeling – 3D point**
    →**Image Modeling – 3D line**
    →**Image Modeling – 3D polyline**
    →**Image Modeling – 3D spline**
    →**Image Modeling – 3D circle**
    →**Image Modeling – 3D circle arc**
    →**Image Modeling – 3D cylinder**
    →**Image Modeling – 3D dimension**
    If you start one of the commands above you are prompted to click alternately on corresponding points in at least two images. Automatically that viewport is active over which the mouse cursor is placed. You can navigate within the viewports as usual using the mouse wheel. An epipolar line helps finding the corresponding image points much easier. It has to lie on this line.

An object point clicked within at least two images leads to a 3D coordinate in AutoCAD. It results from the intersection point of the image rays.

Image rays with calculated intersection point.

The intersection point results from the center of the virtual shortest line between both rays.

Note, it is important for the quality of the image evaluation that the angle between the image rays is neither too obtuse nor too acute. There must not be glancing intersections between homologue image rays. In the Image Management on the ”Settings” tab you may define tolerance values for the distance between the image rays and for their intersection angle. Here you may also configure the display oft he epipolar lines. →**Oriented Images – Image management**

The command →**Image Modeling – 3D point** is transparent, that means you may use it for example to insert AutoCAD blocks at the correct spatial position. At first you have to call up the command Insert – Block and then select the option "Specify On-screen". Of course this command can be used within any AutoCAD command that asks for 3D coordinates.

For the creation of kubit planes and cylinders by means of multiple image evaluation the As-Built Modeling commands have an according button for the object selection, if at least two oriented images are loaded in the drawing or the image management is turn on.

Hint: If you want to change the viewport configuration in between, because you want to interrupt the 3D drawing with two images, it is advisable to work with named views (see AutoCAD help) in the first place. By doing so, you can switch between different configurations for different tasks, without having to define new viewports every time.

Chapters 5.4 and 5.5 describe further ways of evaluation with oriented images. Often a combination of these methods leads you to the desired results.

Please refer to the command reference chapter 7 for detailed information regarding the single commands.

You may try the described on your own using the data of tutorial 4. For this exercise some photos have been taken of two façades of a building. We already orientated the images for you but you may also do it yourself for exercise (see chapter 5.1). The necessary files have not been installed with the setup because of their file size. Please, download them to your machine using following web link

(http://service.faro3dsoftware.com/DOWNLOADS/TutorialsVideos/PointSenseAutoCAD/Tutorial_Oriented_Images_en.zip).

As starting point for the exercise you preferably use the drawing TUTORIAL4_ORIENTEDIMAGES.DWG. This file already contains both oriented images for the building to be evaluated (including control points and original images). You may also open an empty AutoCAD drawing and load the oriented images using the command →**Oriented Images – Load oriented image (kubit ORI format)**.

The drawing TUTORIAL4_3DDRAWING_2IMAGES.DWG shows the result of the exercise.

5.4   3D drawing with one oriented image and surfaces

If a drawing contains surfaces already, *one* oriented image is enough in order to be able to draw on these surfaces. You can choose AutoCAD 3D objects (e.g. meshes, 3D solids, polylines with thickness) or kubit planes, as well as kubit cylinders.

If you want for example draw damages on a cylindrical surface, like a tower, you can generate a cylinder first with the help of the multiple image evaluation (see section 5.3). Afterwards you can trace the damage outline lying on that cylinder with only one oriented image.

The commands, needed for this drawing method are described in the command reference starting from page 7-91.
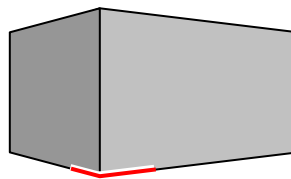
5.4.1   How to draw

You trace the outlines of interest on an oriented image, e.g. as lines. The software calculates the real, spatial run of the outlines.

2D Drawing on one or several oriented images.
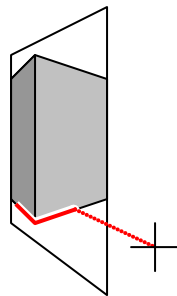
At the same time the **3D graphic** is displayed on spatially optional arranged **surfaces** (solids, nets, kubit planes, kubit cylinders or on a combination of those).

In order to do so, the projection rays, whose course is known for an oriented photo, are intersected with the 3D surface.

To get a true to size result, it is important that the oriented image does not have any distortion (pulvinated or barrel-shaped bending especially at the image edges).

Procedure

In order to use this form of the 3D drawing efficiently, following procedure is recommended:

1. Generation of three-dimensional surfaces (solids, meshes, kubit planes, kubit cylinders, As-Built Total Station Interface meshes etc.) e.g. by using the multiple image evaluation (see section 5.3).

2. Loading of at least one oriented image (→**Oriented Images – Load oriented image (kubit ORI format)**).

3. Starting the camera navigation mode with →**Oriented Images – CamNav on**. The oriented image has to be selected and As-Built automatically generates a view, where image and surface overlay each other.

4. Make default settings for the 3D drawing →**Image Modeling – 3D Drawing - Settings**. The oriented image to be evaluated, as well as the corresponding 3D surface(s), is selected. Besides that you have to select the AutoCAD commands to be used in the 3D drawing mode.
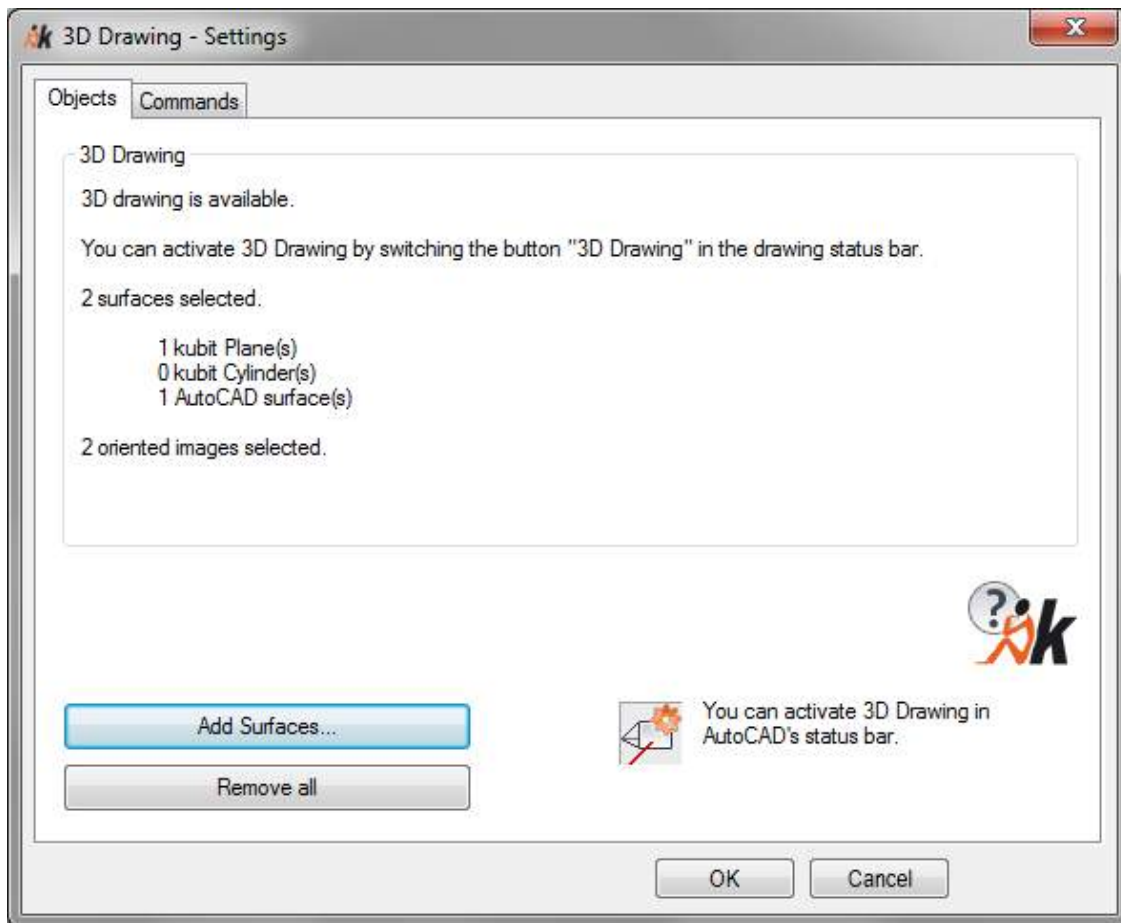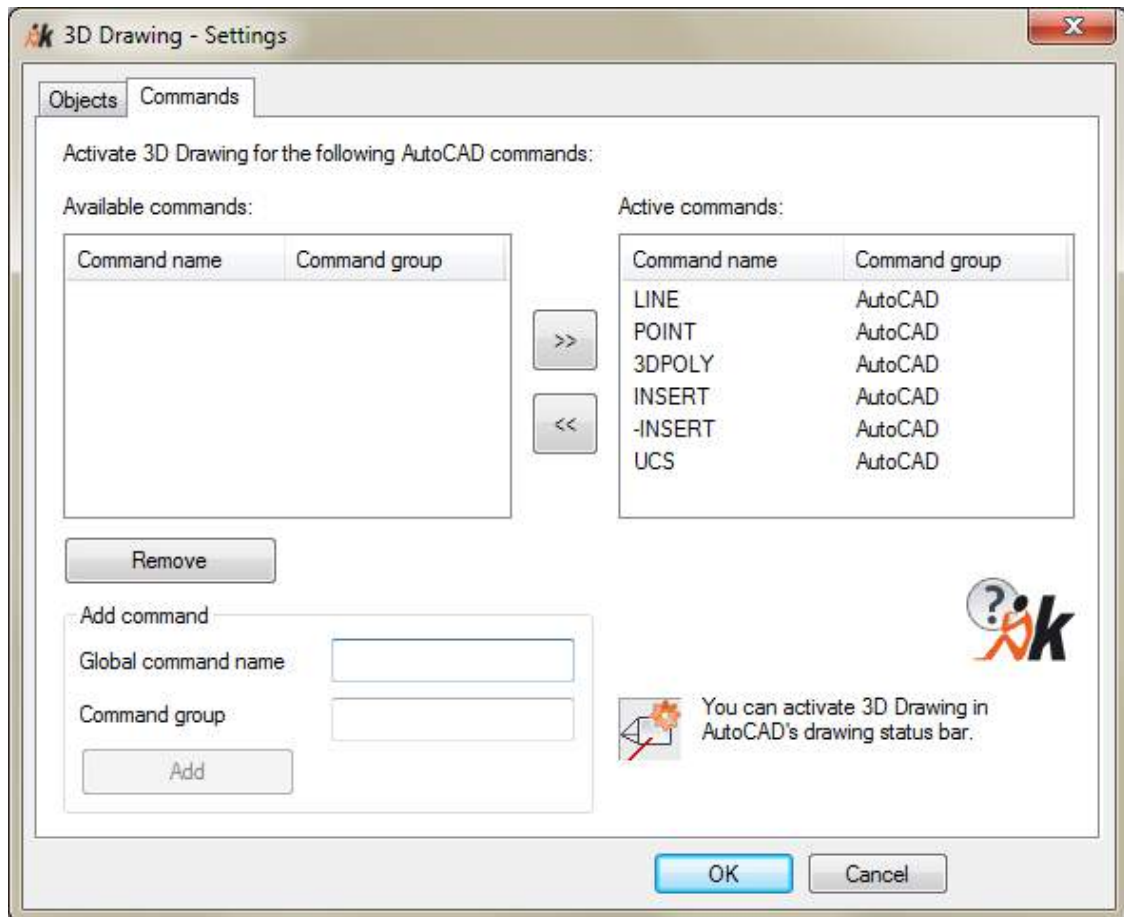
5. Initialization of the 3D drawing by the command **3D drawing on/off**. This button is located in the state bar on the bottom right.
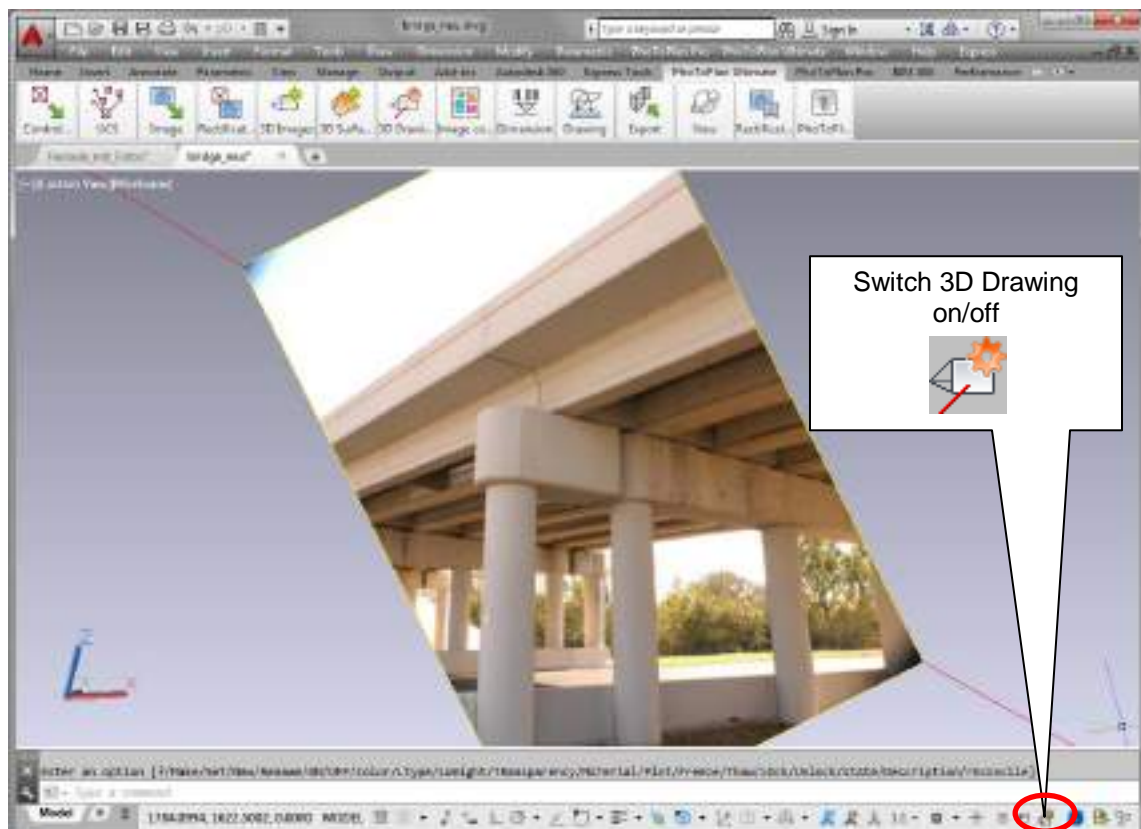
6. You can now start drawing. The following figure shows the evaluation of several bridge components.


Further alternatives

If **several oriented images** are available, you may always select the image, which is most suitable when drawing. To do so, simply select several oriented images within the 3D drawing settings. In order to be able to overlay every image with the surface, a separate viewport has to be defined for every image in AutoCAD. The camera navigation mode has to be switched on for every viewport separately (→**Oriented Images – Image management**). If several surfaces have been selected, you always draw on the closest one in 3D space. If you select more than one kubit plane as surface, it is essential that you set these planes as **limited** for 3D drawing. Otherwise there could be confusing effects.

For an efficient drawing it is advisable to work with several AutoCAD viewports. When doing so, next to the viewport with the oriented image and the overlaid surfaces, an additional viewport with the surfaces but without the image is opened. You also choose a different viewing direction for this viewport and switch to the parallel projection mode. Please use the →**Oriented Images – Image management** command for viewport configuration.

This additional view helps with the supervision of the drawing result, since from the perspective of the camera position not every geometry might be visible. The following figure clarifies this.
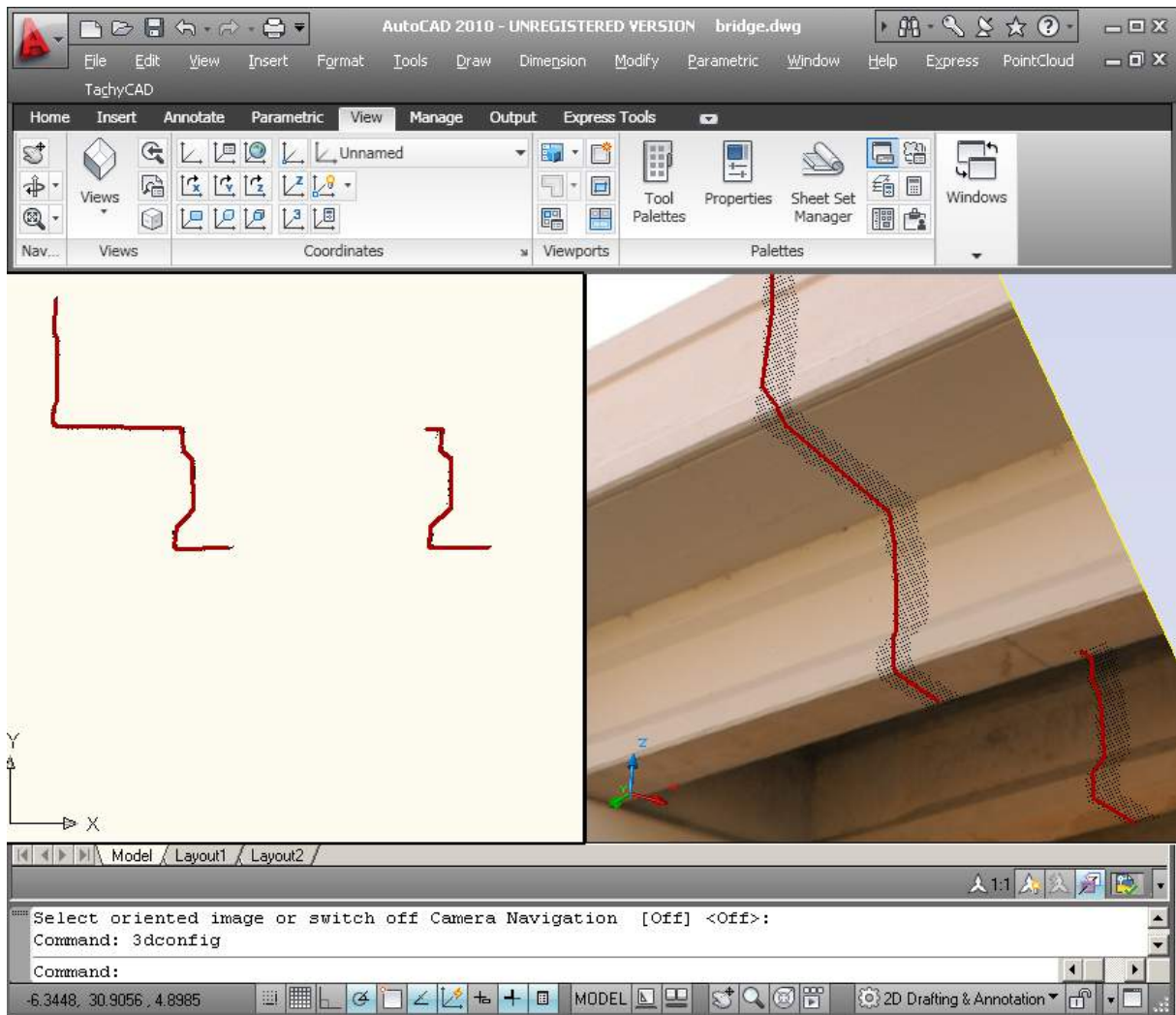
The right window is the drawing window, the left window shows, for checking purposes, the result as profile.

You may try the described on your own using the data of tutorial 4. For this exercise some photos have been taken of two façades of a building. We already orientated the images for you and also created kubit planes via multiple image evaluation as surface. The drawing TUTORIAL4_3DDRAWING_1IMAGE1PLANE.DWG shows how a the 3D results of the evaluation with one oriented image and surfaces may look like. The necessary files have not been installed with the setup because of their file size. Please, download them to your machine using following web link

(http://service.faro3dsoftware.com/DOWNLOADS/TutorialsVideos/PointSenseAutoCAD/Tutorial_Oriented_Images_en.zip).

5.5   Façade plans from oriented images

Besides the methods for the creation of 3D geometry described in chapters 5.3 and 5.4 oriented images can also be used to produce façade plans. In this chapter The possible workflow shall be explained with an example. Mainly it comprises following steps:

Step 1: Loading the oriented images

Step 2: Creating viewports

Step 3: Creating a UCS for the façade

Step 4: Drawing geometry on the main plane of the façade as well as on further parallel planes in the image.

Step 5: Flatten the objects into one single drawing plane

For this example photos have been taken of two façades of a building. We already orientated the images. The necessary files have not been installed with the setup because of their file size. Please, download them to your machine using following web link

(http://service.faro3dsoftware.com/DOWNLOADS/TutorialsVideos/PointSenseAutoCAD/Tutorial_Oriented_Images_en.zip).

Following files belong to the oriented images:

DSC_0027_O.JPG and DSC_0027_O.ORI

DSC_0028_O.JPG and DSC_0028_O.ORI

We want to create a façade plan for the left façade that is structured in multiple planes.

Step 1 – Loading the oriented images

You load the oriented images into an AutoCAD drawing using the command →**Oriented Images – Load oriented image (kubit ORI format)** .

Step 2 – Preparing viewports

As described in section 5.3, viewports can be created and setup using Image Management (→**Oriented Images – Image management**).
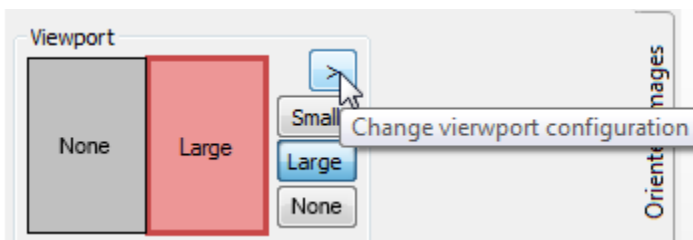
For creating façade drawings it is recommended to have at least two viewports. One viewport is needed to display the oriented images in and alternately to pick the corresponding points. To do this the camera navigation mode must be activated in this viewport. Further the display size of the oriented image should be set to "Large", so that the resultant graphic will not be covered. In the second viewport the geometry of the resulting façade drawing is checked and drawn without any photos. Thereto the viewport should be activated and the button [None] clicked. This switches on the 2D wireframe style and hides the oriented images, so that the geometry is not covered.

Your prepared monitor could now look like this:

Viewport (Geometry in the foreground)

Viewport 2D wireframe mode without images (only geometry)
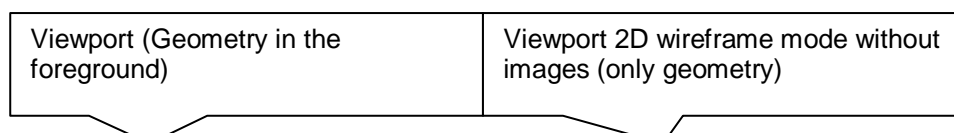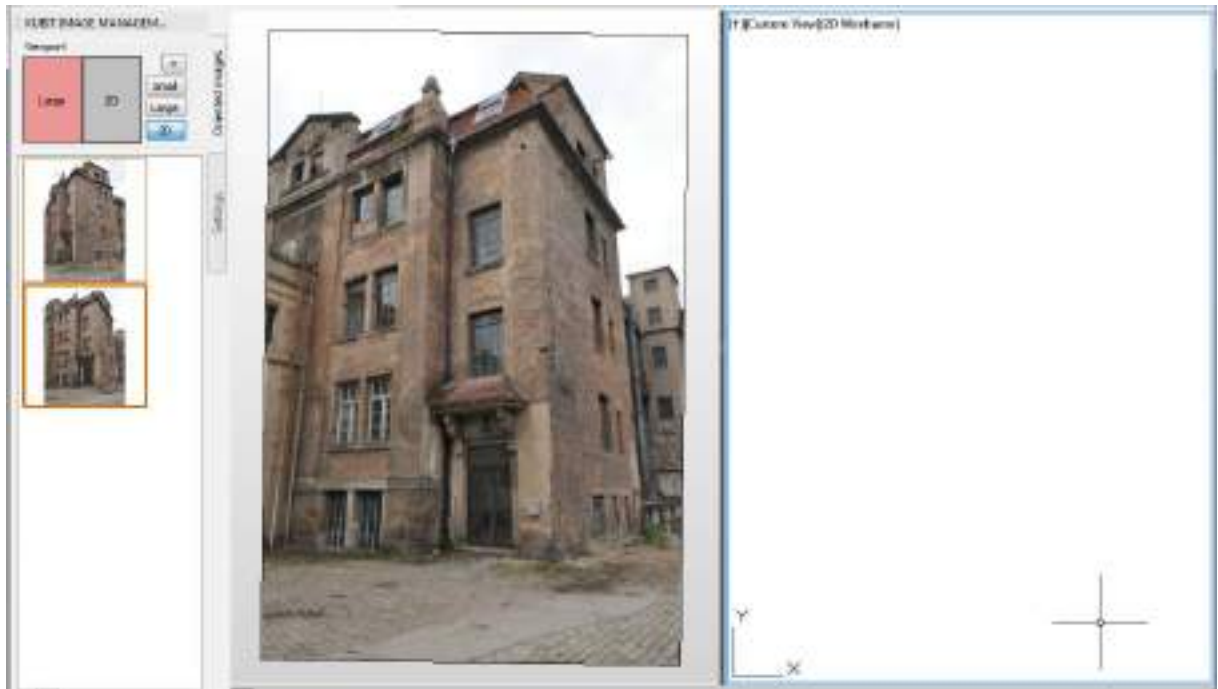
Important, when you are working with just one viewport for displaying the images, then to draw the images in the viewport swap to the desired image by double clicking the image in the image list. If you have, as in this example, in Image Management, not selected under "Settings" a folder for the oriented images, then in the image list only the images will be displayed that are attached to the drawing. The option "When swapping, unload unload the image previously shown in the viewport" must <u>not</u> be selected. Whilst we are working here with just two images please select the option "Image evaluation with two images". This saves clicks because the software automatically ends the prompting for corresponding points after selecting in the two oriented images.
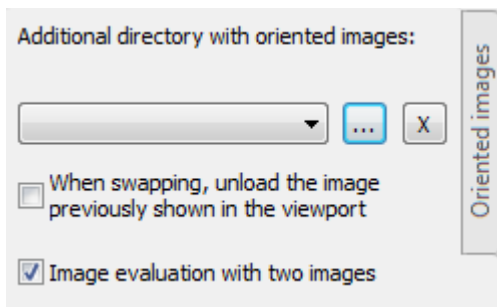
If you don't want to constantly swap between images by double clicking, then simply set up three viewports:
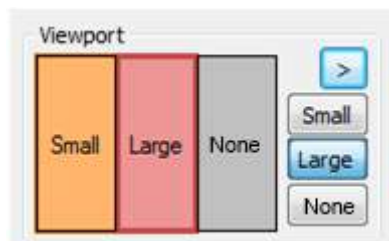
Viewport with image (geometry in background)	Viewport with image (geometry in foreground)	Viewport 2D wireframe mode without images (only geometry)

Step 3 – Creating a UCS for the façade

By creating a UCS you define into which plane or parallel to which plane the façade geometry is drawn to scale.

If you have enough control points on the main plane of the façade (at least 3) from the image orientation, you can create the UCS for the façade using these points. If the number of control points in one plane is not sufficient, you may create the UCS via multiple image evaluation. You need at least three corresponding pairs of points in both oriented images.

You run the command →**As-Built Modeler – Modeling – Fit Plane** . There you click the button [Points on multiple oriented images]. Now you are prompted to alternately click corresponding points in the images. The plane is determined after you assigned at least three points this way. When assigning more points an average plane is calculated and the accuracy of the plane can be estimated. Finally you use the command →**As-Built Modeler – Digitizing Tools – UCS from Plane** . Thus, this plane becomes the XY plane of the coordinate system for the façade. In rare unfavourable cases it could happen that - when changing to the plan view - you may look at the façade from its back (Z axis points into the façade). Then you have to rotate the UCS manually around its X axis or Y axis using AutoCAD commands.

You should name the UCS afterwards. This way you can restore it any time. For naming the UCS you run the AutoCAD command UCSMAN. The UCS window opens, where you select the entry 'Unnamed' and enter a new name for the UCS.

We like to create a plan for the left façade which is structured into several planes. The window corners offer themselves as points for the definition of the UCS. The accuracy of the UCS - and thus the façade plan - depends on how exactly the chosen points lie in one common plane (besides the accuracy of the image orientation of course). We chose the upper left corner of all six windows. The sequence of the points does not matter when defining the UCS via a kubit plane.
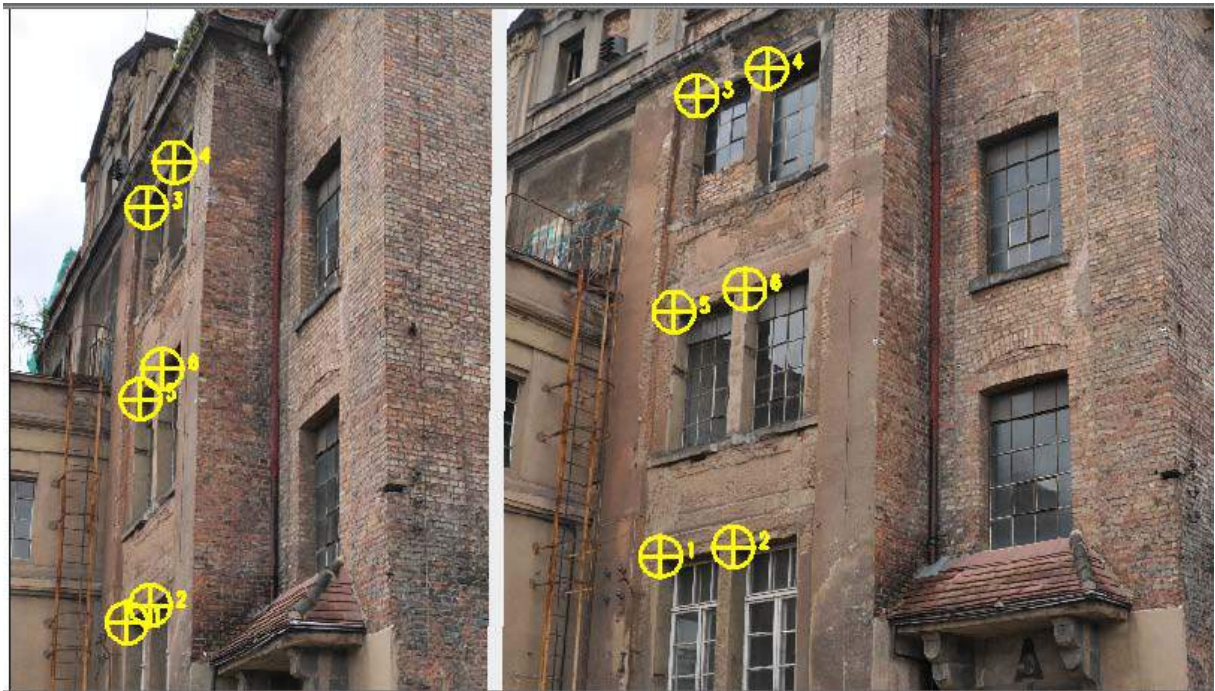
When you created the UCS please give it a meaningful name e.g. 'Fassade_left_1'. Herewith the base for the façade plan is prepared.

Step 4 – Drawing the façade geometry

Thanks to the preparations made with the first few steps now the façade can be digitized by clicking in only one image (the one with the geometry in front).

First of all we draw a rectangle as presentation of the main frame of the façade plane. Run the AutoCAD rectangle command. When you are asked for the first corner point, click the upper left corner of the façade plane where the windows lie which we used for defining the UCS. Then draw the rectangle to the other corner point at the lower right.
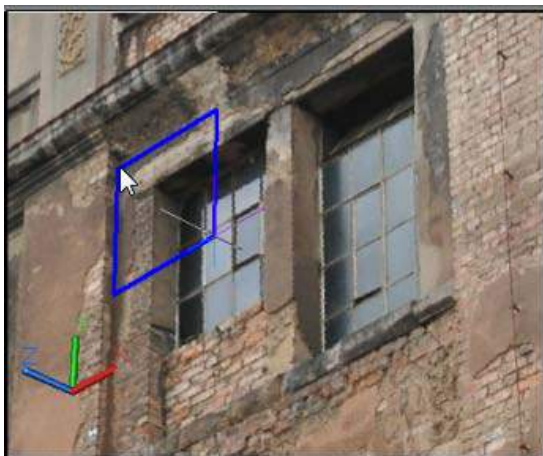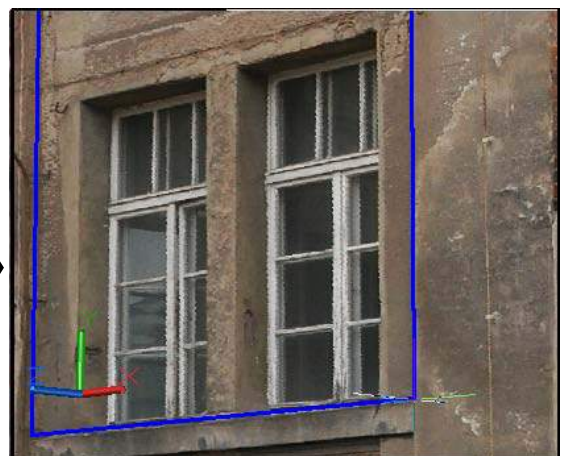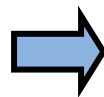
Upper left corner   **Lower right corner**

If you change the geometry viewport to the plan view of the current UCS (PLAN) and then zoom to extends (double click on the scroll wheel of the mouse) you will see the following image:

| Work window when digitizing (geometry in front) | Geometry window for control (without images) |

Now we digitize the window boundaries on the façade plane using the same principle.

If you want to digitize objects which do not lie directly within the façade plane but in a parallel plane you simply set the drawing elevation to this plane. As-Built provides two commands for this:

→**UCS - Set drawing elevation according to XY plane of UCS** is used when geometry already exists on to according plane. You simply enable the object snap and snap a point on the plane inside the geometry window.

→**Image Modeling – Set drawing elevation to XY plane UCS** is used when no geometry exists yet on the according plane. By assigning one corresponding pair of points in two oriented images a 3D point is created. The Z value of this point defines the drawing elevation regarding the UCS.

We want to digitize the outer boundary of the façade which lies a few centimetres in front of the part with the windows. Please run the command →**Image Modeling – Set drawing elevation to XY plane UCS**. Then in the first image zoom in for instance to the foot of the lightning arrester carrier and click there. A magenta coloured cross will temporarily mark this position to help you search the same point in the second image. Now go to the second image zoom to the foot of the same lightning arrester carrier and click there. The epipolar line will help you find the point.
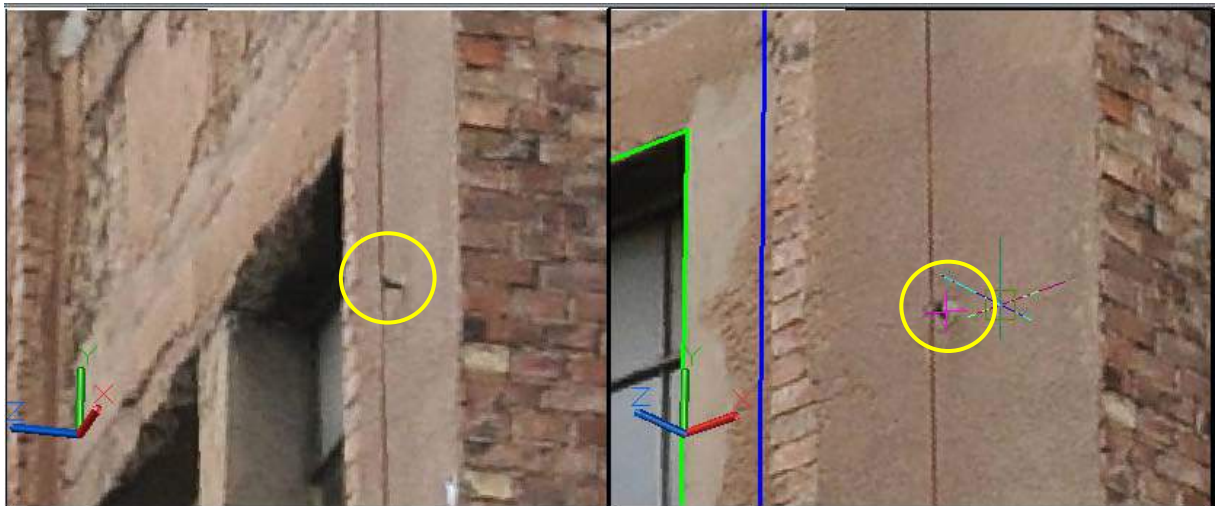
Second click (left viewport)   **First click (right viewport with marker)**

Thus the drawing elevation is set to this new façade plane. The command line shows how far the point is located from the XY plane of the current UCS.

ELEVATION was set to 0.1672.

Now we can draw the geometry. The result looks like this

The small gap between both blue rectangles on the right can be explained by occlusion within the photos. Eventually one has to observe such handicaps while taking the photos.

With the same method we can digitize the plaster damages as well as further objects on planes parallel to the plane of the main façade. Try it yourself.

If the object allows it you may also draw in the geometry window and use the viewport with the image for control. The glass frames of the windows are created this way. The drawing elevation was set and a small rectangle was drawn on the photo.

The small rectangle was then multiplied using the AutoCAD command ARRAY. This way of drawing as well as using the rectangle command instead of e.g. POLYLINE should only be applied if the client and the object allow such a generalization. Plans of true deformation are more time-consuming.
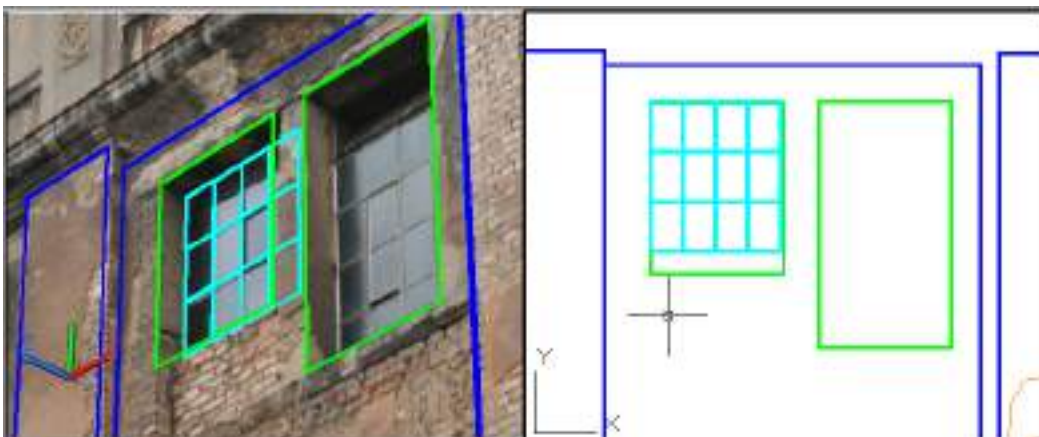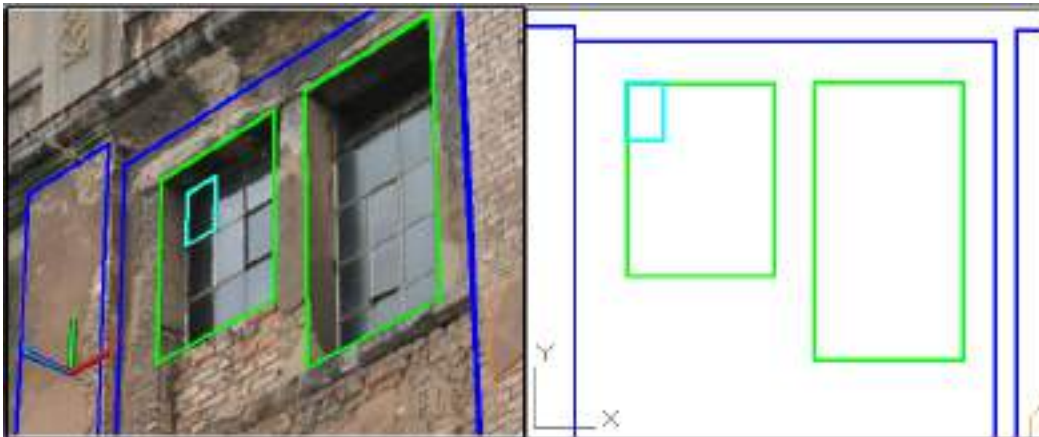
Further completed by using the commands for setting the drawing elevation and digitizing the façade drawing may look like this:

The viewport in the middle shows that at the moment the geometry still lies on different planes in space.

Hints: Façade elements which are not parallel to the main façade can be drawn via multiple image evaluation like described in chapter 5.3 and later be flattened into the plane.

You do not only want vector graphics but an image plan with vectors <u>and</u> photo?

You have the following possibilities:

- Use the multiple image draw to define four control points in every façade plane and rectify the original image one after the other to every single plane using these control points. Then clip the rectified images and merge them. With façades structured into many planes this method using oriented images is more efficient. You need to measure less control points on the façade with your total station than you else would for rectification.

- You can be even more efficient if you create an orthophoto instead of using rectification. You avoid the effort of assigning control points with image points. Just use the multiple image draw and the command for setting the drawing elevation and draw the outer boundaries of the single façade planes (like described above). Then use this geometry for creating kubit planes as a surface model for the computation of the orthophoto. Please note that the planes have to be limited to their boundaries. Use the AutoCAD Quick Select command. Select all kubit planes, open the Properties and set the "Limited" attribute to "Yes". The correct computation of the orthophoto it is important that no plane occludes the other. Gaps between the planes result in gaps in the orthophoto.

Thus, you may also use the multiple image draw for the creation of true to scale photos and digitize details on top of them.

Step 5 – Flatten the objects into one single drawing plane

In order to purge and finalize the façade plan before handing it to the client the drawing needs to be flattened. This means the object are all projected into the same plane. Of course afterwards the oriented images do not serve for control any longer. That is why flattening is done at the very end of the process.

First we switch back from three viewports to one. To do so you first activate the viewport with only the geometry. Then use the AutoCAD command from the menu 'View' → 'Viewsports' →'1 Viewport'.

Now run the As-Built Building Plans command →**Flatten Drawing**.

A dialogue opens where you may enter the Z value (referring to the UCS) you like to flatten to. Besides, you have several options to determine what shall be flattened and what shall be skipped from flattening.

Just keep all default settings for this exercise. Click the button 'Select objects' and select all façade elements from the drawing and confirm with ENTER. The dialogue displays how many objects you have selected. Click OK to finish flattening. Now the complete geometry lies in one plane.

If necessary you can finalize the drawing using AutoCAD commands like 'Trim' and 'Extend'. Finally you may add dimensions and annotations.
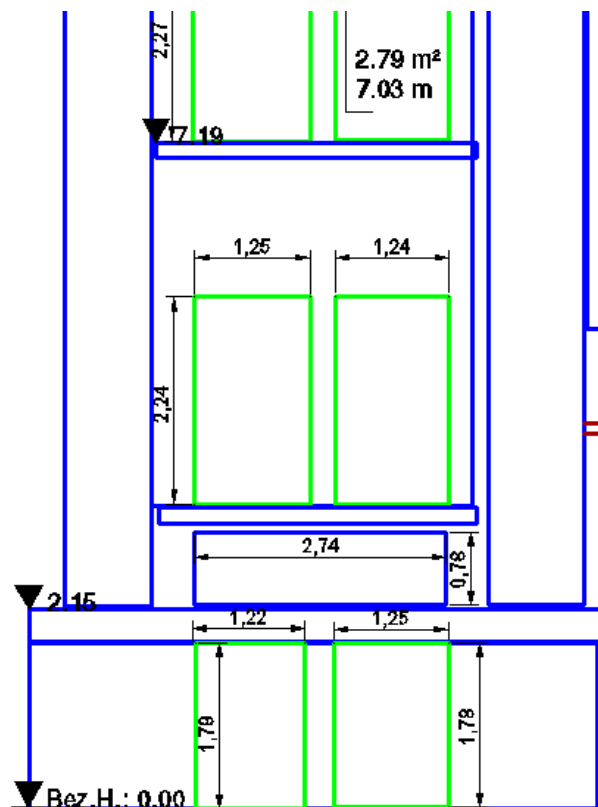
You find a detailed description of the Flatten command in As-Built command reference.

At the end you may overlay the the digitized plan with a coordinate grid →**Dimension - Insert coordinate frame.**

6   Unwrapped images and more

In addition to the functions described so far, there are further interesting possibilities like unwinding cylinders and prismatic surfaces and the generation of true orthophotos.

For **unwinding** photos of cylindrical objects at least one oriented image and measured points on the cylinder surface are needed (command →Image computations – Unwrap cylinder). It is possible to draw to scale within the resulting planar photograph. That way, 2D plans of towers, columns, arches and many more can be produced.

Projective **unwinding of photos prismatic surfaces** requires - in addition to the oriented images – so called 'prismatic surfaces'. This cloud be for instance a wall with a polygonal outline and a consistent extrusion direction.

Orthophotos are generated by the help of oriented images and surface information (planes, cylinders, meshes, etc.). That way central projective distortions are eliminated. Object edges and areas which are parallel to the projection plane are mapped according to scale. A detailed description of how to proceed and the requirements can be found in the command reference →**Image computations – Compute orthophoto**.

6.1   Unwrap cylinders

The 'unwrap cylinder' command of As-Built allows the projective unwinding of the inner or the outer lateral surface of a photographed cylindrical object. Additionally it is possible to project simple CAD geometry, which has been measured or drawn close to the cylindrical surface, into the image plane. The unwound photos can be used to generate 2D image plans.

The requirements for unwinding cylinders differ from the ones for the basic image rectification:

1. The surface has to be cylindrical. Everything lying off the cylinder will not be mapped to scale!
2. Enough evenly spread points on the cylinder barrel are needed in order to generate it as CAD object (→**As-Built Modeler – Modeling – Cylinder**). It is possible to generate these points via the multiple image evaluation. It is mostly advantageous to measure the cylindrical object with a Tachymeter or to scan it. If the cylindrical object is less textured you can still create the cylinder via multiple image draw. Just use the new command →**Image Modeling – 3D cylinder**.
3. Photos of the cylinder surface or of the parts of the surface which are of interest for you, are needed. Please refer to chapter 4.7 and 5.1.2 for advise on taking pictures.
4. Enough control points for the spatial orientation of **every** single photo (→**Oriented Images – Image orientation**) are needed. Please read chapter 5.1.1 for advise on the control points.
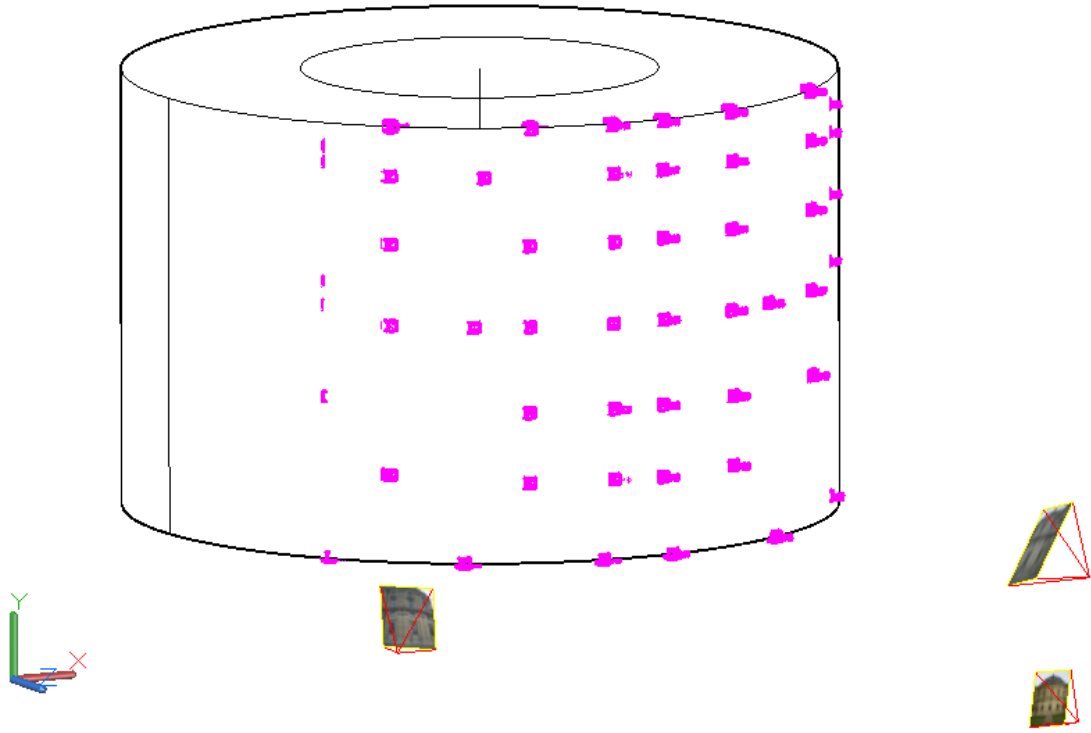
Figure 1: Best fit cylinder using the control points plus three oriented photos of the surface.
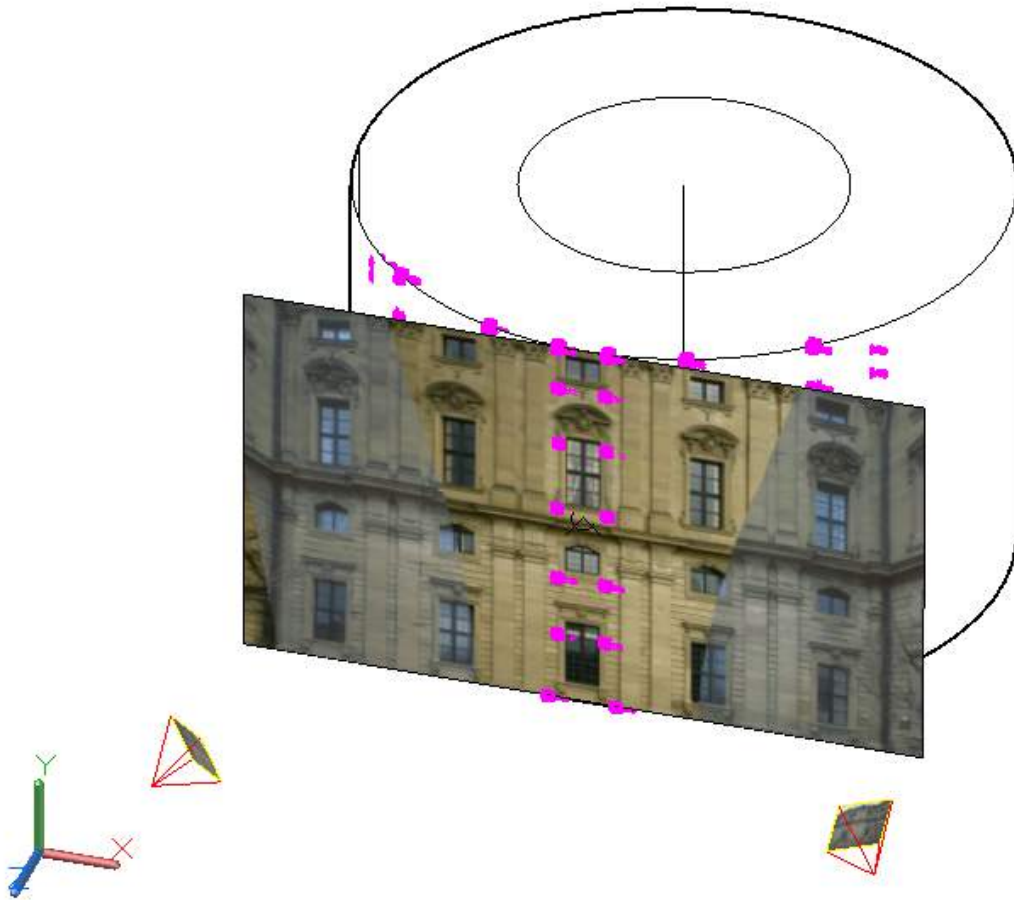
Figure 2: The unwound photograph created using the three oriented images.
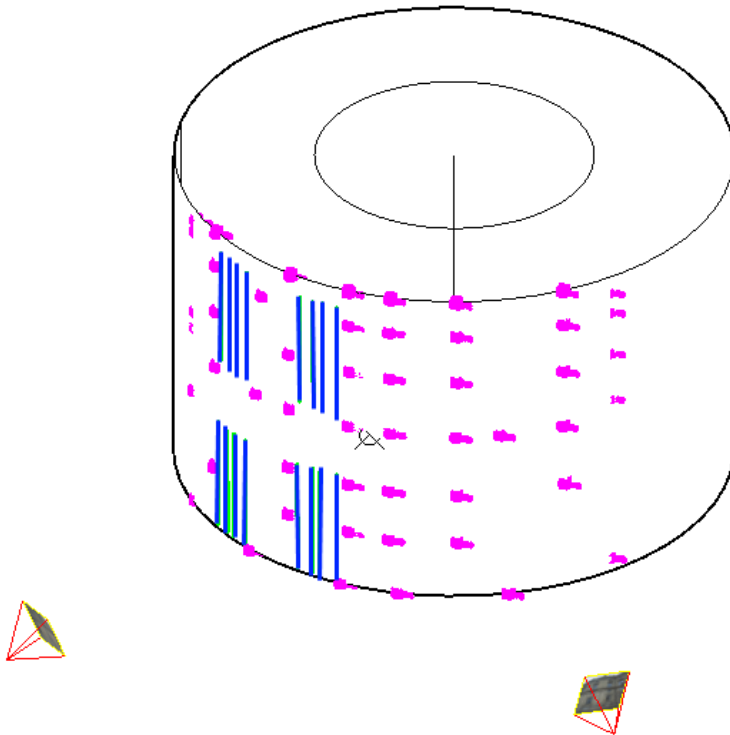
Figure 3: Façade edges (blue) which have been drawn with the help of the image modelling tools. They may also be determined with a total station. The easiest and most timesaving way is to digitize them from the unwound photo though.
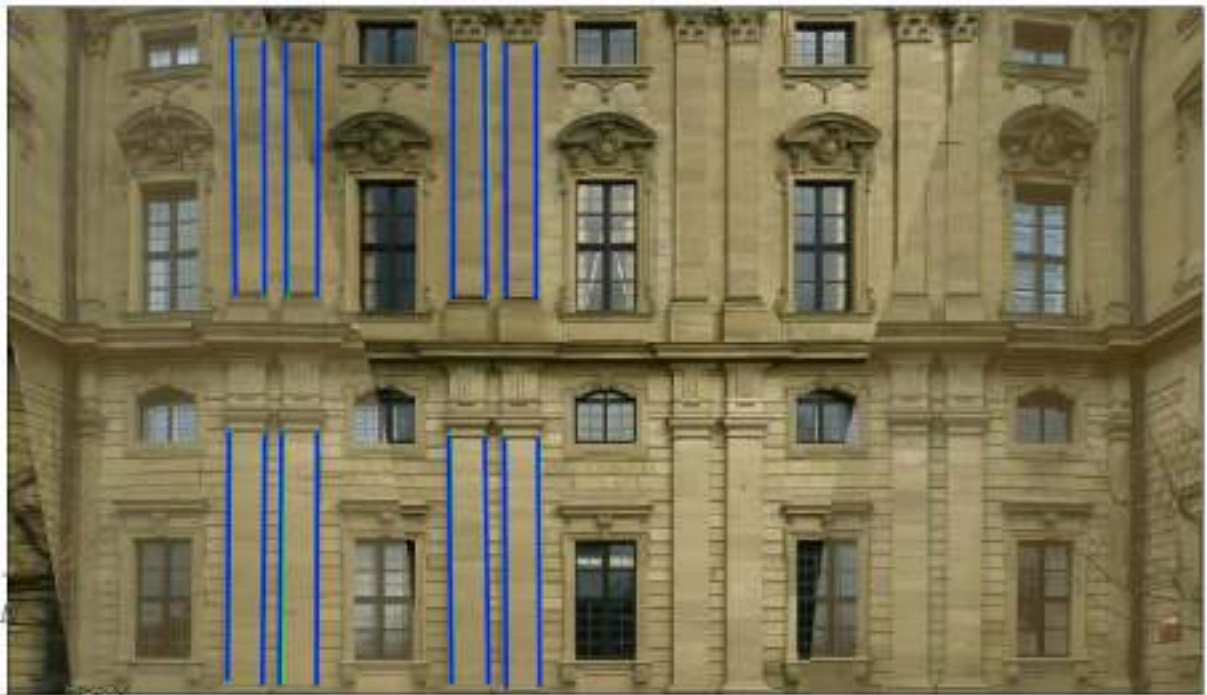
Figure 4: Unwinding of a cylinder with unwound CAD geometry (blue).

The unwinding of cylinders with As-Built is flexible. In combination with other FARO products it may be optimized further more. By the help of the As-Built Total Station Interface, it is possible, to measure the needed control points directly within the CAD. With a total station or a laser scanner the points for the definition of the cylinder can be measured directly at the object, without multiple image evaluation.

With As-Built Photo it is possible to merge several single photos of the cylinder surface, similar to the merging of images. With the different overlapping options it is possible to generate appealing and seamless transition between the charts. The option to output the unwound charts as single image planes allows the further processing of these images in external programs (see chapter 4.11).

A detailed description of the →**Image computations – Unwrap cylinder** command can be found in the command reference.

At the end you may overlay the resulting image with a coordinate grid →**Dimension - Insert coordinate frame.**

6.2   Unwrap prismatic surfaces

What is a "prismatic surface"?

In As-Built a prismatic surface is the lateral surface of a straight prism. The surface does not necessarily have to be closed. Such a lateral surface has a baseline that lies in a datum plane. All subareas of the lateral surface are perpendicular to this datum plane and have the same height.
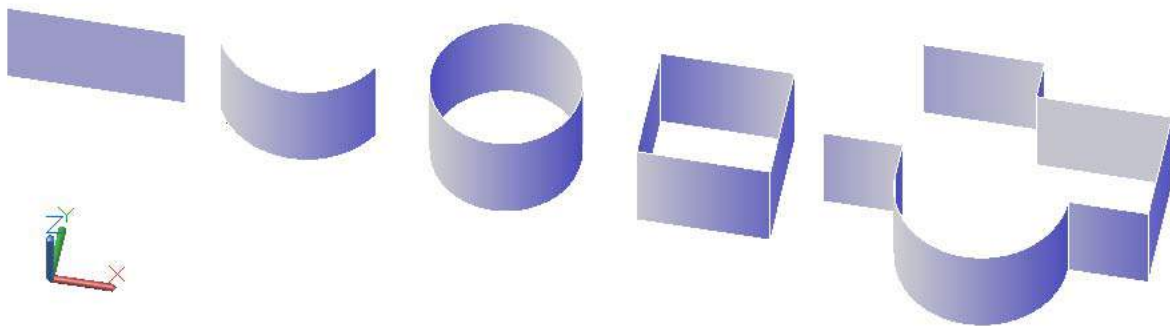
Complete façades of buildings or rotundas can be described by this, but also vaults and roofs etc.

What does unwrap mean?

Unwrapping means the image information is being projected onto the prismatic surface and then the whole lateral surface is being "grabbed" at its ends and "smoothed out" into the plane. To do so use the →**Image computations – Unwrap surface** command. It is described in detail in the command reference.

Prismatic surface (façade)

Oriented images

Unwrapped image
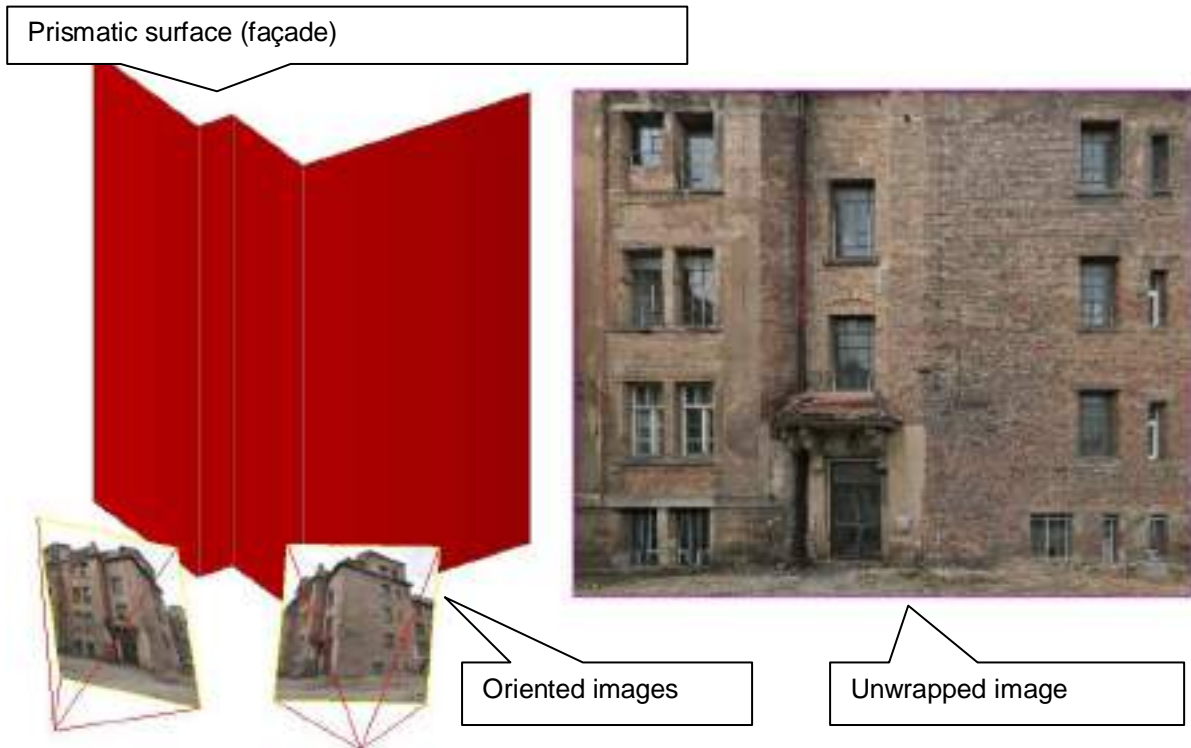
How to construct a "prismatic surface"?

The major task when projecting "prismatic surfaces" is constructing them exactly in AutoCAD, this is done in three steps. First the datum plane has to be defined/constructed, then the baseline hast o be drawn into it and finally the baseline has to be converted into a surface.

How to define the datum plane?

Before drawing the baseline you have to define a UCS with its XY plane representing the desired datum plane. This is most easy if the lateral surface has an edge perpendicular to the datum plane. Then you can simply measure two points on this edge, one at the lower end one at the top end. Or you construct the edge by intersecting two kubit planes, which you may create by measuring points on the surface to be unwrapped. If you have got two points on a perpendicular edge you run the AutoCAD UCS command:

> Command: UCS
>
> Current ucs name: *WORLD*
>
> Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis] <World>: **za**
>
> > *(Option "ZAxis" for selecting the edge perpendicular to the datum plane.)*
>
> Specify new origin point or [Object] <0,0,0>:
>
> > *(Low end point of the edge)*
>
> Specify point on positive portion of Z-axis <152.7660,51.8808,1.0000>:
>
> > *(Top end point of the edge)*

Subsequently you should switch to the plan view of the XY plane of the new UCS. If this is not done automatically, just run the command PLAN with the <Current> option.

How to draw the baseline?

For simplification we here only want to deal with the 2D polyline as representation, since with a 2D polyline you may form or approximate all shapes. Of cause you may also use a circle, an arc or a simple line as baseline.

The 2D polyline is only used to retrace/model or to approximate the baseline. Prior to this you have to measure real world points on the surface to be unwrapped. There are several ways to do so:

- Measure single points or a 3D polyline by total station
- Determine single points or a 3D polyline in two or more oriented images (commands for "3D drawing with multiple oriented images")
- Best fit a polyline to a point cloud section

It is important to have a sufficient number of supporting points on the prismatic surface especially edges and corners. Tin addition the single points or the 3D polyline can be flattend to the datum plane (command →Flatten drawing), but this is not mandatory. Compared to single points a 3D polyline has the advantage that the point information is kept together in one object and therefore can be colored quickly or turned off by layer.
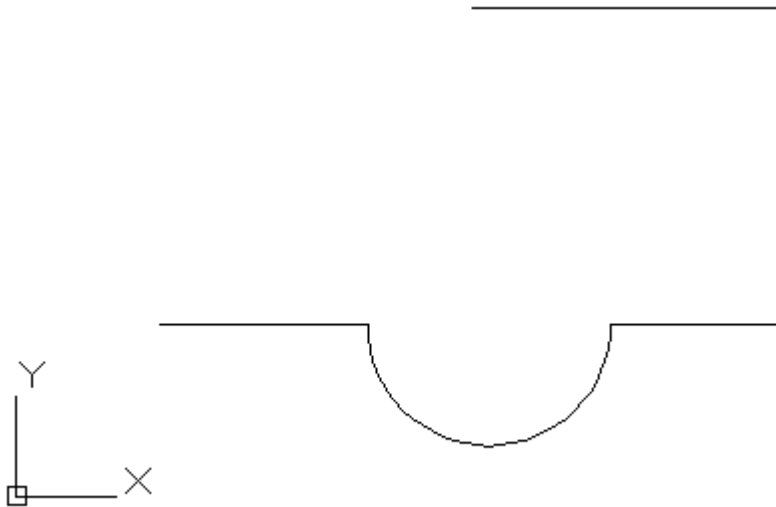
Using the measured points or 3D polyline and the object snap the 2D polyline can now be drawn and adjusted:

A 2D polyline may consist of straight and curved segments. Here exemplary the sequence for the polyline of the above figure. (Note: The 3D polyline measured at the object does not necessarily have to show arcs, but it has to contain the beginning of the arc, a point on it and its end as supporting points):

Command: PLINIE

Specify start point:

(Start point of a straight segment)

Current line-width is 0.0000

Specify next point or [Arc/Halfwidth/Length/Undo/Width]:

(Second point of a straight segment)

Specify next point or [Arc/Close/Halfwidth/Length/Undo/Width]: **a**

(Option "Arc" for drawing curved segments)

Specify endpoint of arc or

[Angle/CEnter/CLose/Direction/Halfwidth/Line/Radius/Second pt/Undo/Width]: **d**

(Option „Direction" for definition of the start direction of the curved segment)

Specify the tangent direction for the start point of arc:

(Point for start direction = Point on the arc)

Specify endpoint of the arc:

(Point for end of the arc)

Specify endpoint of arc or

[Angle/CEnter/CLose/Direction/Halfwidth/Line/Radius/Second pt/Undo/Width]: **l**

(Option "Line" for straight segments)

Specify next point or [Arc/Close/Halfwidth/Length/Undo/Width]:

(Point for straight segment)

Specify next point or [Arc/Close/Halfwidth/Length/Undo/Width]:

…

How to turn a 2D polyline into a surface?

This can be done by setting a special property of the 2D polyline – the so called thickness – to a value different to zero:
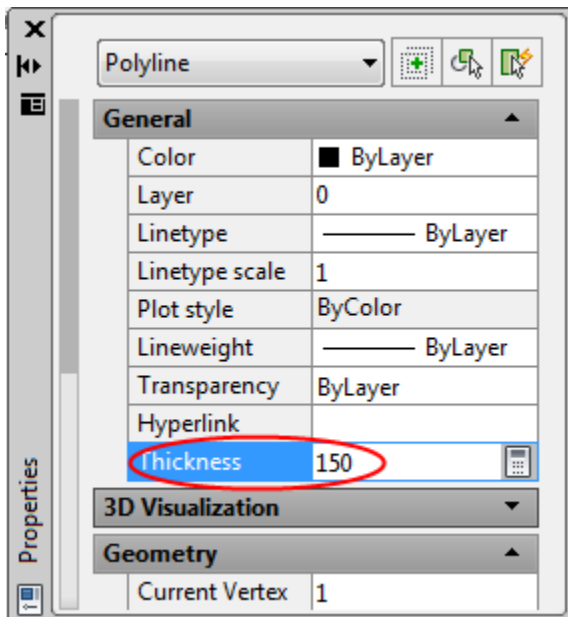
The thickness defines the extend of the prismatic surface (e.g. the height of the façade). If you subsequently rotate the drawing with 3D orbit, the prismatic surface gets visible. If you like you may set the visual style e.g. to "conceptual" in order to visualize the surface in a more graphic way:
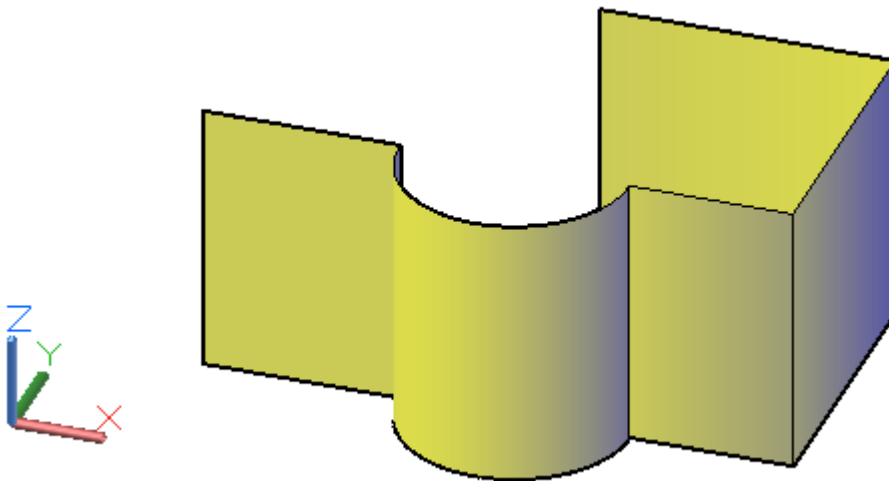
After having drawn the 2D polyline, the extend of the prismatic surface (lower end to top end) can be defined very comfortable by using the →**Image computations – Edit prismatic surface** command.

Once you have created the prismatic surface and loaded the orientated images, use the →**Image computations – Unwrap surface** command for projecting the photos into the plane and thus creating your image plan.

At the end you may overlay the resulting image with a coordinate grid →**Dimension - Insert coordinate frame.**

6.3 Calculation of orthophotos

The calculation of orthophotos with As-Built Photo generates a parallel projected image of a spatial scene from an angle of vision, defined by the user. The most important prerequisite for a high quality orthophoto is – next to the oriented images – a 3D model of the pictured surfaces (e.g. buildings, ground surface, work pieces). The model needs to be sufficiently structured and as accurate as possible. It consists of surface elements or solids. It can be generated by using tachymeter measurements (As-Built Total Station Interface), from laser scans or by the help of the multiple image evaluation. The orthophoto will get its colour information from one or several oriented images.

Surface elements (kubit cylinder, kubit planes, solids, meshes, etc.)

Oriented image

Result: Orthophoto
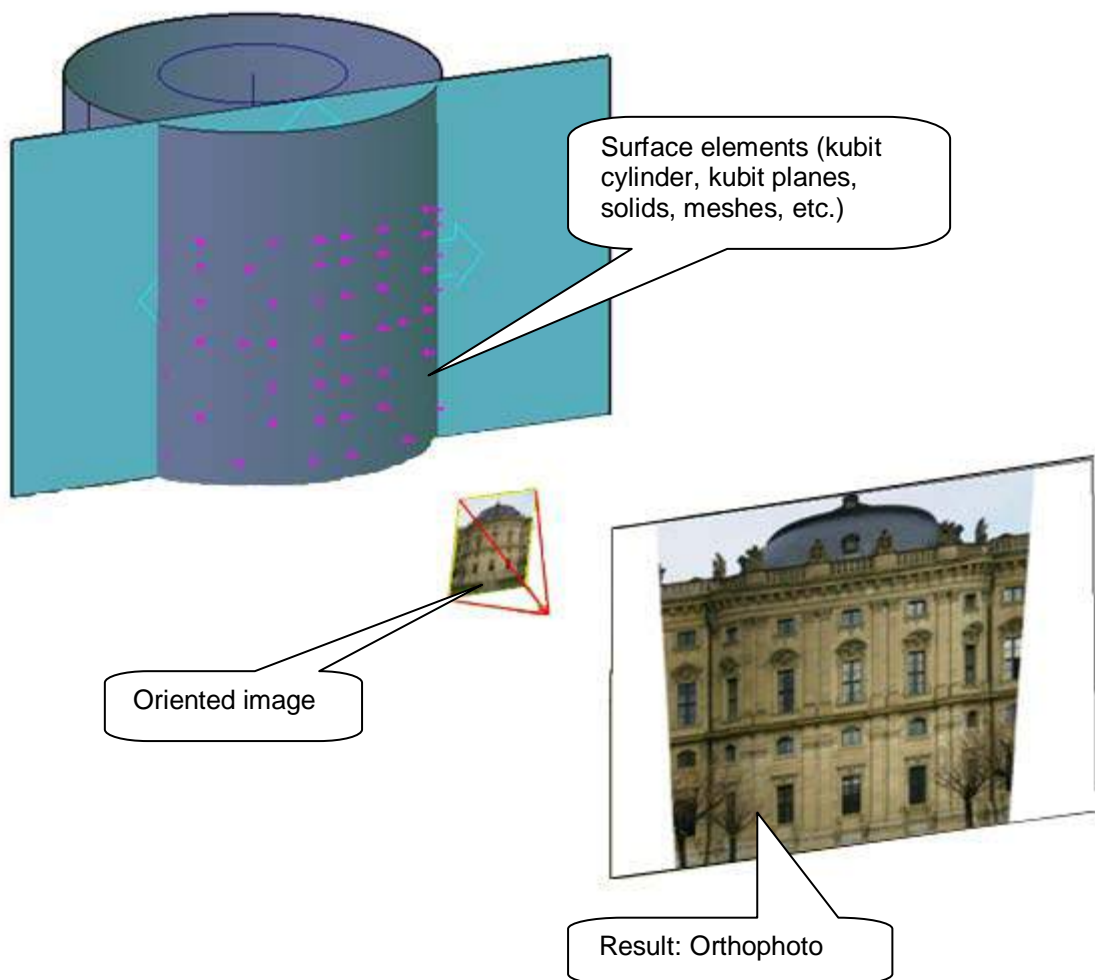
Mostly, orthophotos are used in order to generate to scale 2D image plans, for example from aerial photographs in connection with digital terrain models or in the field of architecture and monument preservation for the generation of vertical building sections and façade views.

The orthophoto is a parallel projection of spatial objects into the plane, therefore only those objects and lengths will be mapped to scale, which are parallel to the projection plane.

For the shooting of the needed photos and for their orientation please regard chapter 4.7 and 5.1 of this manual. You will find a detailed description of the user interface in the command reference under →**Image computations – Compute orthophoto**.

At the end you may overlay the resulting image with a coordinate grid →**Dimension - Insert coordinate frame.**

7   Command Reference

In the command reference all commands are listed in the same order as in the As-Built Photo ribbon tab. The explanation for each command starts with a combination in the following form.

Menu Text		
Button	Command Name:	Menu:
	COMMANDNAME	Name of the menu

Menu text

Under this name you will find the command in the ribbon.

Button

Via the symbol given here you may call up the command.

Command Name

Here you find the command name as it should be entered in the command line of AutoCAD.

Menu

Here you find in which menu (module) the command is contained.

Control points - Import control points

	Command name:	Menu:
	PCIMPORTCP	As-Built Photo

This command reads in control point coordinates from an ASCII file.
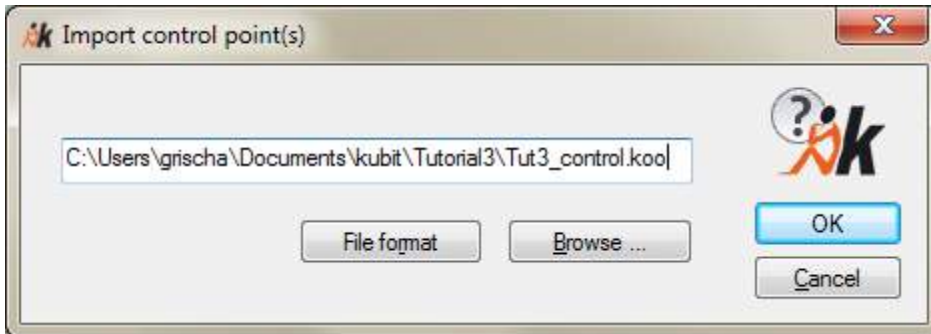
With **Browse...** you will come to a file selection window in which you may select your ASCII-file. The file extension may be chosen randomly. With **Select** and **OK** the points of this file are put into the image. At the same time a layer with the name CONTROL is set up to which all these control points are assigned automatically.

The format of the ASCII file to be read in may be determined via the button **File format**.

The point information has to be organized in columns. Besides the point number X, Y and Z coordinates of the control point are required. In addition it is possible to control the layer on which the single control points are to be placed using an additional column. This makes sense when you like to un-distort multiple facades or structured facades in one single drawing and for a better clearness want to put the control points on separate layers. With a click on the check boxes and entering the column's number you may tell the program which value is displayed in which column.

If you deactivate such a box standard values are assumed for the corresponding value. In this case the point numbers are counted up automatically beginning with '1'. The value assigned under '**Default value**' is assigned to the coordinates.

If the file consists of further columns they will be ignored when the file is loaded into the drawing.

Furthermore you may state here which characters are used to separate the columns from each other. Besides tabulators and blanks you may choose any other separating characters. You may also select more than one character.

During the import each point number is checked whether it already exists in the drawing. In this case the already existing control point is kept and the new point is ignored. In the command line the following message will appear for your information:

> Control point X does already exist. Ignore new definition.

Here the control point number is crucial. The point is thus also ignored if its number already exists but the coordinates vary.

There is the possibility to limit the number of points by entering an interval.

Option "Interpret XYZ values as UCS coordinates (not recommended)" is to be used only by advanced users. You have to secure that coordinates of imported points are conform to your current UCS. Confirm the selection with **OK**

Use the "Shift" (offset) option when you want to transfer from a national coordinates system to smaller local coordinates (usually only with larger airborne projects or AgiSoft PhotoScan projects). Remember or note the offset, in case the processing results have to be delivered with the original coordinates. Enter positive offset values. The software automatically subtracts them from the original coordinates. Care should be taken with respect to the offset, when inserting your project into a drawing that is not empty, but into a drawing that already contains some geometry. The offset values will be stored and offered again when importing photo projects (ReCap/PhotoScan).

Control points - Define control points

	Command name:	Menu:
	PCDEFINECP	As-Built Photo

This command serves for defining new control points in the drawing.
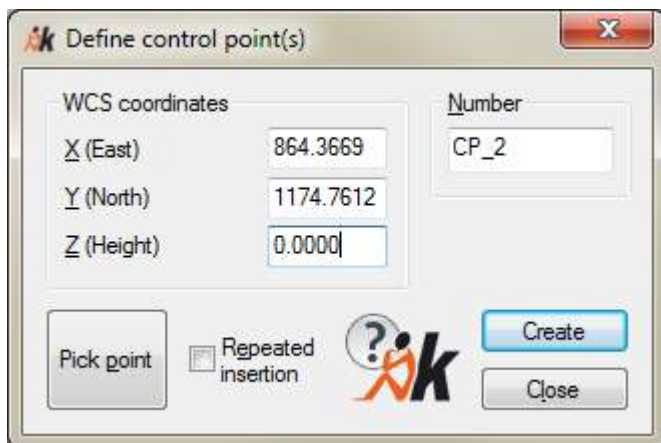
Besides a randomly chosen point number you enter the 3D-coordinates into the corresponding fields. The point numbers may consist of any alphanumerical characters but they may not contain any blanks.

With a click on **Create** a control point symbol with the corresponding number is set at the stated position in the drawing.

As an alternative you may pick the position of a new control point directly in the drawing with the button **Pick point**. This is suited for a later 'fixing" of control points onto marked points of drawing elements, like final points of lines, in order to e.g. provide a constructed net of distances with control points.

Although the coordinates in the dialogue are shown rounded to 3 digits after the decimal point the full accuracy of position defined by mouse click was taken over.

With **Close** you will close the dialogue and return to the drawing.

Note: Alternatively As-Built offers the possibility to define control points directly by measuring them with a total station (As-Built Total Station Interface). After clicking the option **Pick point** the software expects the input of coordinates. This is possible by mouse click but also by measuring and subsequent data transfer. The full accuracy of coordinates is taken over also by application of this procedure.

Control points - Search control point

	Command name:	Menu:
	PCSEARCHCP	As-Built Photo

This command checks whether a control point already exists in the current drawing.

> Command: PCSEARCHCP

> Number of control point: **57**   *(enter name or number, respectively)*

If the control point is found in the drawing As-Built will display the coordinates of the control point in the command line.

> Control point 57 with coordinates (143.109, 499.986, 2.989) found.

> Do you want to zoom to control point? [Yes/No] <Yes>: **y**

If you answer the question with 'Yes' the screen section is zoomed so that the control point you are searching for will be exactly in the centre. The corresponding control point will be brought up front in the display order.

Control points - Control point via arc intersection

	Command:	Menu:
	KUBT_PC_ARCINTERSECTION	As-Built Photo

With this command new control points can be generated constructively, if you have measured the linear distance of the new control point from two distinctive points. By doing so, it is possible to construct a 2D control point grid successively. A measuring tape is all you need.
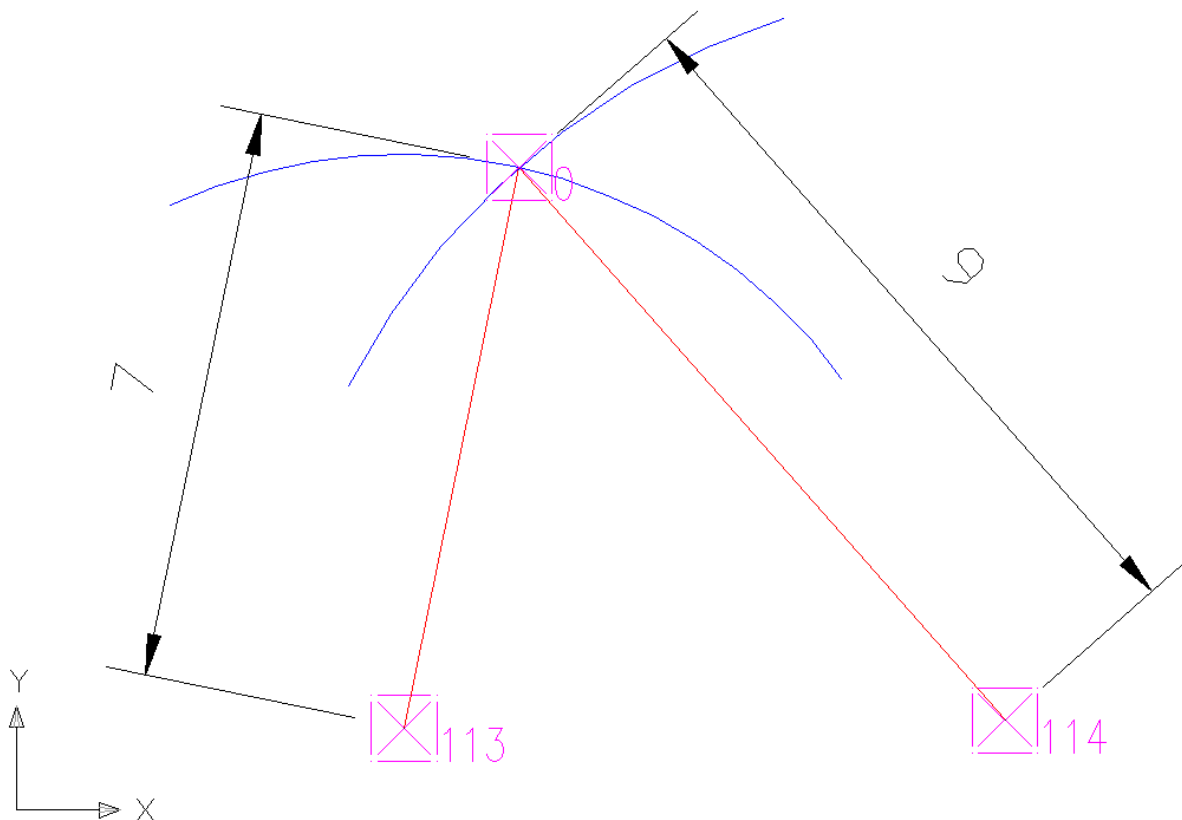
Command: **KUBT_PC_ARCINTERSECTION**

First base point:

Point or [Controlpoint/Number/Finish] <Finish>: **c**   *(Option control point)*

Select control point or [Number/Point/Finish] <Finish>:   *(Select control point 113.)*

Distance from first base point: **7**

                                                (The distance of control point 113 to the new control point is 7 metres.)

Second base point:

Select control point or [Number/Point/Finish] <Finish>:   *(Select control point 114.)*

Distance from second base point: **9**

                                                (The distance of control point 114 to the new control point is 9 metres.)

Point for side of intersection:

                                                (For the example a point above the control points 113 and 114 is clicked.)

Number for new control point <1>: 0   *(Number or name of the new control point.)*

Draw intersection lines [Yes/No] <No>: y

(Option for displaying the intersection lines. Red in the example.)

The arc intersection is executed in a plane that is parallel to the XY plane of the current UCS. The Z-coordinate is equivalent to the mean value of the Z coordinates from the first and second base point.

Control points - Align control points

	Command name:	Menu:
	PCROTATECP	As-Built Photo

This command serves for aligning control points or other AutoCAD blocks with the XY plane of the current UCS. After that all selected control points or other blocks are brought to front in the display order.

> Command: PCROTATECP
>
> Align all control points or [Control points/dimension Symbols] <Control points>:   *(Press ENTER)*
>
> Align with [Ucs/current View] <Ucs>:

A typical application for this command is the change into another UCS during the rectification of more than one image onto various rectification planes, where control points are possibly not visible anymore as they may lie e.g. rectangular to the top view.

Control points - Change size of Control points

	Command name:	Menu:
	PCRESIZECP	As-Built Photo

This command allows you to adjust the size of As-Built blocks (control points or dimension symbols) to your individual needs.

Different projects often differ in depicted images of the world. The standard setting of As-Built uses symbol (block) sizes (e.g. Control and Image point blocks) which are adjusted to facades between 5–20 m (AutoCAD units). If you want to rectify smaller objects (e.g. a painting) control points may be too large. You can change these settings by using the command 'PCRESIZECP'.

When running the command a dialogue appears, in which you change the scale factor which relates to the AutoCAD drawing unit.

Afterwards all control points, area and height blocks in the drawing will be adjusted.

UCS - Define rectification plane (UCS)

	Command name:	Menu:
	KUBT_PC_UCSCP	As-Built Photo

The XY plane of the current user coordinate system (UCS) is used as rectification plane in As-Built. You can use the command KUBT_PC_UCSCP for an easy definition of a rectification plane. It allows you to define a mean rectification plane through a set of control points.
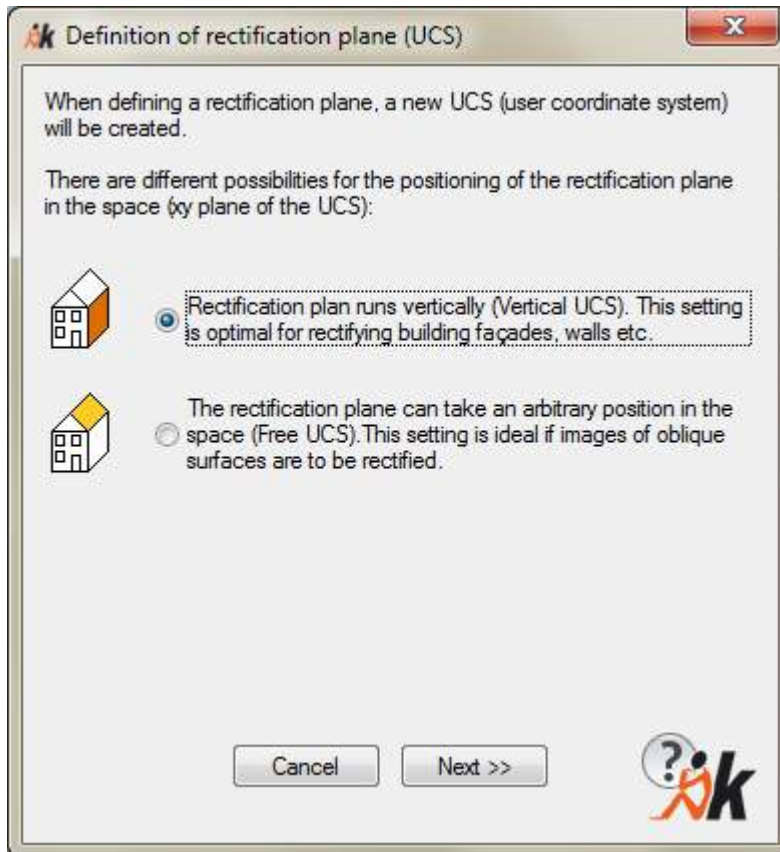
In the first step you have to decide of which type the rectification plane is to be.

Vertical rectification plane

Vertical means that the XY plane of the UCS runs parallel to the Z axis of the world coordinate system (WCS) as it may be necessary for facades.

façade with
control points
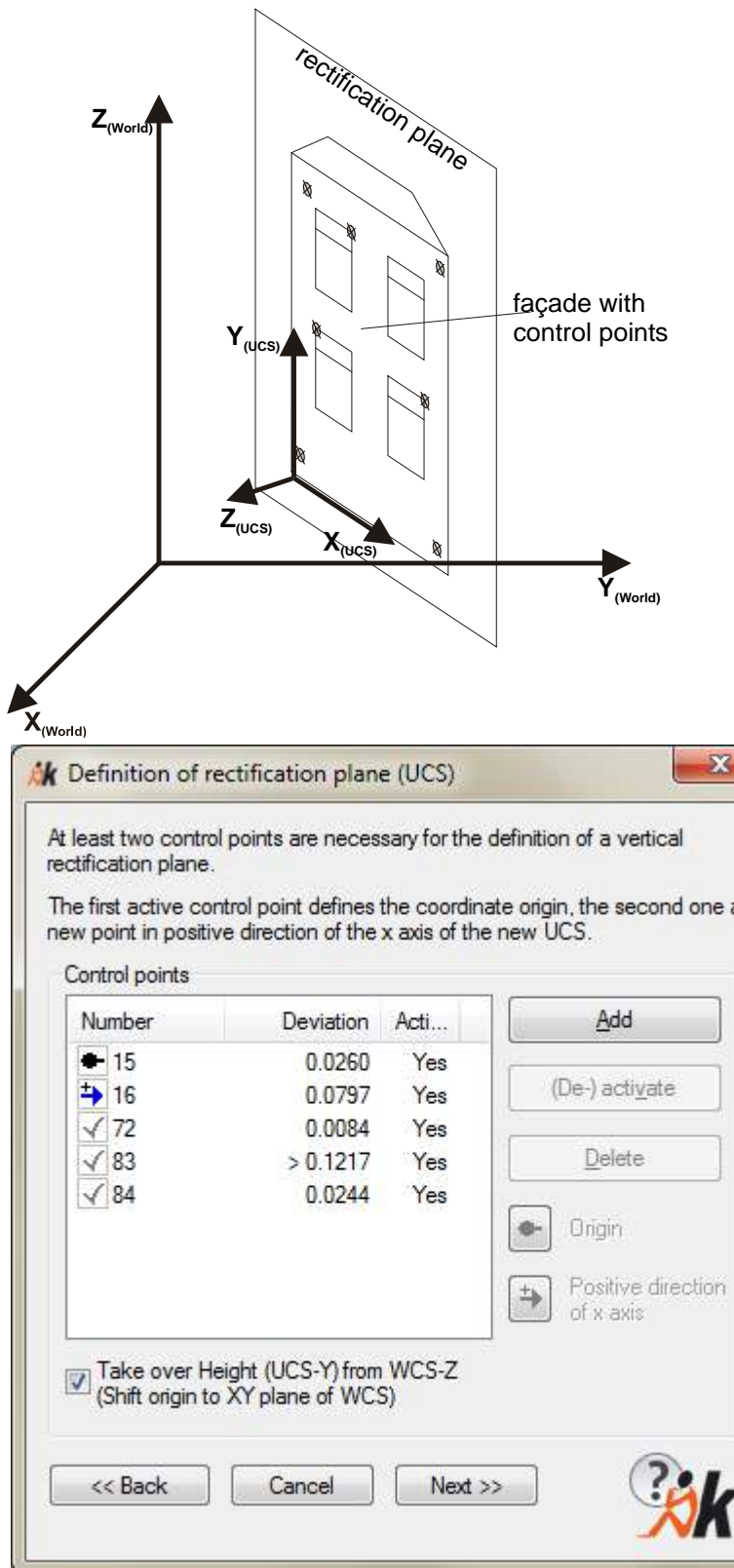
With "**Add**" you indicate a set of control points that are to be used for the calculation of the rectification plane. The indication of two control points is sufficient to align the rectification plane. The first control point determines the coordinate origin. The second control point determines a point in positive direction of the X axis of the UCS, which always runs parallel to the XY plane of the WCS. Thus, you also determine from which side you look at the plane since the X axis always points to the

right. In order to define a different point as origin or as X direction please use the buttons

 and .
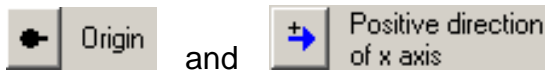
If you want to keep the height information click the option "Take over Height (UCS-Y) from WCS-Z (Shift origin to XY plane of WCS)" and you will place the origin of UCS in XY plane of WCS.

If you indicate more than two control points, a mean vertical plane will be created through these points. We recommend indicating all control points that have been used for a rectification process to create a plane that reflects the rectification plane as good as possible.

Possible deviations of individual points from this plane will be shown in the column "Deviation". The deviation should be as small as possible. Here you can see a point protruding out of a plane. With "(De)activate you can exclude one or more points from the calculation of the plane.

Instead of selecting the control point directly in the drawing, you can also indicate its number. To do so use the command option "Number" in the command line content:

> Select existing control point or [Number/Measure/Finish] <Finish>:

The option "Measure" prompts you to click any point instead of a control point. You can get such a point with object snap or you measure it directly with a total station (As-Built Total Station Interface).

If you are satisfied with the definition or deviation respectively, you will be asked to enter a name for the rectification plane in the last step.

If you work with several photos and several rectification planes, you should name the UCS. However, you can also leave the entry field empty.

After you have clicked '**Finish**', the software will automatically switch to the top view of the new UCS and the control points will be aligned respectively.

Free rectification plane

For an easy definition of an oblique rectification plane, choose the option "Free rectification plane". It is suitable for oblique areas (e.g. roofs, facades of old frame work houses, ceilings etc.). In contrast to the vertical rectification plane, three control points are necessary.

The first point ⊕ determines the coordinate origin again. The second control point ⇥ determines a point in positive direction of the X axis of the UCS. Thus you determine from which side you look at the plane as the X axis always points to the right.

For the final determination of the rectification plane you also need to indicate the direction of the y-axis. In order to keep that simple, there are three options: "Front elevation" is used for approximately vertical facades which you want to view from the front. "View from top" is used for approximately horizontal planes which you want to view from top. And "View from bottom" is used for ceilings of which you took photos from below. The X axis of the new UCS will then be aligned parallel to the XY plane or the XZ plane of the WCS.
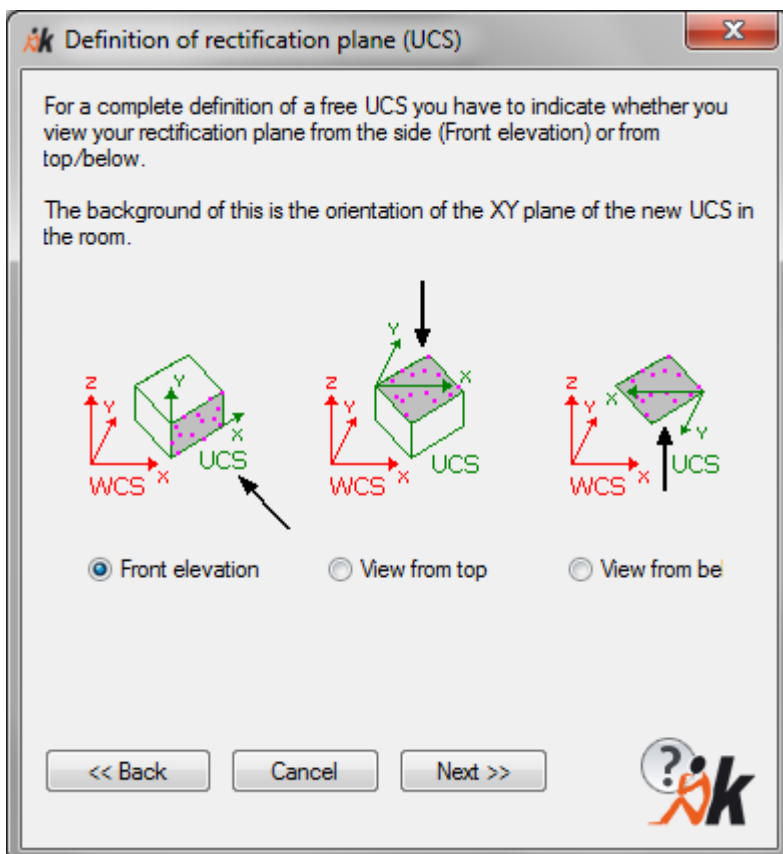
The definition of the rectification plane will be logged in an ASCII file with following naming convention: DRAWINGNAME_UCS_UCSNAME.PRK.

UCS - Define rectification plane by 3 points (UCS)

	Command name:	Menu:
	KUBT_PC_UCS3P	As-Built Photo

This command will set up a new user coordinate system (UCS) with the help of three points.

During a rectification according to geometry the rectified image is always stored on the XY-plane of the current UCS. Thus it serves as rectification plane. With the definition of a new UCS you may determine before the rectification process how the rectified image is to be positioned in space.

After calling up the command the following prompt will appear:

Command: KUBT_PC_UCS3P

Point for origin: *(click a point for the nought of the coordinates)*

Point at positive X-axis: *(click a point for the direction of the X-axis)*

Point with positive Y-coordinate in the XY-plane of UCS: *(click a point for the direction of the Y-axis)*

The display now is aligned with the new XY plane.
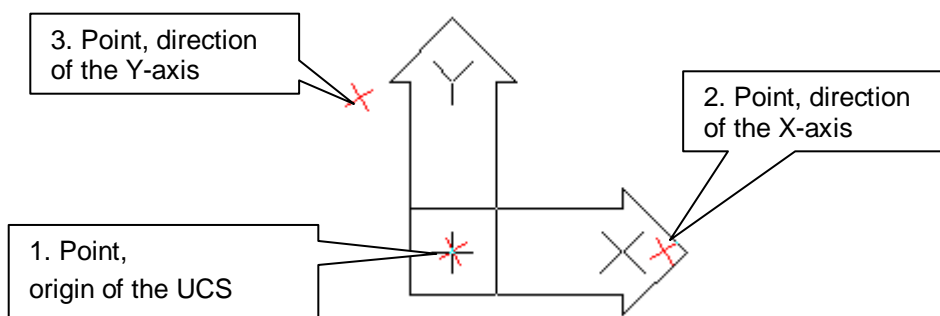
Naming the UCS makes it easier for you to return to it later:
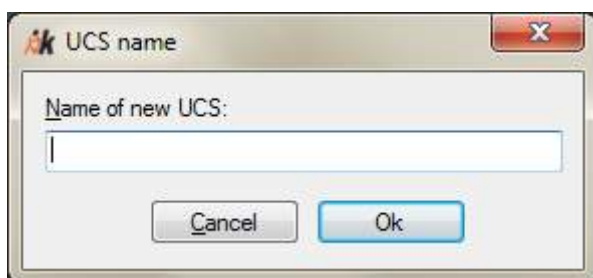
Insert an easily recognizable name. If you do not want to name the UCS press **Return.**

The definition of the rectification plane will be logged in an ASCII file with following naming convention: DRAWINGNAME_UCS_UCSNAME.PRK.

Hint: If you work with more than one photo and more than one rectification plane we recommend that you name the UCS. You may just return to it easily later. To do so use the command "**Restore rectification plane (UCS)**". Choose the required UCS from the list and click on "Current".

UCS - Restore rectification plane (UCS)

	Command name:	Menu:
	KUBT_PC_UCSRESTORE	As-Built Photo

With this command you can restore previously defined and named rectification planes. All control points will be aligned anew.
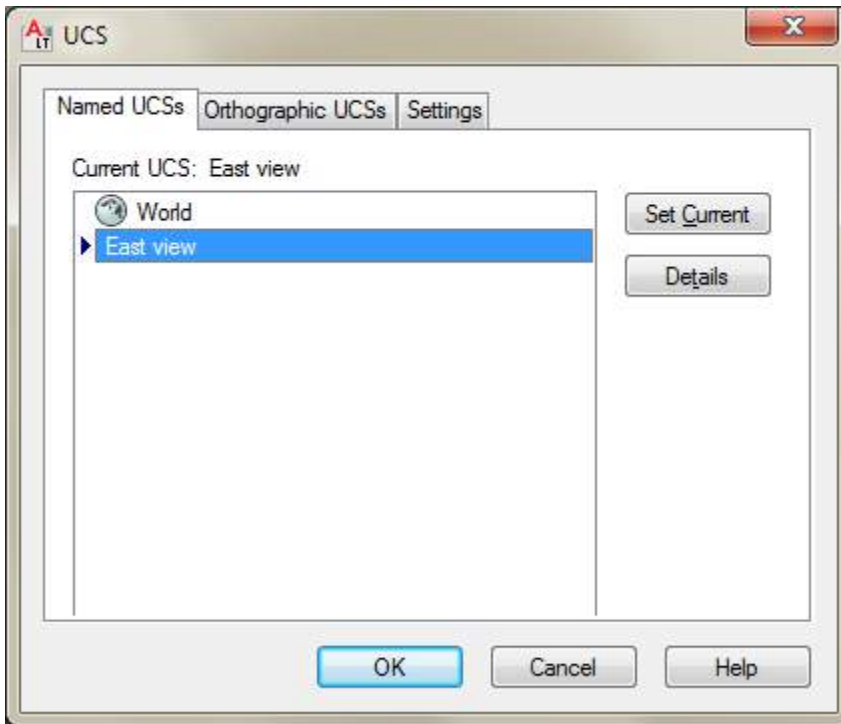
Select the rectification plane (UCS) to be restored in the list, click on '**Set Current**' and finally '**OK'**.

UCS - Set drawing elevation according to XY plane of UCS

	Command name:	Menu:
	KUBT_IM_SETELEVATION	As-Built Photo

With this command you can easily set the AutoCAD system variable ELEVATION to a Z value of a point you snap in the drawing. That allows you to digitize on a plane parallel to the XY plane of the current UCS at the depth you selected. This helps to simplify e.g. digitizing of spatial structured facades.

> Command: KUBT_IM_SETELEVATION
>
> Please select a point. The Z value of this point defines the new AutoCAD
>
> drawing elevation.
>
> Point for AutoCAD drawing elevation or reset elevation to 0 [Reset] <Reset>:
>
> > *(Select any point or "R" for reset. OSNAP is being activated)*
>
> The drawing elevation (ELEVATION) has been set to <VALUE>.

After having set the ELEVATION all lines and other AutoCAD objects are drawn with the corresponding z value. Usually the command is used to draw at a certain elevation without OSNAP "Point".

Please also read chapter 5.5 of this manual.

UCS - UCS from current view

	Command name:	Menu:
	PCSETUCS	As-Built Photo

This command generates a new UCS according to the current view. The XY layer of the new UCS lies exactly within the currently visible screen plane.

This function is helpful when orientating images (→**Oriented Images – Image orientation**). After you have imported or defined the control points needed for the image orientation, you should rotate the drawing, so its orientation is almost the same as the viewing direction of the camera. After you created this rotated view, you generate a UCS according to the current view by running the command 'UCS from current view'. Select a control point as origin for the new UCS. The same control point is to be used for the following image orientation as well.

> Control point for origin of new UCS:

> Select control point or [Number/Measure/Finish] <Finish>:

The UCS is set and all control points are aligned accordingly.

Now you can load the image to be orientated next to the control points.

Image - Load image

	Command name:	Menu:
	PCLOADIMG	As-Built Photo

With this command you may load a pixel image into an AutoCAD-drawing. In principle this may also be done with the AutoCAD-command 'Insert/Pixel Image' which is not available under AutoCAD LT.

The command runs as follows:

Command: PCLOADIMG
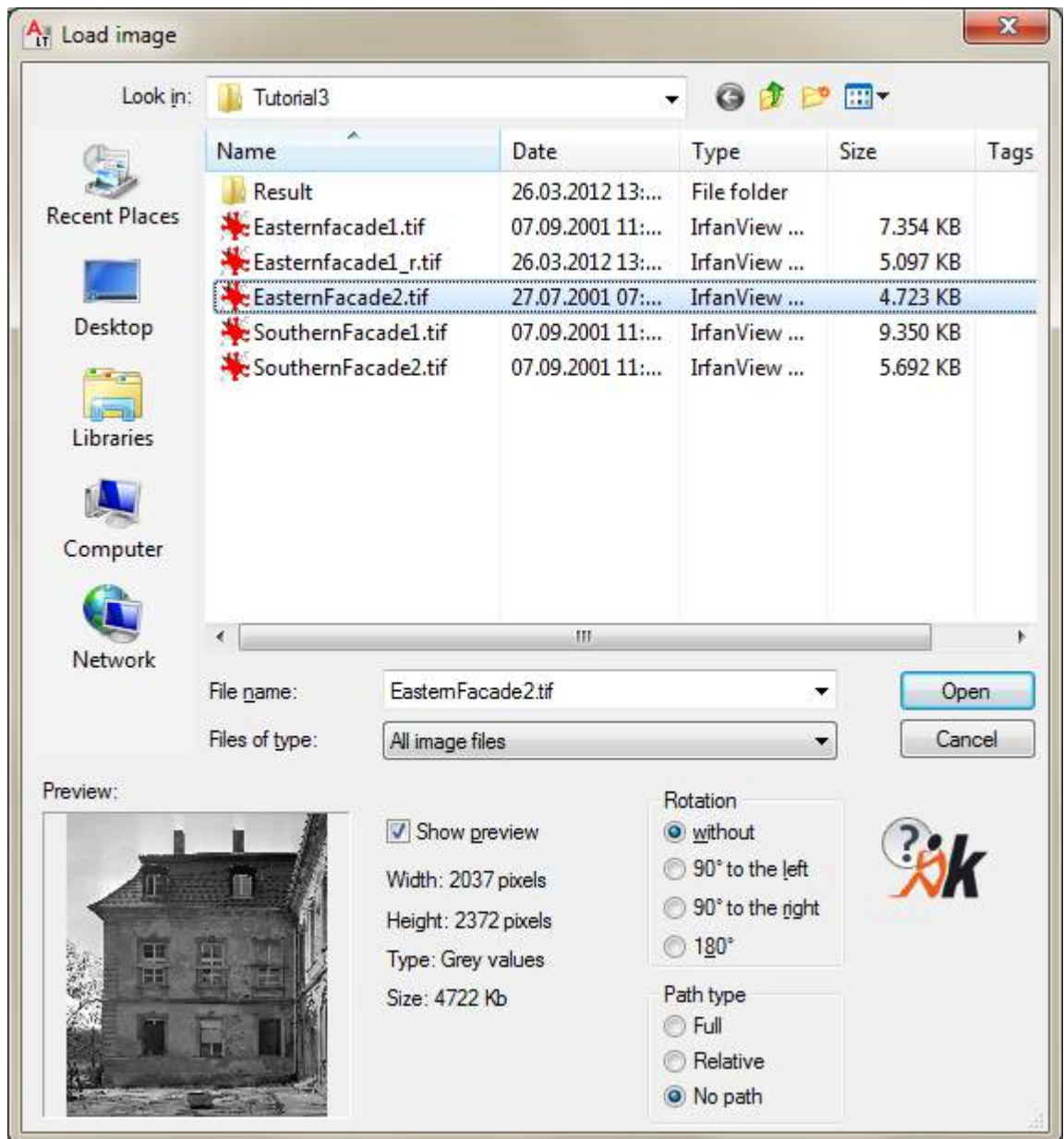
After opening the image, you will be prompted to indicate the position of the image in AutoCAD:

Insertion point for image: (click a point for the bottom left-hand image corner)

Second point for image size: (click a point for the top right-hand image corner)

When inserting the image, please set the image size to the approximate dimensions of your measuring object. Thus, you can avoid that the size of the distorted image deviates from the size of the rectified image to a large degree.

If a PhoToPlan (previous product) or As-Built image information file (*ppb) exists for the image, you will be asked whether the information on position, size, UCS and clipping saved there should be taken over. In this case, the image will be positioned and scaled automatically. Such an image information file exists for all images that were rectified or montages created with PhoToPlan (previous product) or As-Built.

Additionally to the indicated image formats, you can also read in all image formats that are supported by AutoCAD. To do so select "All files (*.*)" if necessary. The indicated image formats only represent the least common denominator of the different AutoCAD versions.

Loading of geo-referenced images (world file)

As-Built allows you to load images which were not created by PhoToPlan (previous product) or As-Built but are geo-referenced by a world file in correct positional arrangement. For a closer look at "Geo-referencing and world file" please read the description at command reference →**Export - Create ESRI World Files.**

Exists a world file for the selected image in same folder, As-Built will ask you for taking over the image position that is saved in this world file.

If you click "**Yes**" the image will be scaled and positioned according to the data of the world file. Because of interpreting coordinates as UCS coordinates take care that your current UCS in the drawing is conform to the coordinate system that was used for creating the world files.

Option Rotation

If you process images taken with a digital camera, the images may appear rotated 90 degrees (e.g. those taken in the panel format). The rotation options of the command "**Load image**" allow you to insert images rotated without the need to calculate the image anew.

Option Path type

Images are not directly embedded in an AutoCAD drawing but only the path to an external image file is saved. Such a path can be:

- complete (full),

- relative to the drawing file or

- empty (no path).

Full: The complete path of the inserted image is saved. This is the default setting and always works without limitations. The drawback of this method is that the image will not be found if you hand on the project data (Copying to another computer, burning on CD) since the path will render incomplete or will not exist in that form any longer. The images will then have to be linked manually.

We recommend this option for small local projects that will not be handed on and which are processed by one editor.

Relative: Only the path relative to the drawing file will be saved. The advantage is that the project directory with all its subdirectories (with images) can be moved or handed on as long as the relative organizational structure is kept. However, relative paths only work if the drawing file is located on the *same* drive as the image file. They are especially suitable for large projects in which image files have to be organized in subdirectories. Here an example:

J:\..\Project1\Drawing1.dwg refers to images in

J:\..\Project1\Images1\Facade1.tif and *J:\..\Project1\Images1\Facade2.tif*

The path indications are ".*\Images1\Facade1.tif*" and ".*\Images1\Facade2.tif*". There will be no problems if you move or copy the complete project directory "Project1" with its subdirectory "Images1" from drive J: to drive X: If you had used absolute path indications, the images would always have been searched for on drive J: which does not necessarily have to be existent on another computer.

We recommend using relative paths for large projects with many editors. The data should be organized in sub file structures.

No path: No separate path will be saved for every inserted image. AutoCAD will rather try to search for an image at the following positions (in this order):

- current folder of the drawing

- "Tools - Options – Search path for project data" (not under AutoCAD LT)

- "Tools - Options – Search path for support file"

- Start file in the application link of AutoCAD

The option "no path" can be suitable for small projects in which data have to be handed on and which are processed by many editors. The images will then be saved in the same file as the drawing file.

With large projects with many editors in a network, in which images are used in several drawings, the images should be saved in central directories of the network and should be embedded in the individual drawings "Without Path". In AutoCAD the necessary search paths for project files (image files) are defined and set.

Image - Detach all unused images

	Command name:	Menu:
	KUBT_PC_IMAGEDETACH	As-Built Photo

With this command you detach all images that are not used (invisible) from the drawing. Since, if you just delete images from an AutoCAD drawing by selecting them and pressing the delete button, these images are still referenced within the drawing even if they are no longer visible as drawing objects.

Only by detaching them the references of the images are removed too.

Command: KUBT_PC_IMAGEDETACH

Detach all unused (invisible) images from drawing ? [Yes/No] <No>:

Image - Clip image

	Command name:	Menu:
	OICLIP	As-Built Photo

With this command you may clip a pixel image to a desired detail. A randomly selected polyline serves as the clippings' boundary. You have to draw this line before calling up the command 'Clip image'. If you did not draw a clipping boundary in advance you have the option to click points for the cut after you selected the image.

Command: OICLIP

Select image to be clipped or <Cancel>:   (*click on image's periphery*)

Then you will get the message

Polyline for boundary or [Points/Further boundary/Delete cut/Back/Finish] <Finish>:

(*click on polyline boundary*)

The following message will appear:

Polyline for further boundary or [Points/Select boundary/Delete cut/Back/Finish] <Finish>:

(*click on further polyline boundary or Enter*)

Now you have the possibility to exit this command with [Return] or to choose further polylines to define outer or inner parts of the new image (holes).

And finally - if you used polylines for clipping - you will get:

Delete used polylines?

After answering this question with either Yes or No the clipping will be carried out.

If you instead of selecting polylines use the option "p" for points, the prompt in the command line looks slightly different:

Polyline for boundary or [Points/Further boundary/Delete cut/Back/Finish] <Finish>: **p**

Start point or <Cancel>:   *(Click first point of the boundary.)*

Next point or [Close/Cancel] <Close>:   *(Click further points on the boundary.)*

…

Next point or [Close/Cancel] <Close>:   *(ENTER in order to close the boundary.)*

Polyline for further boundary or [Points/Select boundary/Delete cut/Back/Finish] <Finish>:

(Click on boundary polyline or "P" for an additional boundary or ENTER to finish.)

The parts of the image that were clipped out are not deleted. AutoCAD just cuts them out. If you want to carry out corrections on the image part after the clipping, just mark the boundary with a click and move one of the corner points with the mouse to the desired position. If you want to undo a clipping select the option 'Delete cut'.

If you like to delete only the parts of the images that you cut away and keep just the relevant parts of the clipped image, you may use the command 'Merging of images…'. This command considers only the clipped part and calculates a new image from it. Further information on this command is to be found within the command reference under '**Merging of Images**'.

Only the clipped image part is taken for the rectification. Thus this command is suited to exclude image parts that are not needed from the rectification. Thus it is possible to save a lot of storage capacity and computer time when working with slanted photos.

Example:

distorted original image   clipped original image

rectification of clipped image

Image - Intersect image boundaries

	Command name:	Menu:
	KUBT_PC_INTERSECTIMAGES	As-Built Photo

With this command you may trim and extend image boundaries of two images up to their common intersection line. This can be useful to create accurate intersection lines in 3D projects.

Select two images to intersect. If necessary please delete or displace at background active polylines for an easier click of images.

Command: KUBT_PC_INTERSECTIMAGES

Select first image to be intersected or <Cancel>:   *(click on image frame)*

Select second image to be clipped or <Cancel>:   *(click on image frame)*

Click images on those sides, which are **not** to be trimmed or extended. After selection you have to decide for one of two offered options:

Intersection type for image boundaries [Trim/trim And extend] <trim And extend>:

To illustrate these options following picture shall help you:
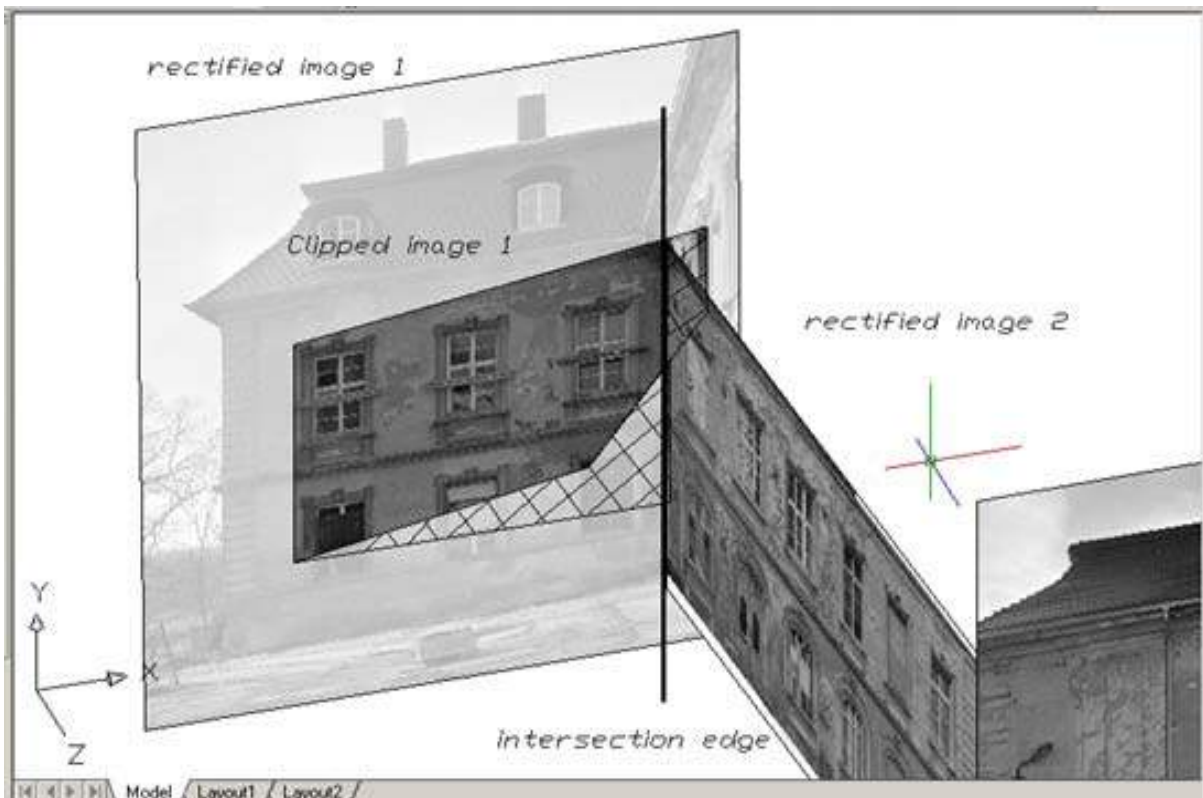
You can see a (rectified) clipped image, the rectified original (transparent in the background for visualization) and a second rectified image. For intersection the clipped image and image 2 were clicked.

By choosing only option **"Trim"** the part of the clipped image right to intersection line is trimmed up to this line. If option **"trim And extend"** is selected right hand side is trimmed like described before <u>and</u> left hand side part of clipped image is extended based on the maximum width up to intersection line. This is possible because cut off parts are only hidden but not deleted after clipping an image, see →**Image - Clip image**. Image data still exist. The result of the intersection you can see in following picture.
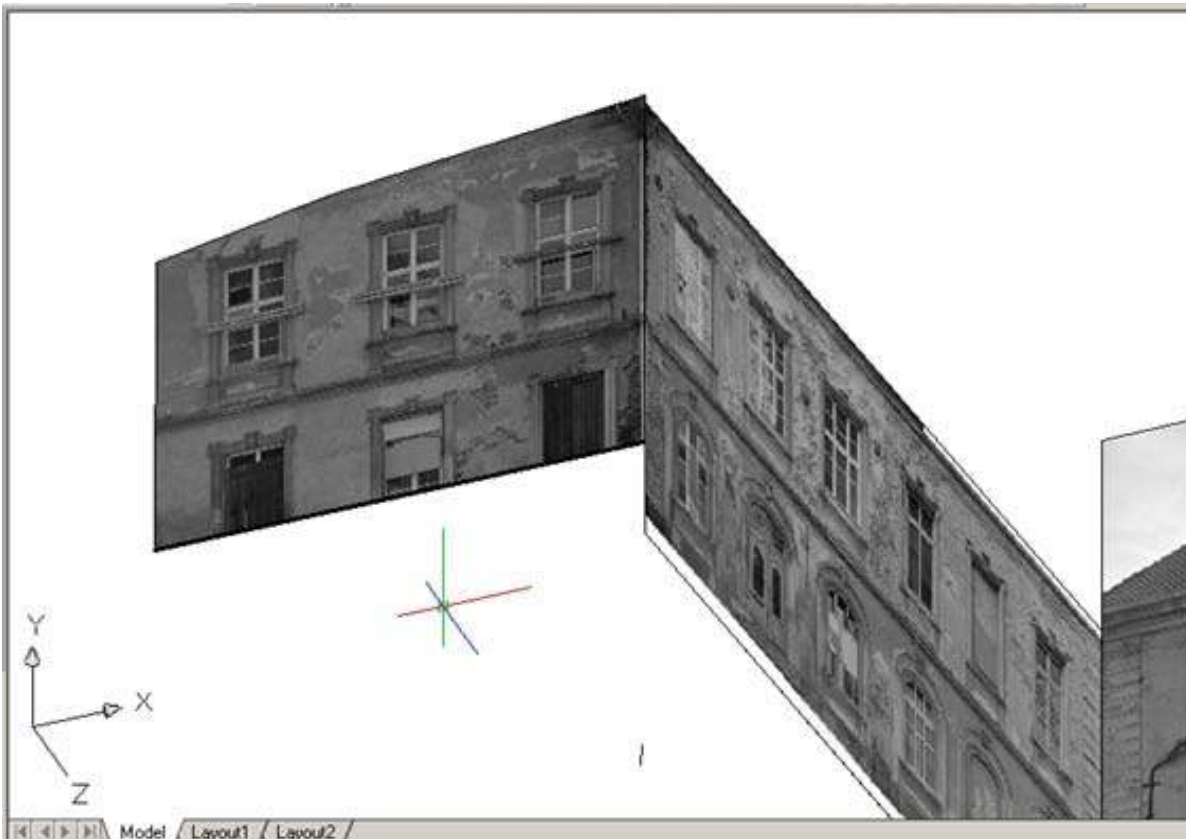
If at least one of two images to intersect does not reach up to the intersection line the following message will appear in the command line:

First image does not reach up to the intersection edge.   *(and if so)*

Second image does not reach up to the intersection edge.

Are two coplanar images selected an intersection is not feasible. And following message appears:

Cannot compute intersection line of these images.

Image - Adjust image

	Command name:	Menu:
	_IMAGEADJUST	As-Built Photo

Here you can set brightness, contrast and the degree of fading the image with the background colour.
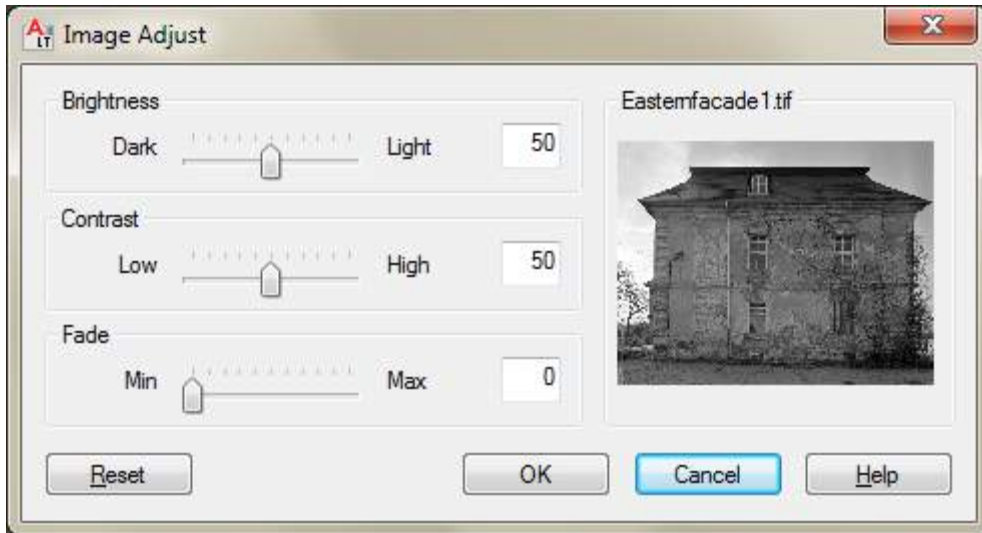
Image - Image transparency

	Command name:	Menu:
	_TRANSPARENCY	As-Built Photo

In some file formats you can create images with transparent pixels (e.g. PNG, GIF).

If the image transparency is enabled with this command, AutoCAD will recognize these transparent pixels and will display them transparently in the drawing area. Background pixels in bicoloured images will be treated like transparent pixels.

Creating such transparent images is, however, not possible with AutoCAD. To do this you need an external image editing program (e.g. Photoshop or GIMP).

Image - Image frame on/off

	Command name:	Menu:
	KUBT_PC_IMAGEFRAME	As-Built Photo

With this command you can show or hide the frames around the images in your AutoCAD drawing. Please keep in mind that images cannot be selected if the frame is hidden.

If your drawing contains a set of images of several sub-images, you can easily hide the disturbing frames around every individual image. If you intend to present the drawing visually or to plot it, you can save the often tiresome step of "Image montage" and still end up with one final image.

Image - Image quality high/low

	Command:	Menu:
	KUBT_PC_IMAGEQUALITY	As-Built Photo

With this command you can control the presentation quality of blown up images. However, a high image quality also results in higher calculation time, which, on the other hand, should not pose problems to modern graphic cards. This setting only influences the display in the 2D Wireframe mode.

Image quality high – Individual pixels "blurred"
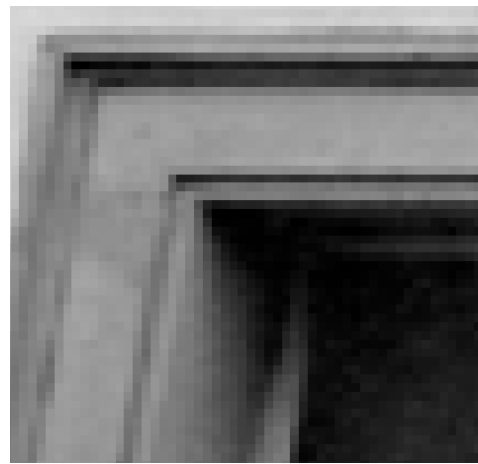
Image quality low – Individual pixels visible

Image - UCS from image

	Command:	Menu:
	PCSETUCSFROMIMAGE	As-Built Photo

With this command it is possible to establish a UCS, with the XY plane matching the image plane exactly. The coordinate origin is in the bottom left corner of the image.

Optionally it is possible, to switch to the plan view of this image, if you answer "yes" to the following question in the command line:

Zoom to image? [Yes/No] <Yes>:

Rectification by control points - Rectification of photos (Projective Transformation)

	Command name:	Menu:
	KUBT_PC_RECTIFY	As-Built Photo

With this command the actual rectification according to control points is carried out. Within this process you can also correct image distortion.

The command opens an extensive dialogue, which is sub-divided into different sections.
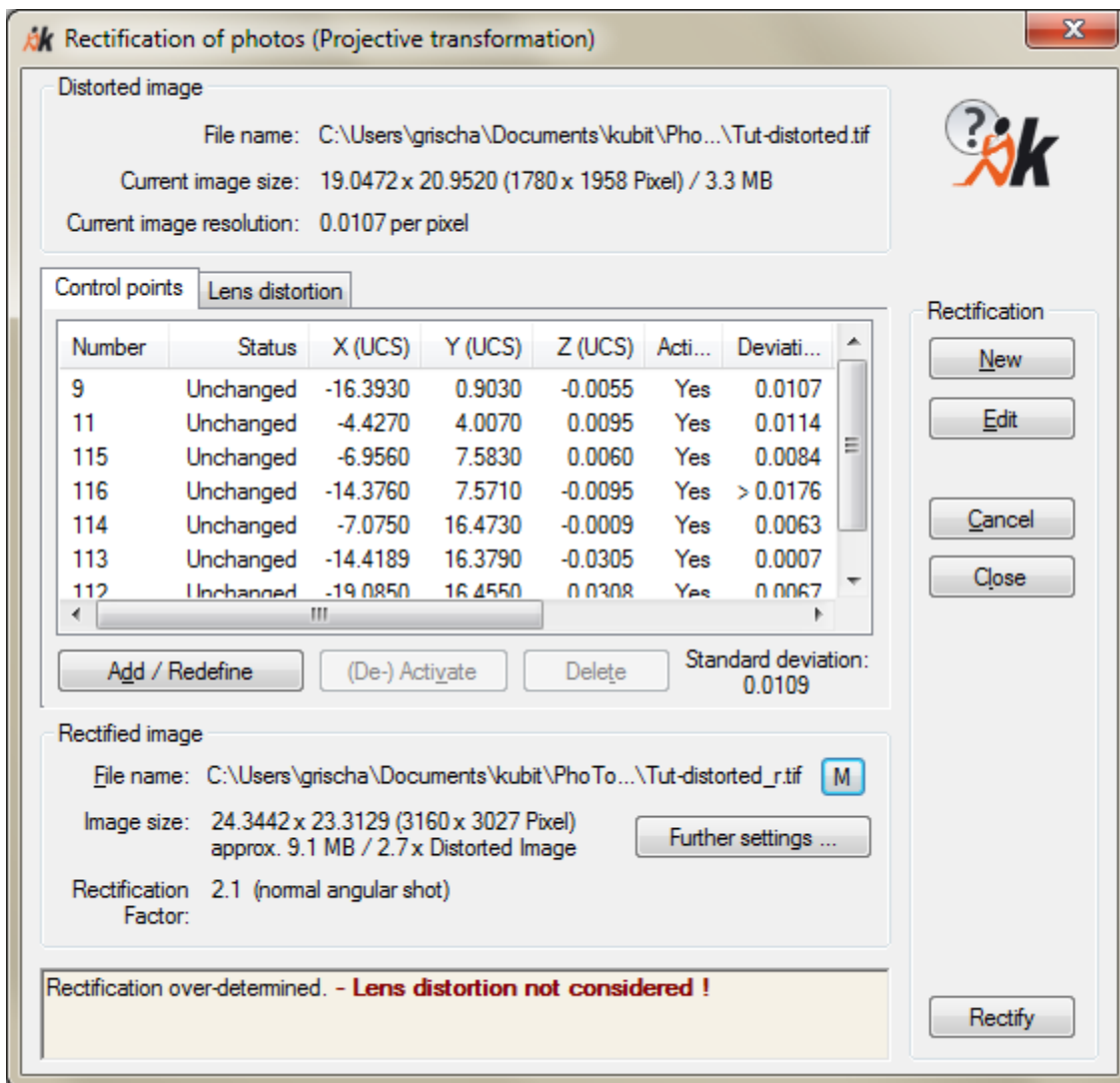
1. The Frame 'Rectification'

Here you may determine in general what you want to do next.

- With [**New**] you start a new rectification. With a click on this button you will leave the dialog and the following call will appear in the command line:

  Choose distorted image or <Cancel>:   *(select pixel image in the drawing)*

  After that the dialog returns. The control point list is empty and you may assign control points now (see 3.: List of Control Points).

- With [**Edit**] you call up a completed rectification again and may alter it and/or repeat it. The following message will appear in the command line:

  Choose rectified image, which has to be edited or <Cancel>:   *(click on image's periphery)*

  The already assigned control points of this rectification are displayed in a list.

  A rectification can only be processed if the corresponding distorted and rectified image still exists in the drawing.

- With [**Rectify**] you start the rectification process. The button is only activated when all conditions for a rectification are fulfilled: the rectification has to be determinable (that means enough control points have been previously measured before) and all statements concerning the rectified image have to be complete.

- With [**Cancel**] you leave the dialogue. All alterations that were carried out are rejected. With [**Close**] they are stored on the other hand.

2. Information concerning the distorted Image

In the upper part of the dialogue you will find a few statements concerning the distorted image.

- Under '**current image size**' you will find two statements: The current measures of your drawing and behind it in brackets the number of pixels in height and width.

- The **current image resolution** states – based on these values – the size of a pixel.

3. List of Control Points

The control point chart takes up a central position. Here you find all control points you assigned to an image point that are to be used for the corresponding rectification.

In addition to the object coordinates (UCS) of the control points you find information concerning the corresponding status, activation mode and the positioning error. Under the chart you will find three buttons:

- In order to assign all control points relevant for this rectification in the distorted image click on [**Add/Redefine**]**.** You come back to the drawing and obtain the following call in the command line:

  Select control point or [Number/Measure/Finish] <Finish>:

  Click on the control point you want to assign next. You can also insert the number of a control point or create a new control point. Use either the option <Number> or <Measure>.

  Now you are asked to determine a zoom region:

  First point for zoom region to control point 114 or [Cancel] <Cancel>:

  Second point for zoom region to control point 114 or [Cancel] <Cancel>:

  Go into the image with the mouse and open up a zoom region around the control point mark. If you do not want to zoom, press the Enter key instead this will cancel the zooming.

  The next message asks you to assign the corresponding image point:

  Image point for control point 114 or [Zoom window off/Connecting lines off/Cancel] <Cancel>:

Just click with the mouse on the corresponding place in the distorted image. After that you zoom back automatically to the previous view and you will see that control point and image point are connected by a line. This serves for clarity and better orientation during the assignment. With the option <Cancel> you finish the assignment and come back to the rectification dialogue. Hint: If you generally want to turn off the prompt for the zoom you may do it using either the command line option [Zoom window off] or the →**Settings** command (section "System"). If you do not like the temporary connection lines between the control and the image points you may turn them off using the command line option [Connecting lines off].

- With the button [**(De)activate**] single control points can be switched off. They are then not considered for the calculation of the rectification parameters. In the column 'Active' the control point is then marked with 'No'.

- The button **Delete** serves for the final removal of control point assignment from the chart. In order to do so first you have to mark the point with a click on its point number.

The column '**Deviation**' is of special importance. With more than four measured control points you will have an over-determination and a compensation calculation is carried out during the calculation of the rectification parameters. Here the error value is the deviation of the control point coordinates from the position of the rectified image point assigned to it. Errors in the assignment can be detected by a specific de-activation of single control points. In the end the error is resulting from the absolute positioning error during the measuring of the control point, the assignment error in the distorted image and from the distortion caused by the lens during the image creation process of the image to be rectified.

In the column '**Status**' you will find information on whether the control point was deleted in the drawing or altered in its position. In this case a corresponding remark is entered and the point is de-activated just to be sure. If you re-activate it As-Built calculates with its original point position during a rectification! If you want to use the control point's new position you have to re-assign it.

4. Frame 'Lens distortion'

During the rectification by control points you can carry out a correction of lens distortion as well. Check the option '**Correct lens distortion'** on the tab '**Lens distortion'.** You will find further information in section **4.7 Photos – Shooting and Digitizing** or under **Rectification according to geometry - Correction of lens distortion.**
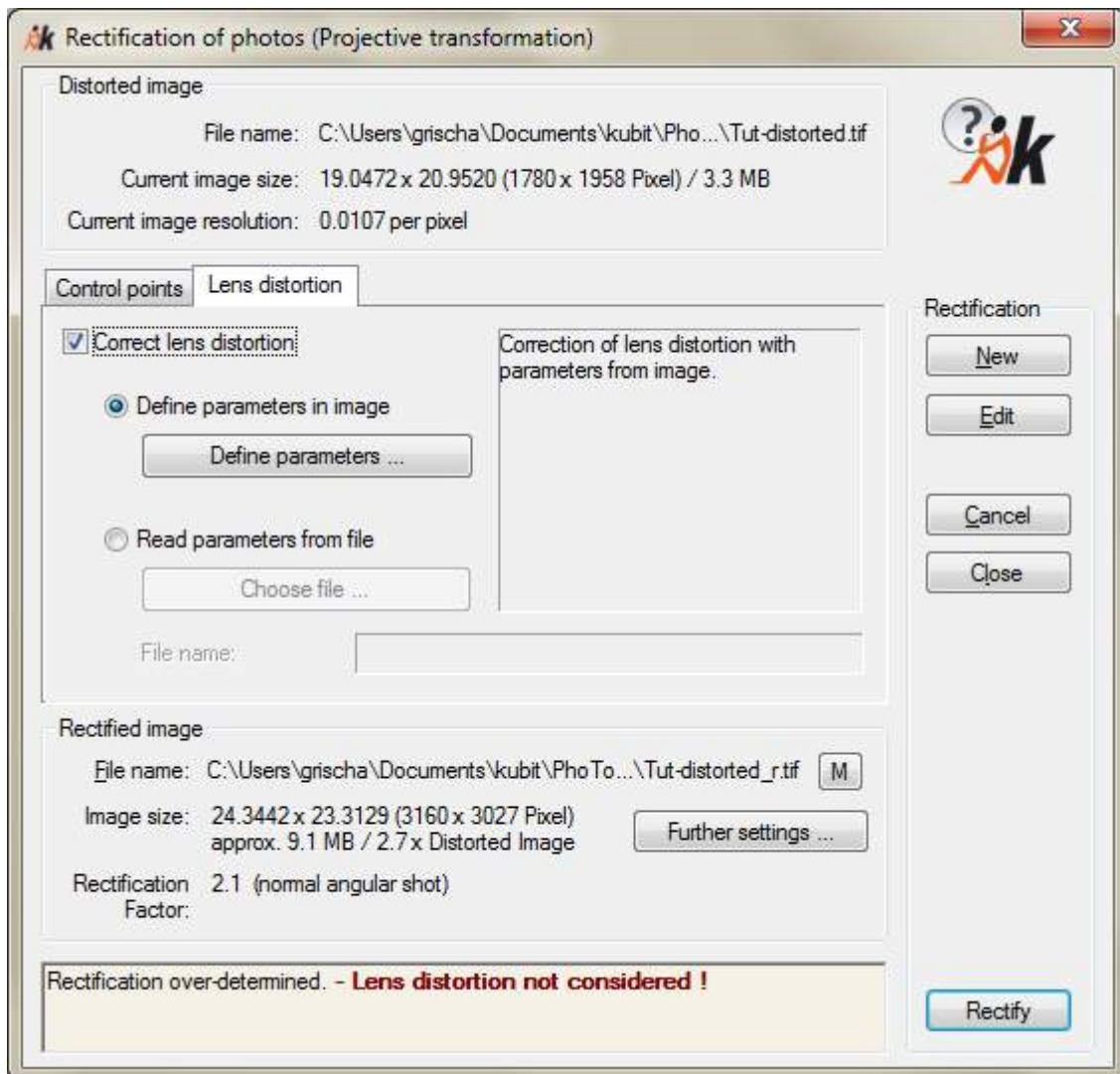
The command offers two ways of distortion correction:

- If you choose '**Read parameters from file**' you can load certain distortion parameters for your camera settings from a file. It is essential that the picture was taken under the same conditions as those pictures that were used for determining the distortion parameters. You find more information in unit '**Rectification according to geometry - Correction of lens distortion**'

- If you choose '**Define parameters in image**' you can determine the distortion parameters directly within the image. A dialogue opens as described in point 4) of section '**Rectification according to geometry - Correction of lens distortion**' of the command reference, where you find further information.
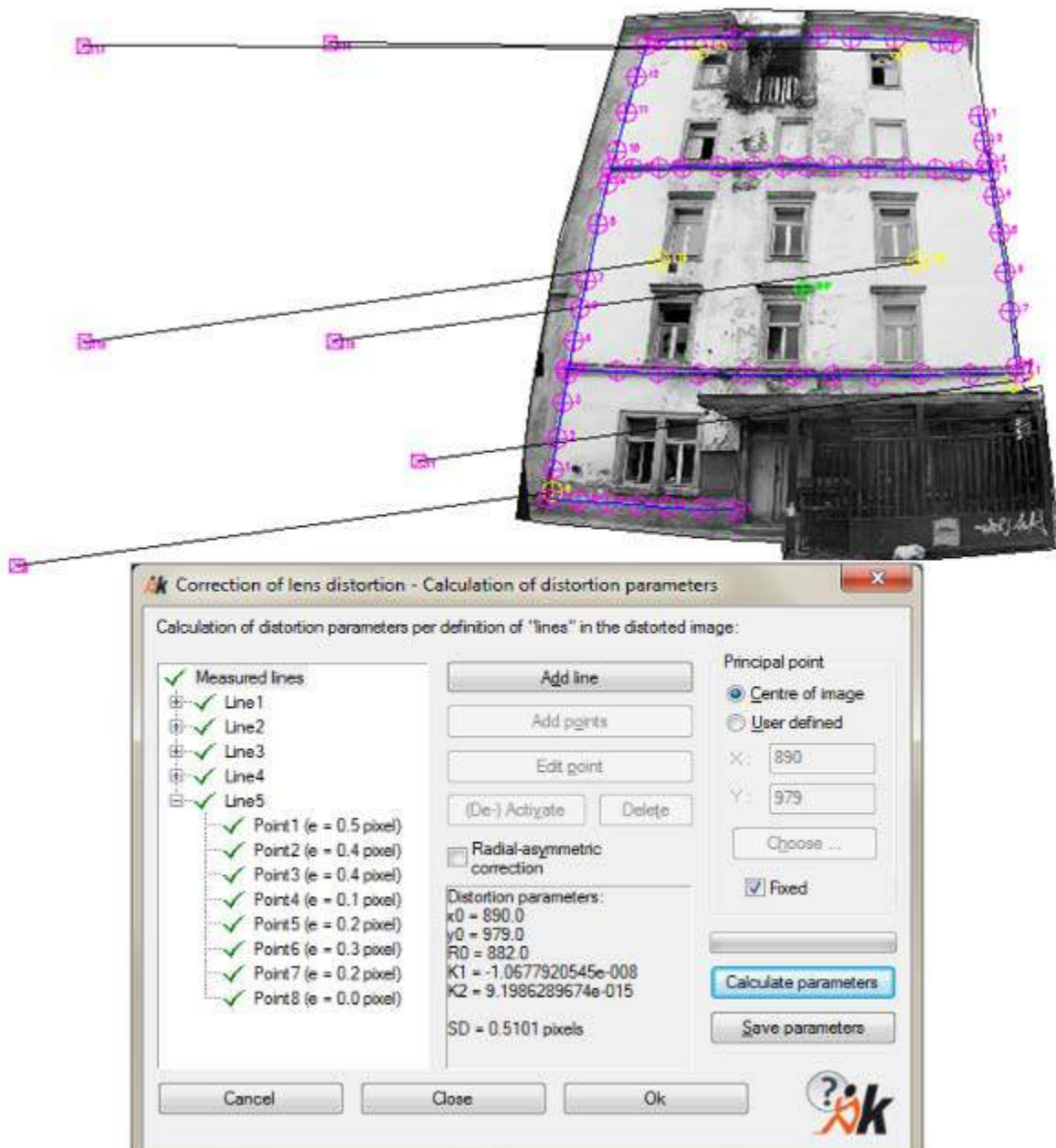
5. Information concerning the Rectified Image

At the bottom of the dialogue window you will find a few statements concerning the rectified image.

- **File name**

Before you can start the rectification process, you have to enter a file name for the rectified image. Use the buttons [...] or [M] to enter name and path manually. BMP, TIFF, JPEG and PNG are at your disposal as file formats for the rectified image. With the button [A] you enable the automatic naming. You may determine where the rectified images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

- **Image size settings**

    With the button "**Further settings**..." you can adjust the properties of the rectified image. You will be shown the optimal values for the number of pixels, image size and pixel size/resolution. Optimal means that the image to be created contains exactly as many pixels that a maximum of image information is available without wasting memory at the same time.

- - **Number of pixels in width and height:** Here you can adapt these values to your individual needs. The two values are always proportional to each other, i.e. if you change the number in width, the number in height will also change. Then the required disk space (calculated from the number of pixel – uncompressed) and a message on how much disc space will be required for the rectification result compared to the distorted image will be displayed. The indicated disc space is an estimated value which can be much smaller, depending on the selected file type. (e.g. JPEG). With images with a high projective distortion, the file size can increase. In this case you should clip the image before the rectification process and only rectify the relevant area. To do so use the command '**Image - Clip image**' (see command reference).
    - **Image size in AutoCAD:** This is the resulting representation size of the image in AutoCAD units. In order to see the correct values here, you have to indicate the equivalent of an AutoCAD unit in the drawing (e.g. Meter, Millimeter, Feet…).

- **Pixel size in AutoCAD:** Optimal size of a pixel in AutoCAD units. Here you can see how large a pixel of the rectified image would be in reality (e.g. on the rectified façade). This value can be adjusted. A higher value leads to a smaller number of pixels and a lower resolution. Thus, it does not seem preferable to decrease the optimal value.
- I**mage size:** The designations within this frame are only of interest if you intend to further process the image outside your AutoCAD drawing (e.g. editing and printing to scale in Photoshop or GIMP). You find details on this in chapter 4.11 of this manual.
- **Image resolution:** Indicates the resolution of the target image in DPI (dots per inch). It results from the number of pixels, the pixel size and the image size. Here too, an optimal value is offered which can be changed. The number of pixels and the pixel size will then automatically adapt. In some external images processing software packages this image resolution has to be set in order to influence the image size in a way that the image can be printed to the chosen scale. You find details on this in chapter 4.11 of this manual.
- **Image background:** Here you may define a background color for the resulting image.

- **Image size**

  Here you see the information on an image in a compressed way:
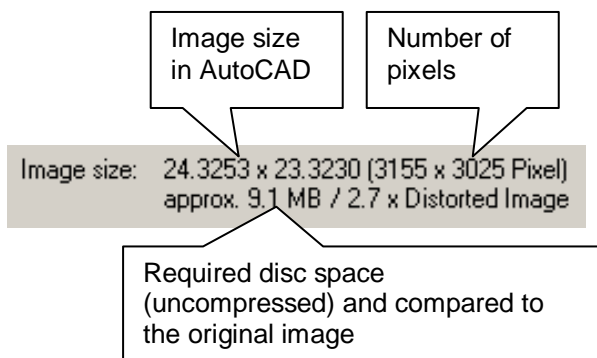
- **Rectification factor**

  The rectification factor specifies the relation of rectified image area and distorted image area at optimal resolution. The higher the projective distortion in the original image, the higher is this factor. Usually this factor lies between 1 and 3. Higher values are only to be expected with a very high projective distortion.

6. The Status Bar

At the bottom of the dialogue you will find a status line that provides you with information concerning the current calculation status of the rectification. The following messages are possible:

- '**Rectification not determinable. Rectification parameters not complete.**' means that too few control points (less than four) were measured or activated, respectively. The button **Rectify** will be inactive in this case.

- '**Rectification determined**' means that exactly four control points were considered for the calculation. A rectification is possible but no error check.

- '**Rectification over-determined.**' means that more than four points were assigned and a compensation calculation was computed. An error check is now possible.

- '**Error calculating boundary.**' may have various reasons, generally it is a grossly incorrect control point assignment.

The rectified image has a rectangular matrix just like the distorted image. During the rectification process a more or less irregularly shaped image is formed. The peripheral areas that come into being, because no image data of the distorted exist, will be filled in with the currently set background colour of the AutoCAD drawing surface. You can make this visible by clicking the image boundary of the rectified image to draw a new boundary. New parts within the boundary will be filled with current background colour.

The Image Position File

For each rectified image a file 'FilenameRectifiedImage_FileExtension.PPB', in which the image position information is stored, will be set up in the same directory. If you have deleted the rectified image from your drawing by mistake you can reconstruct it exactly with the help of this file and the command '**Image - Load image**'.

The Protocol File

In the same directory a file 'FilenameRectifiedImage_FileExtension.PRK' is set up for each rectification as well. This protocol file in ASCII format contains all important information for each rectification such as name, size, resolution and scale of the distorted and rectified image as well as rectification parameters, control point coordinates and UCS definition.

Hint:

The rectified image will automatically be placed on the layer which you have defined with the As-Built command →**Settings**... under Layer "LayerRectifiedImages". If no layer is defined (default) the image will be placed on the current layer.

Rectification by control points - Rectification of maps and plans (Polynomial transformation)

	Command name:	Menu:
	KUBT_PC_RECTIFYPOLY	As-Built Photo

Map rectification by control points allows you to rectify scanned maps, plans or ground plans. In contrast to the rectification of photos by control points this command works with the mathematical approach of a polynomial transformation.

The practical procedure of a map rectification is largely the same as for the **Rectification of photos (Projective Transformation)**.

The polynomial transformation requires the setting of the so-called degree of the polynomial. A polynomial of first, second or third degree can be used. However, you have to decide whether the distortion is linear or 'cannot be defined in detail'.

Linear distortions can be the result of scanning errors (shear, compressive strain, rotation), whereas undefined distortions are caused by storage of the object's material (paper, fabrics) over many years. The knowledge about these parameters is important since it determines which degree of polynomial is to be used. Linear distortions can be described by first degree polynomials, other distortions require higher degree polynomials. Further details are to be found in section **4.5 Map Rectification according to Control Points.**
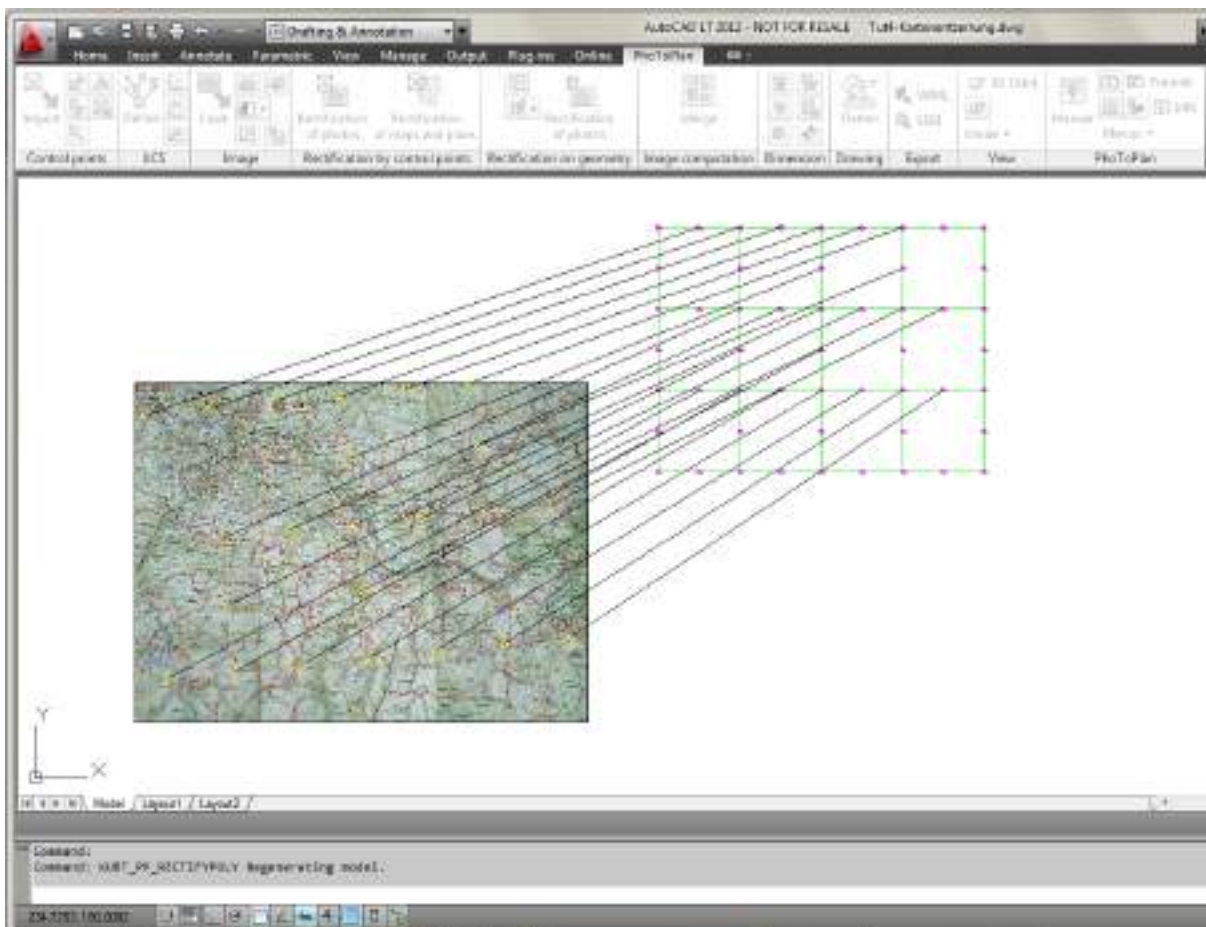
It is important to distribute defined control points equally throughout the map area to be rectified. An over-determination is recommendable.
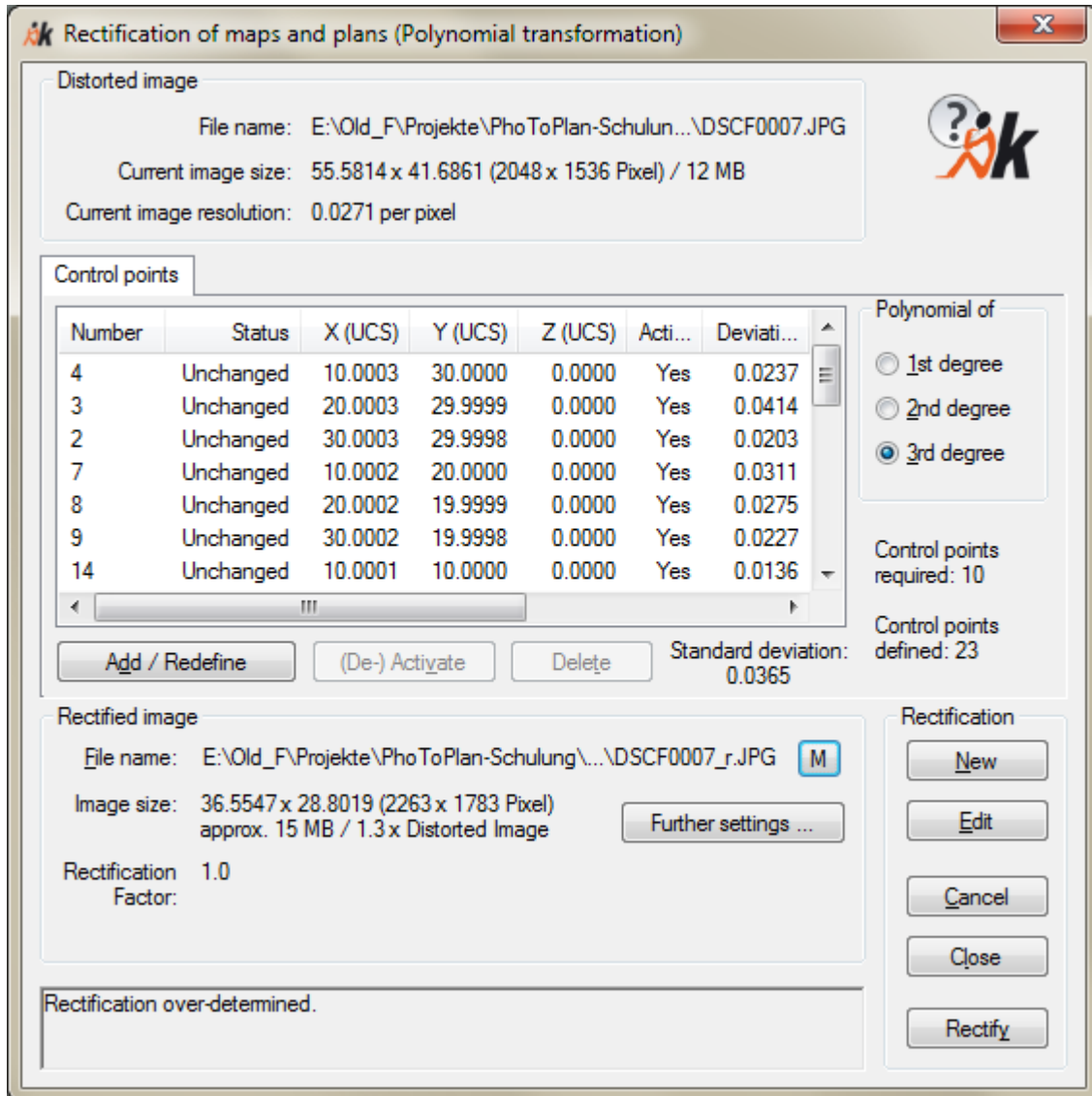
It is not always possible to determine a meaningful rectification function, which is most often the result of dissatisfactory distribution or an insufficient number of control points. Another problem arises with second and third degree polynomials when the edges of the map are too distant from the area which is described by a set of control points. Therefore try to clip the map close to the control points.

Check your result: If you think that the rectification is inaccurate add more control points and repeat the rectification process.
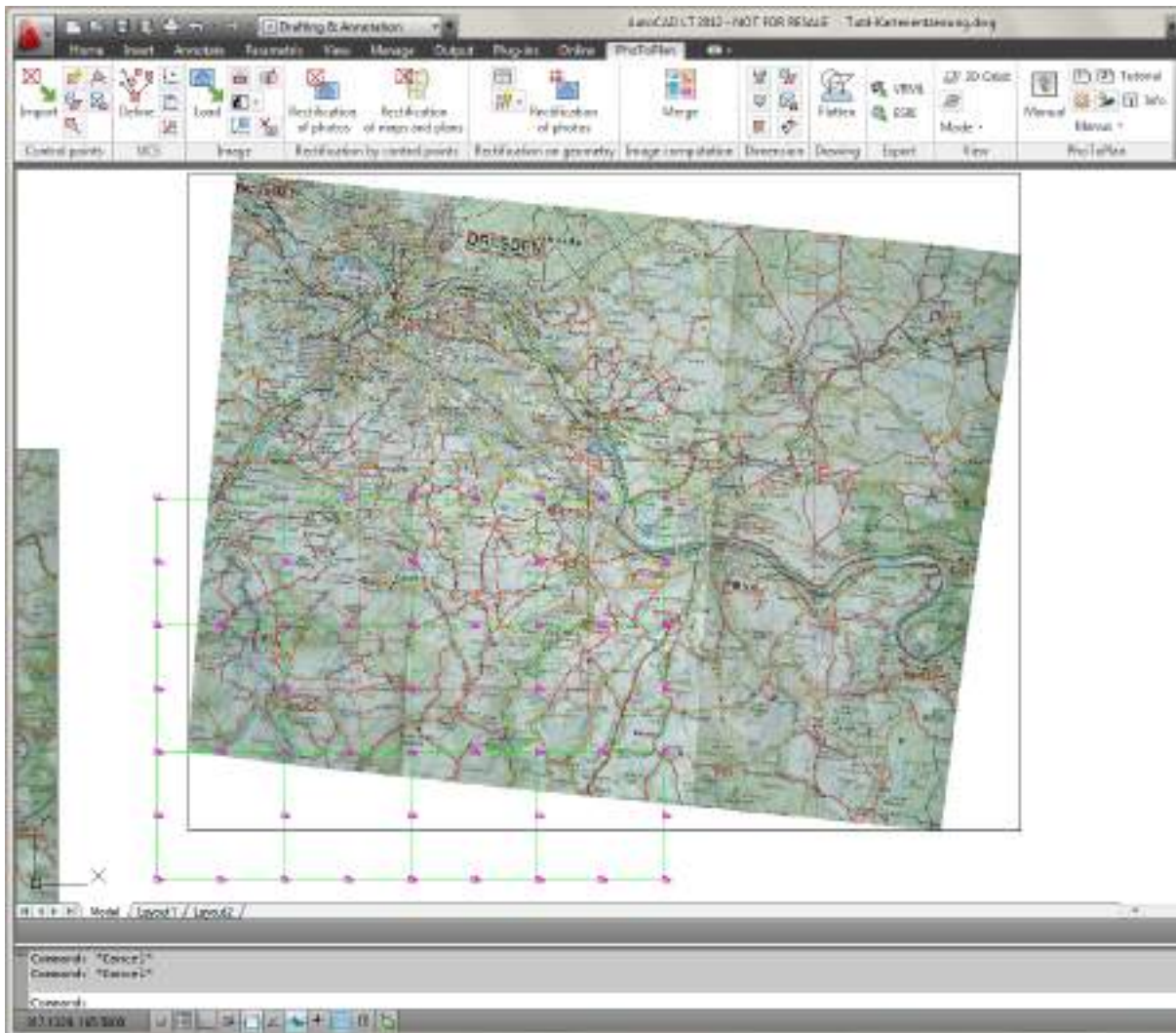
Hint: The rectified image will automatically be placed on the layer which you have defined with the As-Built command →**Settings** under Layer "LayerRectifiedImages". If no layer is defined (default) the image will be placed on the current layer.

You will find information on the mathematical basics of the map rectification by polynomial transformation on the next two pages.

Map Rectification with As-Built Photo

The transformation equation for a single point $P = (x, y)$ in the source image to $P' = (x', y')$ in the rectified image is given like this:

$$x' = a_0 + a_1 \cdot x + a_2 \cdot y + a_3 \cdot x \cdot y +$$
$$a_4 \cdot x^2 + a_5 \cdot x \cdot y + a_6 \cdot y^2 +$$
$$a_7 \cdot x^3 + a_8 \cdot x^2 \cdot y + a_9 \cdot x \cdot y^2 + a_{10} \cdot y^3$$

$$y' = b_0 + b_1 \cdot x + b_2 \cdot y + b_3 \cdot x \cdot y +$$
$$b_4 \cdot x^2 + b_5 \cdot x \cdot y + b_6 \cdot y^2 +$$
$$b_7 \cdot x^3 + b_8 \cdot x^2 \cdot y + b_9 \cdot x \cdot y^2 + b_{10} \cdot y^3$$

Black we have the linear (1st degree), additional blue the 2nd degree and additional red the 3rd degree terms. $\{a_1 \ldots a_{10}, b_1 \ldots b_{10}\}$ are the unknown parameters of the transformation we have to calculate. For every pair (a_i, b_i) with $i > 0$ we need at minimum one control point. (a_0, b_0) we get from the average translation.

In contrast to the projective transformation we don't have a very good physical/mathematical model for the type of deformation of maps. Unfortunately we have only the assumption of a small, smooth (differentiable) transformation. For those cases it has been established to use polynomial equations to describe the transformation. First we have to calculate the parameters. Than – during the rectification process of the raster image – we use the same functions in the space between the control points for interpolation.

What is the best degree?

See the figure on the right. The higher the degree the less errors we get in the control points. On the last sketch we have no errors at all but (!) the space between the control points will be deformed very strong. We would prefer the 2nd degree in this example.

We have two ways to find the best degree.

Mathematical argumentation

The best degree is obviously the lowest degree with already a reasonable error. This is the point where the curve in following figure has made a big step downwards:
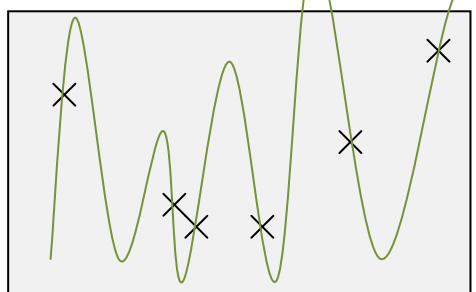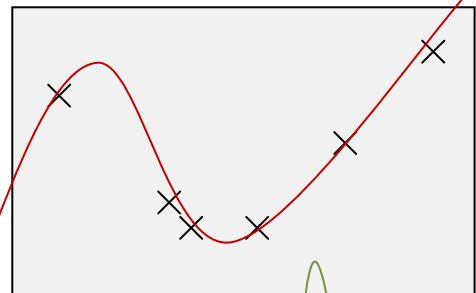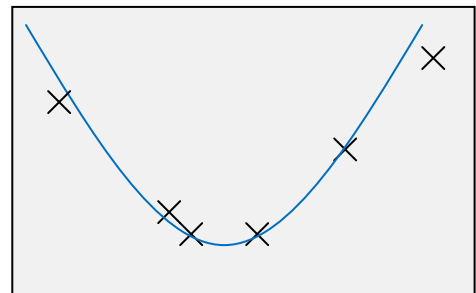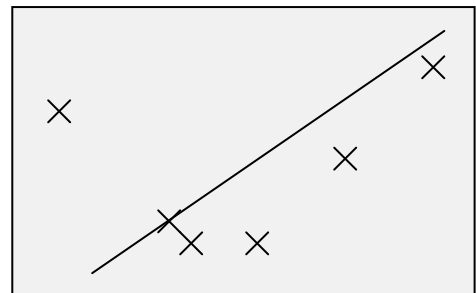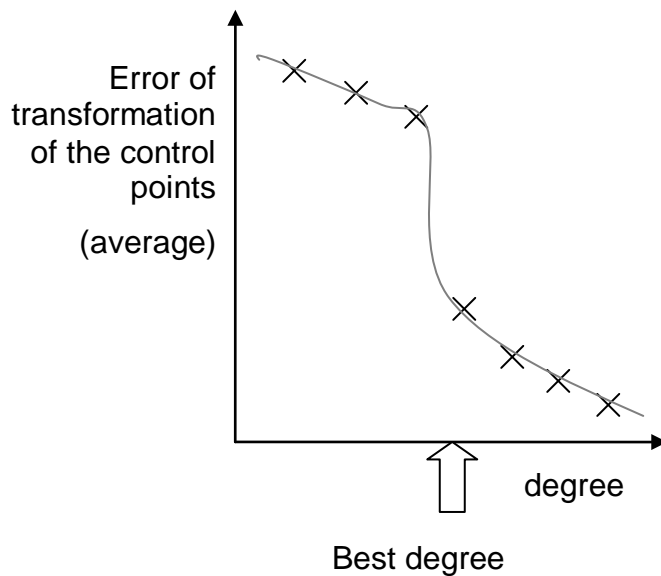
Best degree

The reason is that on this point (best degree) we have no over-adaption to the data. In the space between the control points we will get a more linear interpolation in the raster image. If the degree becomes too high we get unintended curves or even curls in this spaces and in the area outside the convex hull of the control points.

Deformation driven argumentation

Here a summarized recipe for the decision of the best degree regarding the type of deformation:

- If the deformation of the map is of a type that **straight lines remain straight lines** we use 1st degree.

- If the deformation **makes curves** of former straight lines and
  - o If the deformation has only one minimum
    - ▪ and a **symmetrical** shape in one axis and we use 2nd degree
    - ▪ and **not a symmetrical** shape we use 3rd degree.
  - o If the deformation has two local optima we use 3rd degree.

Oriented Images – Image orientation

	Command name:	Menu:
	PCIMGORI	As-Built Photo

Image orientation means the process of positioning an image, taken with a camera, within the three-dimensional space (CAD drawing) as it was, when captured. That means the determination of camera position and photograph direction.

There are different possibilities. As-Built works with a method that uses control points. Therefore you have to take the three-dimensional coordinates of **at least ten** marked points (control points) at the same time that you are taking the photo. It is important that you

a) have pictured all control points within your photo and that you can identify them all (they are rich in contrast),

b) they are spread evenly across the image

c) the control points are also spread evenly across the 3D space that means that they ought to have different depths.

d) Additionally every control point should be as even as possible, so there won't be any mistakes when measuring with the total station. This is - because of the lacking bundling of the laser beam - the case when measuring corners.

The most exact way to get control point coordinates is by measuring with a total station. You may load the control points using the command →**Control points - Import control points**. Or you use the As-Built Total Station Interface to measure the control points directly. Alternatively you may extract the coordinates from a laser scanner point cloud.

Every control point has an individual control point number.

If the distortion does not have to be calculated automatically, the **number of** the **control points** needed is **reduced to six**. This is the case if the image to be orientated has already been undistorted or if the parameters of the distortion are already known. If in addition the focal length of the camera and the size if the sensor elements (pixels) are known one only needs a **minimum of four control points** for the image orientation.

General procedure

According to your preferences you may execute the image orientation with one or two viewports.

Image orientation with one viewport

1. Import/define control points (→**Control points - Import control points** or **Control points - Define control points**).

2. Rotate the control points with the help of the 3D orbit (3DORBIT), so you approximately look at them like form the camera position. All control points contained in the image should be clearly visible.

3. Set UCS according to this view **(→UCS - UCS from current view)**.

4. Import the image to be orientated next to the control points (→**Image - Load image**).

5. Start image orientation.

Image orientation with several viewports

1. Select first viewport

2. Import/define control points (→Control points - Import control points or Control points - Define control points)

3. Rotate the control points with the help of the 3D orbit (3DORBIT), so you approximately look at them like form the camera position. All control points contained in the image should be clearly visible.

4. Align control points according to current view **(→UCS - UCS from current view)**

5. Select to second viewport

6. Import image to be orientated (→**Image - Load image**)

7. Start image orientation

If you are working with several viewports, please select the viewport in which the image is to be imported previously to the start of the command.

Start the command.

The command will first switch to the parallel projection mode and the plan view for the XY plane of the current UCS. The following window will open:
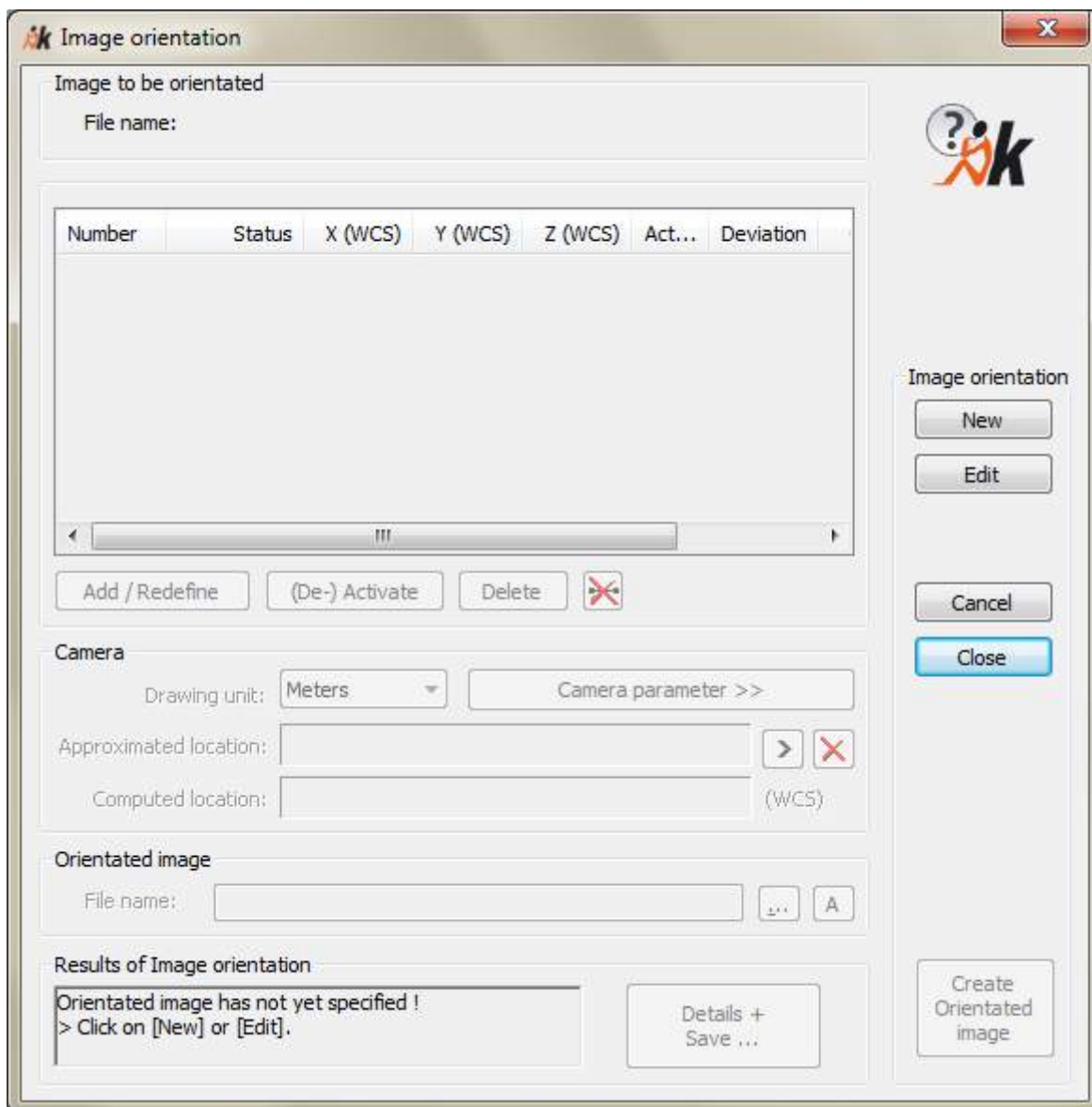
Heading "Image orientation"

Here you can generally state what you wish to do next.

- With [**New**] you start a new image orientation. An image selection which might already exist will be dropped. When clicking on this button, you leave the window and the following prompt appears in the command line:

  Select image to be orientated or <Cancel>:   *(Select raster image in the drawing.)*

  Now the dialog returns. The control point list is empty and you may now assign control points.

- With [**Edit**] you call up an orientation that has already been conducted and you may then change it and/or process it again. The following prompt appears in the command line:

  Select image to be orientated or <Cancel>:   *(Click image at its frame.)*

The already assigned control points of this image orientation are displayed in the list. An orientation can only be processed, when the according original image and the oriented image are still present in the drawing.

- With [**Cancel**] you leave the dialogue. All changes are dropped. When you click [**Close**] though, they will be saved.

- If you click [**Create orientated image**] the calculation of the oriented image starts. The button is only active, if all requirements for an image orientation are met. The orientation has to be definable (that is, enough control points were assigned in advance) and all information according the oriented image has to be complete.

Heading "Control points"

The control point table has a central position. All control points, that have been assigned to an image point and which are to be used for the respective image orientation are listed here. Next to the object coordinates (WCS) of the control points you will find information about the respective status, activation mode and the positioning error here. Underneath the table are four buttons:
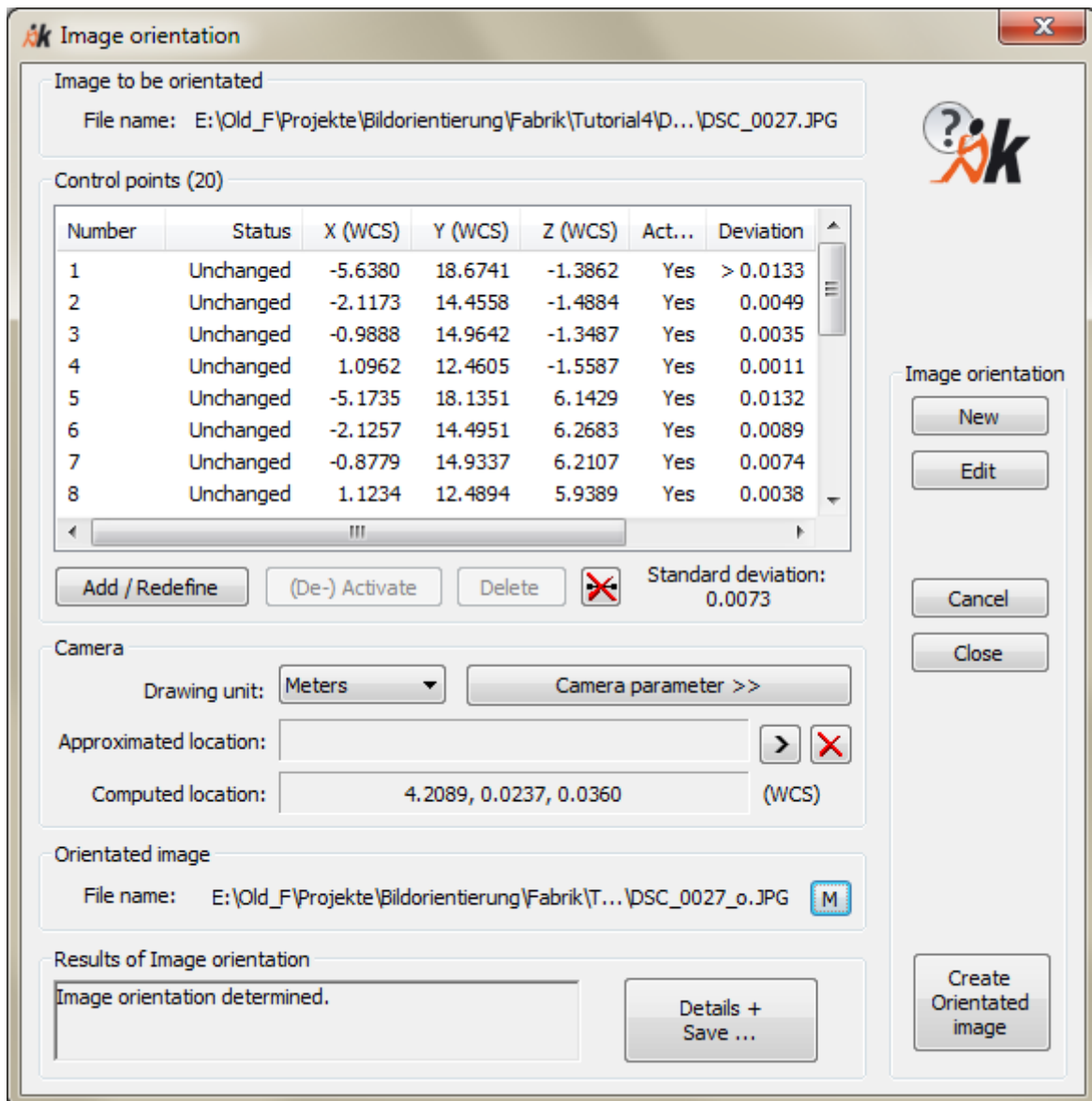
- In order to assign the relevant control points in the image to be orientated, click [**Add/Redefine**]. You get back to the drawing and are prompted as follows:

  Select control point or [Number/Measure/Finish] <Finish>:

  In the drawing click on the control point that you want to assign next. You may alternatively enter the control point number or generate a new control point directly. In order to do so use the options <Number> or <Measure>.

  Now you have to assign the image point belonging to the control point within the image to be orientated.

  Option "Zoom window" turned on:

    You will be prompted to enter a zoom region:

      First point for zoom region to control point 17 or [Cancel] <Cancel>:

      Second point for zoom region to control point 17 or [Cancel] <Cancel>:

    Move the mouse over the image and draw a zoom window around the according position of the image. If you do not want to zoom press the ENTER key cancel it.

Now you are prompted to assign the corresponding point within the image.

Image point for control point 17 or [Zoom window on/Connecting lines on/Cancel] <Cancel>:

With the mouse click on the according position within the image to be orientated. Afterwards the program zooms back to the previous view automatically.

Option "Connecting lines" turned on:

You can see that control point and image point have been connected by a line. This line is for clarity and for a better orientation during the assignment.
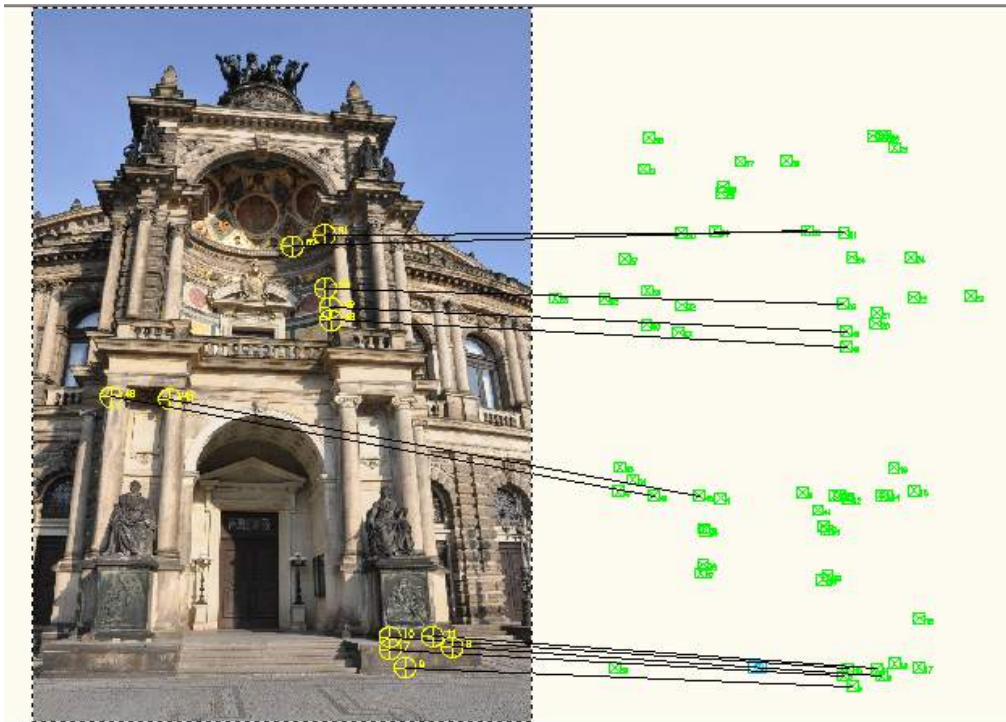
By selecting the option <Finish> you close the assignment and get back to the rectification window.

- You may turn off single control points with the button [**(De-)Activate**]. Thus they will not be used for the calculation of the orientation parameters. The control point then reads "no" within the "Active" column.

- In order to delete a control point permanently from the list, use the [**Delete**] button. Before deleting a point you have select it by marking its point number.

- You control the display of the connecting lines by the buttons [icon] (turning connection lines on) and [icon] (turning connection lines off).

The "**Deviation**" column is of special interest. The deviation value is the distance of a control point to the view ray (camera position → assigned image point). By selective deactivation of several control points deviations during the assignment can be detected. Finally the deviation results from the absolute position error when measuring the control point, the allocation error within the image to be orientated and its distortion. The "**standard deviation**" of all individual errors may serve as global quality criterion.

The "**Status**" column displays information whether the control point has been deleted from the drawing or whether its position has been changed. If this is the case, an according note will be entered and the point will be deactivated. ***If you reactivate it, As-Built is calculating with its original point position for the image orientation!*** If you want to use the new position of the control point though, you have to assign it anew.

Heading "Camera"

Select the used drawing unit (the unit that matches an AutoCAD drawing unit). When clicking on the [Camera parameter >>] button, the window extends and shows options for the camera (see page 7-130). Besides that the coordinates of the calculated camera position are displayed.

Occasionally the camera position may not be calculated automatically. In this case the status line at the bottom of the dialogue will indicate "Image orientation is not computable. Unfavourable input data." even though enough control points have been assigned. This may occur, when – as advised – the control points are very close or even very far from the camera position that is when they are spread evenly across the area (a typical scenario for wide angle shots). In this case you will have to estimate the camera position. Click the ⟩ button in order to state a point or alternatively a control point within the drawing as estimated value for the camera position. Since the image orientation algorithm is quite robust, a rough estimation value is generally enough. In order to delete the 'approximated location' use the ✕ button.

Heading "Oriented image"

Select the file name of the oriented image. Use the buttons ⋯ or Ⓜ to enter name and path manually. With the button Ⓐ you enable the automatic naming. You may determine where the oriented images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

Heading "Results of image orientation"

The status of the calculation is displayed here. If any input is still missing or if the deviation values are to large or if for any other reason the image orientation cannot be calculated, you get an according message here. When all input has been done, you get the message "Image orientation determined".

With [**Details + Save…**] you can display a detailed protocol. It is also possible to save the calculated camera parameters into a VP2 file. You will find a detailed description of the camera parameter file (VP2) in chapter 4.8.

```
Details of Image orientation                                             ✕

Parameters of inner orientation
-------------------------------
Image width [Pixels]                        4288
Image height [Pixels]                        2848

Lens length [mm]                              50.000  (default value)

Size of sensor element X [µm]                15.526
Size of sensor element Y [µm]                15.526

Sensor size in X [mm]                        66.576
Sensor size in Y [mm]                        44.219

Radial symmetric distortion

  Principal point of image X [Pixels]         2144.0
  Principal point of image Y [Pixels]         1424.0
  R0 [Pixels]                                 1607.4
  K1 [Pixels]                                -1.5448184998e-008
  K2 [Pixels]                                 8.6266244616e-016

  Principal point of image X [mm]             0.000
  Principal point of image Y [mm]             0.000
  R0 [mm]                                    24.957
  K1 [mm]                                    -6.4083627742e-005
  K2 [mm]                                     1.4844998127e-008

Radial asymmetric distortion

  P1 [Pixels]                                 1.1073309956e-006
  P2 [Pixels]                                 1.9424322657e-007

  P1 [mm]                                     7.1320153660e-005
  P2 [mm]                                     1.2510673702e-005

Parameters of outer orientation
-------------------------------

Camera position (WCS-X)                       4.2089
Camera position (WCS-Y)                       0.0237
Camera position (WCS-Z)                       0.0360

Viewing direction (vertical angle)            18
Direction of view (horizontal angle)          98
Viewing direction (twist angle)               273

              Save camera parameters              Close
```

Following sketches shall explain the parameters of the direction of view.

Vertical angle:
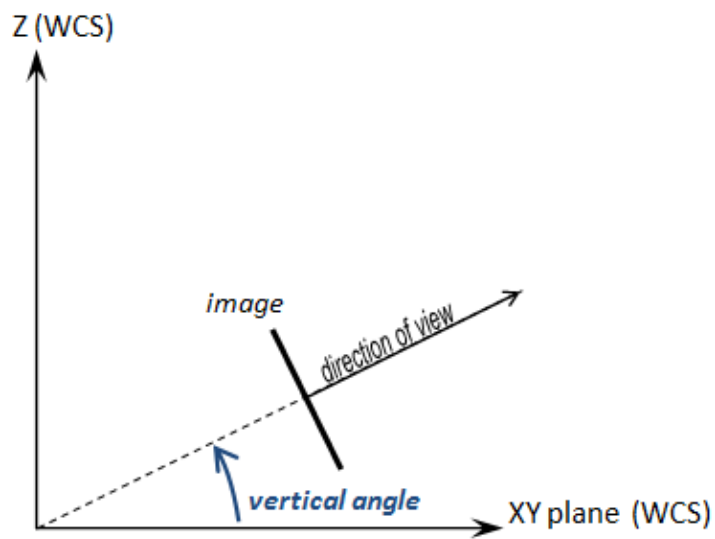
Horizontal angle:

Twist angle:

Generating the oriented image

If you are satisfied click on the bottom right button [**Create orientated image**]. The oriented image will automatically be placed on the layer which you have defined with the help of the command "Settings…" under Layer "LayerOrientedImages". If no layer has been defined (default) the image will be placed on the current layer. In addition to the raster image a file will be created which contains the parameters of the orientation (*.ORI). The format of this file is explained on page 7-59.
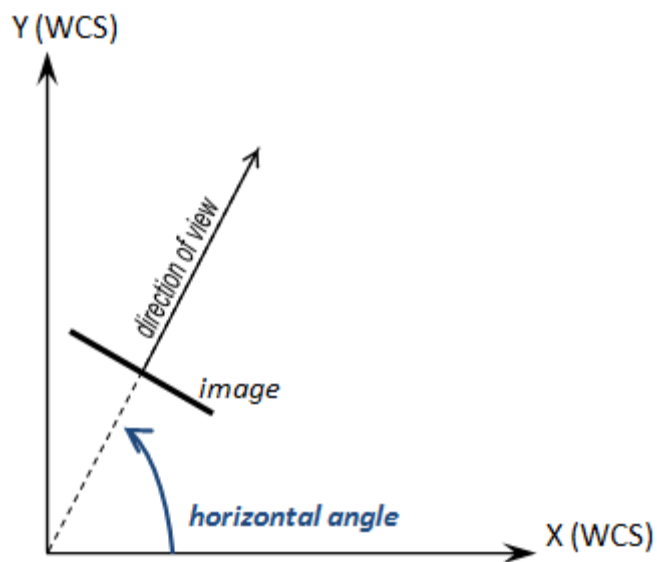
After the calculation of the oriented image you are directly led to a perspective view onto the oriented image. To navigate please use the mouse wheel (zoom) or the pressed middle mouse key (wheel) in order to shift the view.

Check the assignment of the control points to the image points visually.
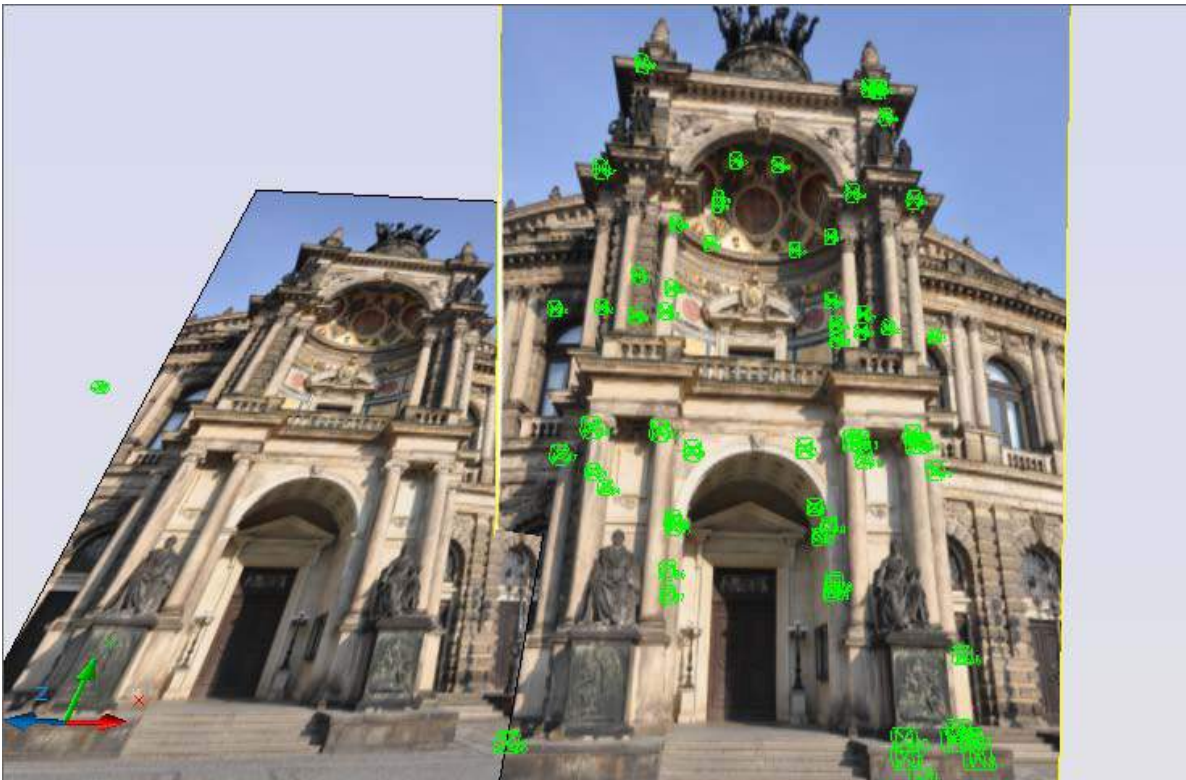
Thanks to the so called camera navigation mode you are able to navigate with the mouse in this way at all.

Please note, that you cannot measure distances in order to check the accuracy of the image orientation. It is easiest to estimate the deviation visually, when the dimension of their control label is known.
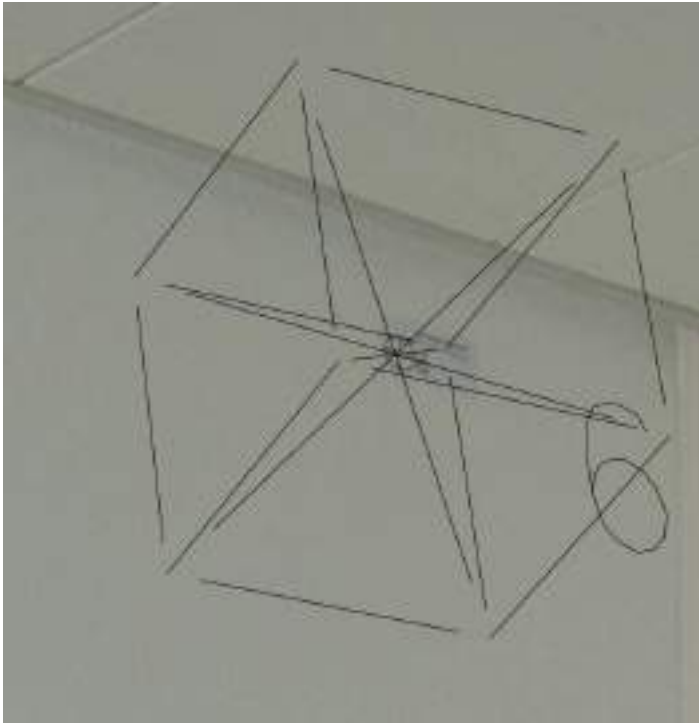
The radius of the control label in the example above is 10mm. The deviation of the control point is therefore about 7mm.

In order to be able to move normally within the drawing you have to deactivate the camera navigation mode. To do so call up the command →**Oriented Images – CamNav on** and select the option "off".

You may now look at the position of the newly oriented image in the orbit. Via the scaling factor (to the focal length) within the properties of every oriented image you can state in which distance to the camera position the oriented image shall be drawn. The scaling factor should be big enough so the image is drawn behind all relevant geometry. You may also simply use the command →**Oriented Images – Set size**.

Heading "Camera parameters" within the extended window

You can open the extended window via the [Camera parameter] button under the "Camera" heading.
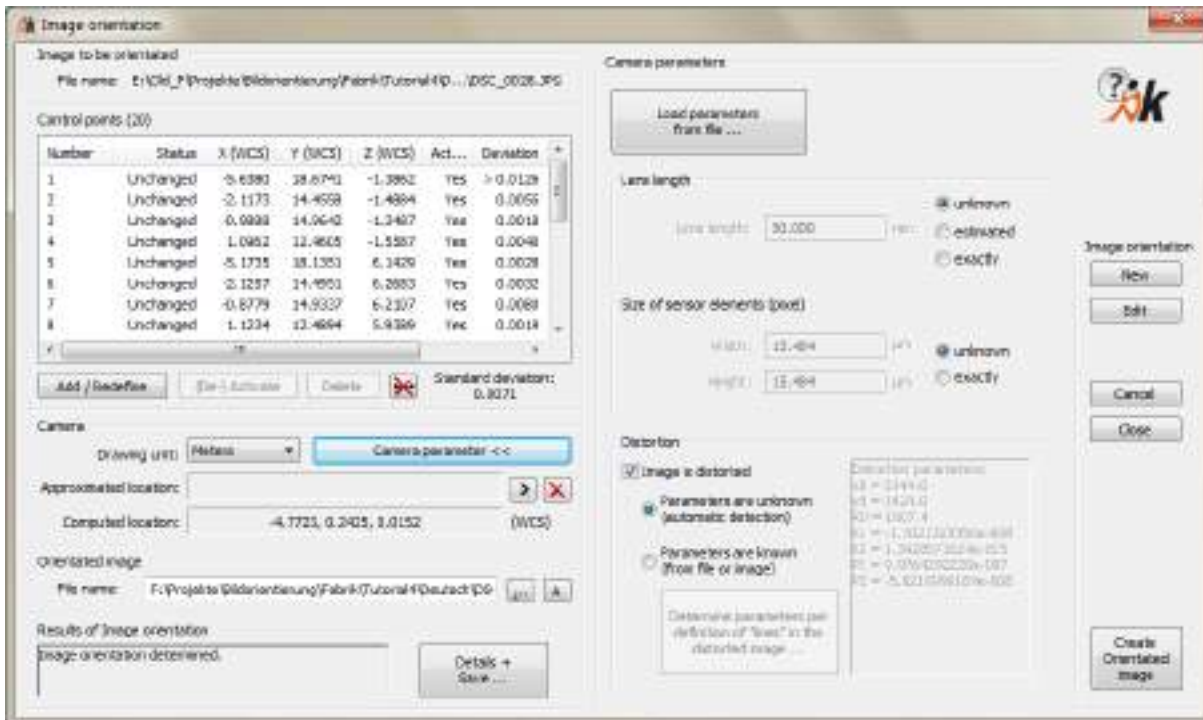
Lens length

One of the parameters of the inner orientation of a camera is the focal length of the used lens. Usually you do not have to state it, it is set to 50mm by default.

Size of sensor elements (pixel)

The same goes for the statement of the size of a pixel of the sensor matrix of your camera. The image orientation will automatically calculate them depending on the stated or estimated focal length.

Distortion

In general the used images have distortion errors. The distortion of a lens will in most cases be visible. When you look at the originally straight edges, they will be "bent" in the picture. Especially in the border areas this effect is visible. There are lenses that turn squares into a "pillow" (curvature to the inside) as well as lenses that turn a square into a barrel (curvature to the outside). The degree of the distortion of an image point depends on the distance to the principal image point. The principal image point is that point in the image through which the axis of vision of the recording system runs (usually the image center point).
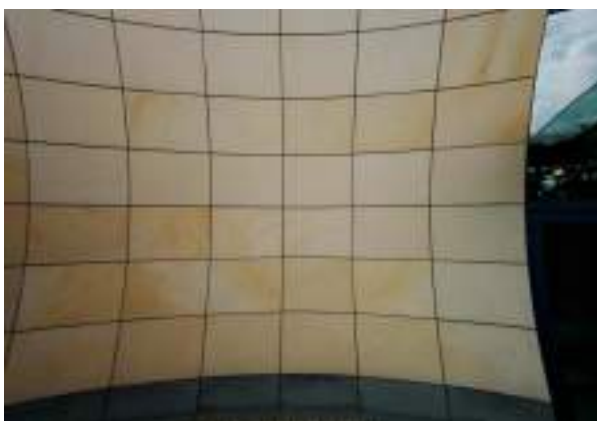
pulvinated distortion (pillow shaped)   **barrel-shaped distortion**

Due to distortion errors the accuracy of an image orientation can fall off in quality. Therefore it is highly suggested to determine the distortion parameters of the camera, so they can be regarded for the calculation during the image orientation. There are several ways to do so:

   a) having the distortion parameters calculated automatically. That requires a large number of evenly spread control point though "**Parameters are unknown (automatic detection)**" or

   b) you load them from a parameter file "**Parameters are known (from file or image)**" or

   c) you determine the distortion parameters directly within the image [**Determine parameters per definition of "lines" in the distorted image…**]

a) Having the distortion parameters calculated automatically

This is the easiest and suggested method. Unfortunately it will not always work, due to too less or unevenly spread control points. In such a case select one of the alternatives.

b) Parameters are known – load them from file

Via the **[Load parameters from file]** button you may load certain distortion parameters from a file (VP2 file) that was previously determined with PhoToPlan (previous product) or As-Built. They will then be regarded for the calculation of the image orientation. *Caution:* The distortion parameters are only valid for a certain zoom level and focusing. If another focal length and shooting distance has been used, the parameters have to be determined again.

Select a VP2 file appropriate for your camera system. This file may contain, next to the distortion parameters, information regarding the focal length and the sensor size. Then select the parameters to be applied.
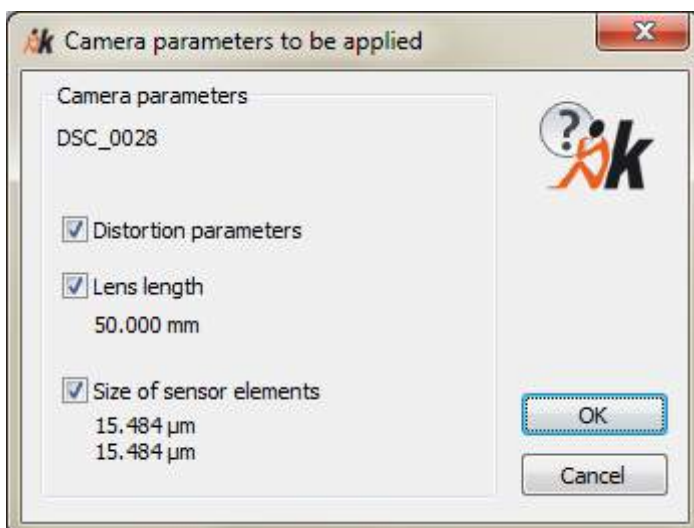
Sometimes you own a manufacturers calibration protocol for your camera system containing all necessary information regarding the distortion and the parameters of the inner orientation. Under certain conditions it is possible, to convert these parameters into a VP2 file. Please contact FARO in such a case.

c) Determination of the distortion parameters directly within the image

In order to determine the optical distortion you have to trace many straight edges within an image. Of course the edges are only straight in reality. Within the image they are, due to the optical distortion, more or less bent.

If you click the button [Determine parameters per definition of "lines" in the distorted image…] the "Correction of lens distortion – Calculation of distortion parameters" dialog opens. You find a detailed description of the dialog and of this method for the determination of the distortion parameters within the command reference under →**Rectification according to geometry - Correction of lens distortion**.

Note: The value for the **standard deviation** bottom right of the control point list should be significantly smaller when applying the distortion correction.

We recommend reading section 5.1 **Image orientation** of this manual thoroughly.

Oriented Images – Load oriented image (kubit ORI format)

	Command name:	Menu:
	OILOAD	As-Built Photo

With this command you can load an oriented image that exists in the kubit ORI format into the current drawing file.

Please keep in mind that for the oriented images a lens distortion correction should possibly be carried out as otherwise, due to the distortion, errors could occur when evaluating.

By default the oriented images are put on the current layer. You may orientated images yourself using the command →Oriented Images – Image orientation. For further details on the orientation process please refer to section 5.1 Image orientation of this manual.
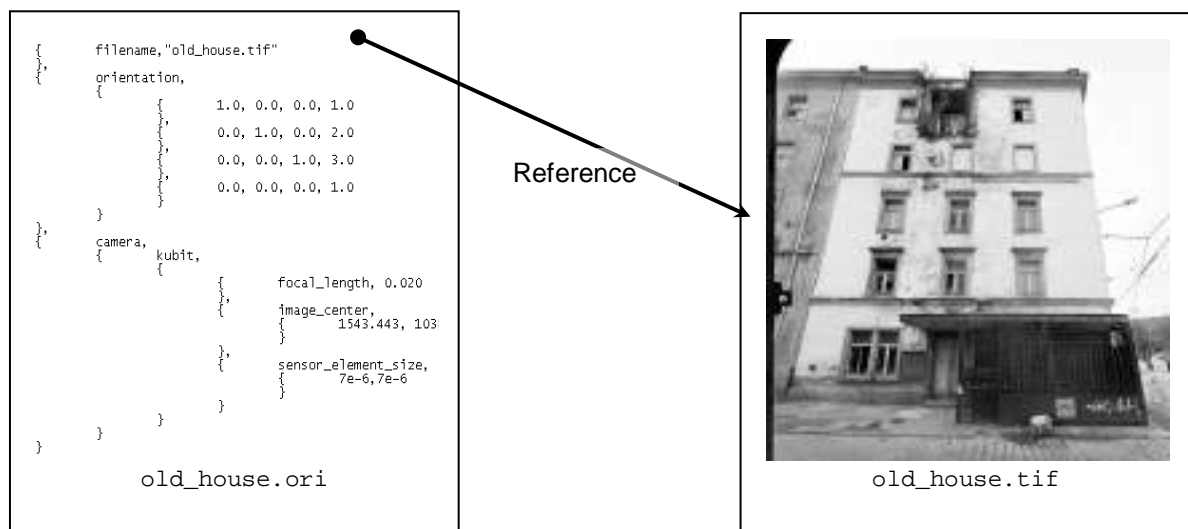
The kubit file format for oriented images

An oriented image consists of two files:

- an image file in a conventional format (e.g. JPEG, TIFF, BMP, PNG, ...)

- a text file (Extension ORI) that contains the parameters of the interior and exterior orientation as well as the file name of the referenced image.


```
{
        filename,"old_house.tif"
},
{       orientation,
        {
                {       1.0, 0.0, 0.0, 1.0
                },
                {       0.0, 1.0, 0.0, 2.0
                },
                {       0.0, 0.0, 1.0, 3.0
                },
                {       0.0, 0.0, 0.0, 1.0
                }
        }
},
{       camera,
        {       kubit,
                {
                        {       focal_length, 0.020
                        },
                        {       image_center,
                                1543.443, 103
                        }
                        {       sensor_element_size,
                                7e-6,7e-6
                        }
                }
        }
}
```

old_house.ori

Reference

old_house.tif

The orientation file (.ori) contains three important entries:

1.   the file name of the referenced image

2.   the camera position and its spatial orientation (exterior orientation)

3.   the internal camera parameters (interior orientation)

All entries are separated by commas. If entries contain subentries, these are enclosed in braces. Tabs, spaces and line breaks are ignored and only serve for a better readability.

File name of the referenced image

Syntax:

```
{filename,"old_house.tif"},
```

The file path must be indicated relative to the position of the orientation file (.ori). Both files should ideally be stored in the same directory.

Camera position and its spatial orientation (exterior orientation)

Syntax:

```
{       orientation,
        {       {       1.0, 0.0, 0.0, 1.0
                },
                {       0.0, 1.0, 0.0, 2.0
                },
                {       0.0, 0.0, 1.0, 3.0
                },
                {       0.0, 0.0, 0.0, 1.0
                }
        }
},
```

The matrix transforms (homogeneous) camera coordinates into (homogenous) world coordinates. The last column $((1.0, 2.0, 3.0)^T$ in this example) represents the displacement vector.

The camera coordinate system is a right-hand-coordinate system (as usual in AutoCAD), and is defined as follows:

The origin is the projection centre of the camera.

The Z axis corresponds to the optical axis.

The X and Y axes correspond to the image axes. The X axis runs from the left to the right, the Y axis from top to bottom.

Internal camera parameters (interior orientation)

Syntax:

```
{       camera,
        {       kubit,
                {       {       focal_length,
                                0.020
                        },
                        {       image_center,
                                {       1543.443,
                                        1038.20
                                }
                        },
                        {       sensor_element_size,
                                {       7e-6,
                                        7e-6
                                }
                        }
                }
        }
}
```

- `focal_length` is the focal length of the camera stated in *meters*

- `image_center` is the image centre in *pixel coordinates*. The image centre is the point of intersection between the optical axis and the image plane. The origin of the image coordinate system is the bottom (!) left corner. The X axis runs from the left to the right, the Y axis from bottom to top.

- `sensor_element_size` is the length of the edge of a single pixel element of the image matrix in *meters*.

Oriented Images – Import Agisoft PhotoScan project

	Command name:	Menu:
	OIIMPORTPHOTOSCAN	As-Built Photo

You can with this command load oriented photos and point clouds of an Agisoft PhotoScan project into your AutoCAD drawing.

What does Agisoft PhotoScan do?

Agisoft PhotoScan creates a coloured point cloud, (if needed also textured) and a 3D surface from a number of images that have been taken (following certain rules) of a natural object and with PhotoScan Pro also 2D ortho-projections of your object.

With PhotoScan Pro you can also, for positioning and scaling of your scene, take simple distance measurements, or use 3D points and the GPS information of your camera.

How does Agisoft PhotoScan work?

Agisoft PhotoScan (www.agisoft.com) works - contrary to Autodesk ReCap Photo - as an independent piece of software on your computer. An internet connection is not required. However the hardware requirements lie on the workstation level.

The advantages of PhotoScan and especially PhotoScan Pro lie in the extensive range of intervention and control possibilities during the creation, positioning and scaling of your 3D model. This qualifies it for use in professional surveying and documentation.

To obtain good results from PhotoScan we recommend that you take particular attention of the tips and rules of the manufacturer for taking the photographs. The quality of your PhotoScan project is decisive for the quality of the further processing in As-Built.
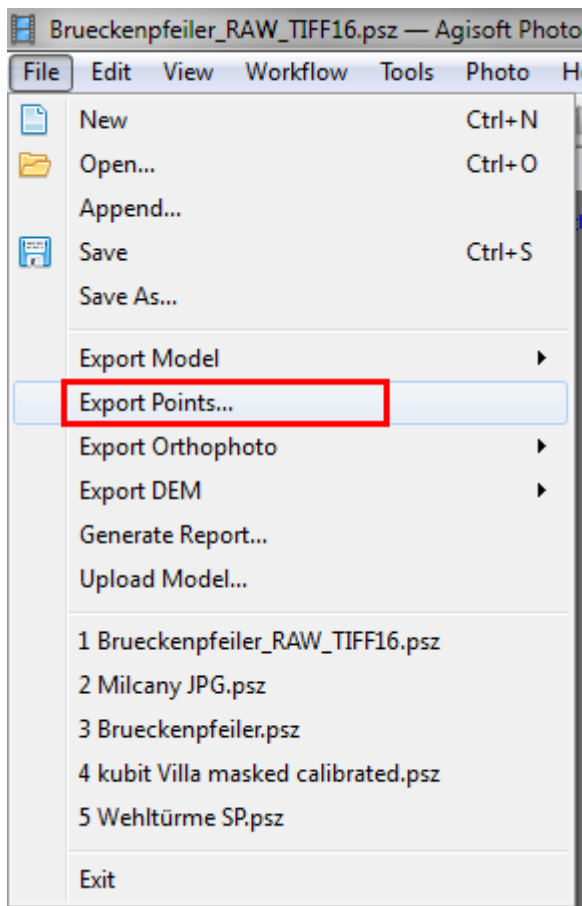
What data can be exported from Agisoft PhotoScan and in what format?

*The orientation data of the individual photos (cameras)*
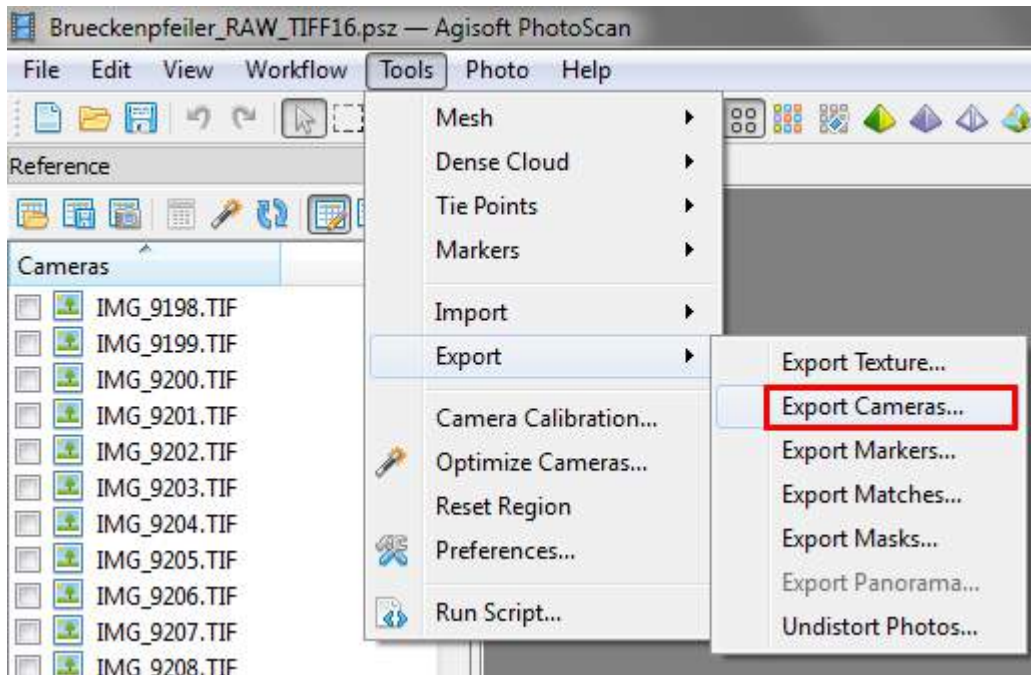
Save the orientation data as "PhotoScan XML" files in the same folder as where you placed the images. It is recommended to use the project name as the file name. These XML files are required for importing into As-Built.

The dense point cloud

It is best to save the point cloud data as an "ASPRS LAS" file. Thereafter you convert the LAS files with Autodesk ReCap into an Autodesk ReCap point cloud project (*.rcp). Here also, give the project name as the file name and save this project in the same folder as the images. This is only necessary if you also want to bring the point cloud into AutoCAD.

Orthophoto (only in Agisoft PhotoScan Pro)
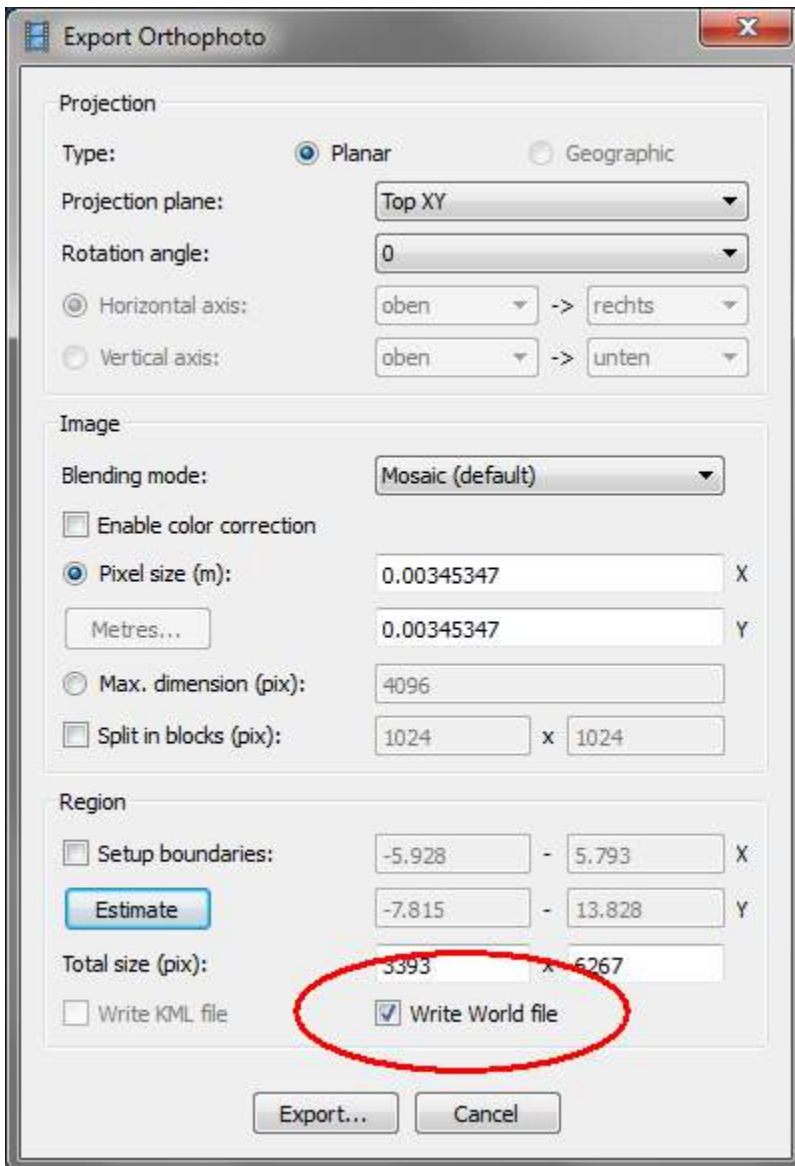
Sometimes it is useful to export an orthophoto (2D ortho-projection) of the model. Don't forget here to tick the box "Write World file". When loading the image into AutoCAD using the As-Built command "Load image", the image will be correctly positioned in the XY plane of the current UCS. You must have previously set the correct UCS.

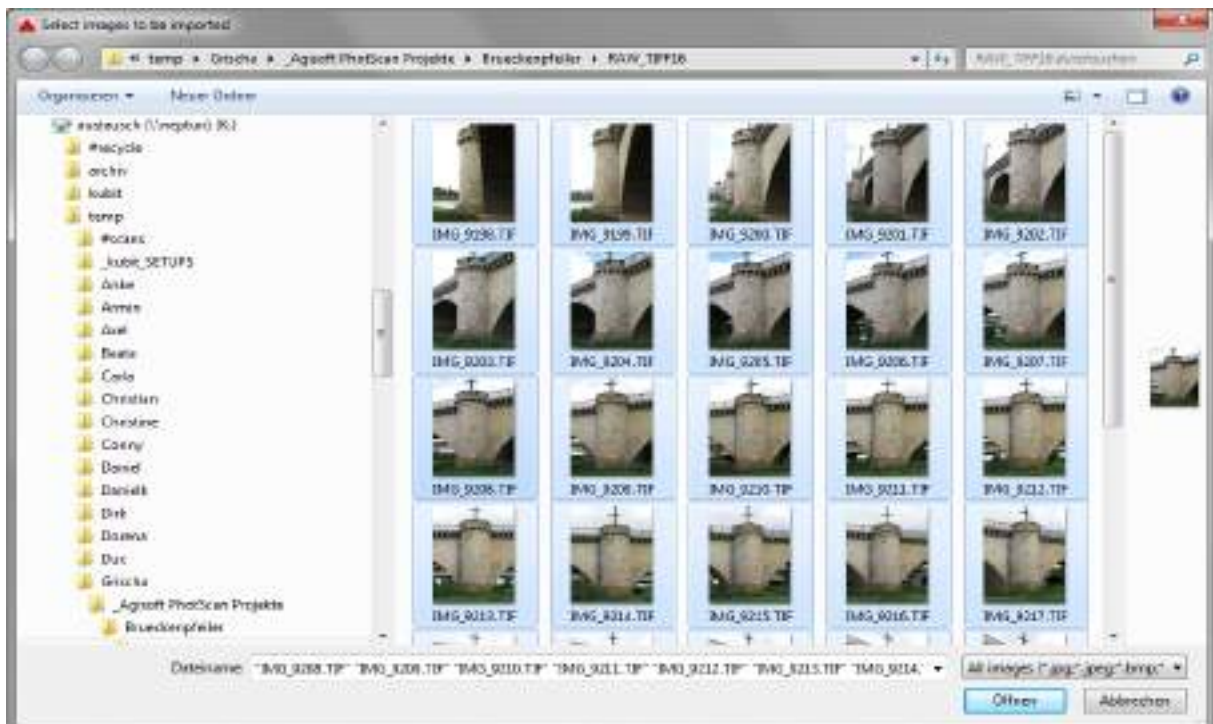**Import an Agisoft PhotoScan Project into an AutoCAD Drawing**

Start AutoCAD and call the PhotoScan import command from the As-Built Photo menu:

Command: **OIIMPORTPHOTOSCAN**

A dialogue box appears to open a PhotoScan XML file. Here you should select the XML file that you created over "Tools/Export/Export cameras...".
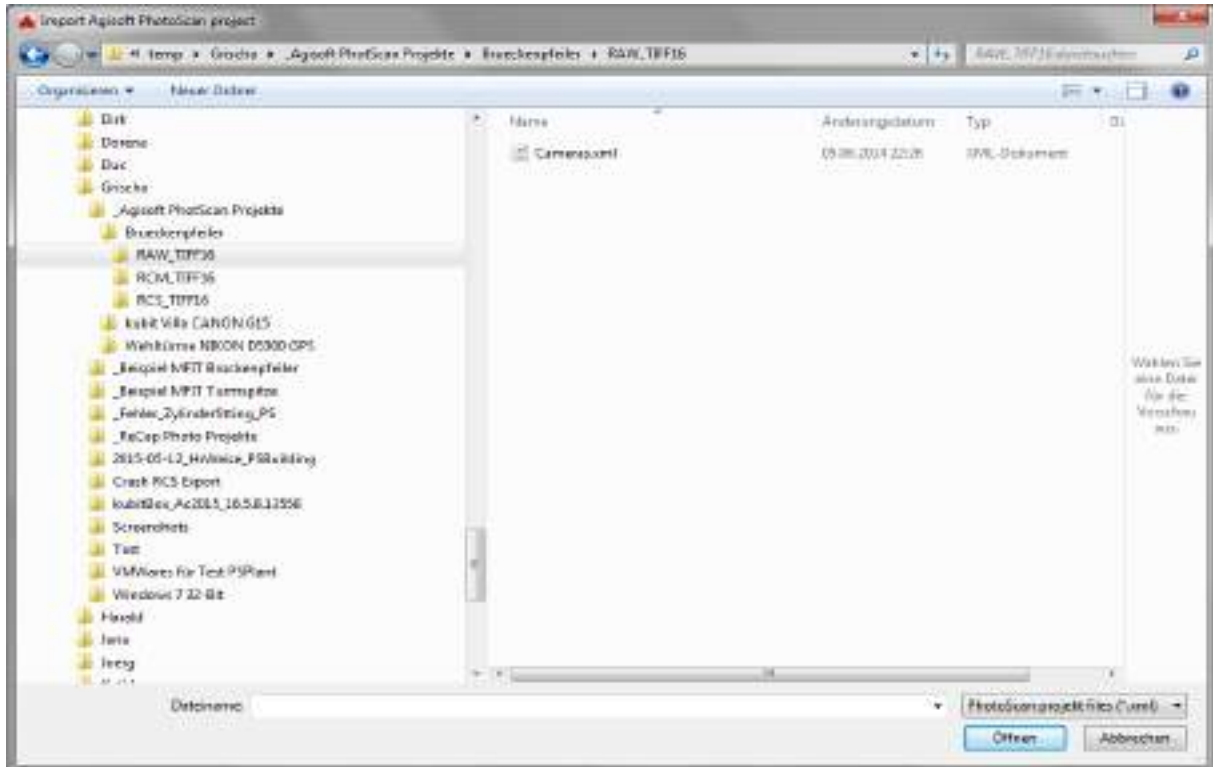
In the next step you select the oriented images that are to be imported:

In the subsequent dialogue box you can set the unit of length for the photo project and the drawing, and an offset when want to transfer from a national coordinates system to smaller local coordinates.

By default a folder will be created "_kubit_oriented_images_[project name]" as a sub folder of the folder of the images, in which the rectified images together with their orientation data are also saved. You can change the name of this sub folder. This is useful when you want, for example, to create multiple import variants with different units of length and offsets.


Hint: Remember or note the offset, in case the processing results have to be delivered with the original coordinates. Enter positive offset values. The software automatically subtracts them from the original coordinates. Care should be taken with respect to the offset, when inserting your project into a drawing that is not empty, but into a drawing that already contains some geometry.

The progress of the project import is displayed in the status bar:

When the import is completed and there is to be found in the same folder as the XML file (PhotoScan orientation data) an RCP file (ReCap point cloud project) with the same name, you will be asked if this point cloud should also be loaded into the drawing (Attention: This functionality is **not** available in AutoCAD LT):
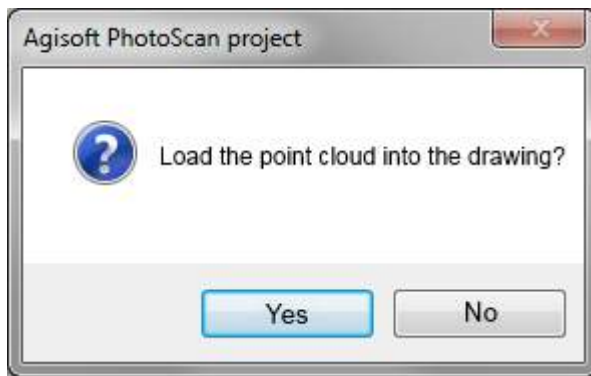
If everything is successfully completed you will be asked if the Image Management should be opened.

Sometimes not all selected images can be imported. This may happen if they are not contained in the project file (.xml) or if it was not possible to orientate them due to missing parameters.

If you answer with yes, the image management palette will open on the left (→**Oriented Images – Image management**) and you will be looking, where applicable, at your loaded point cloud:
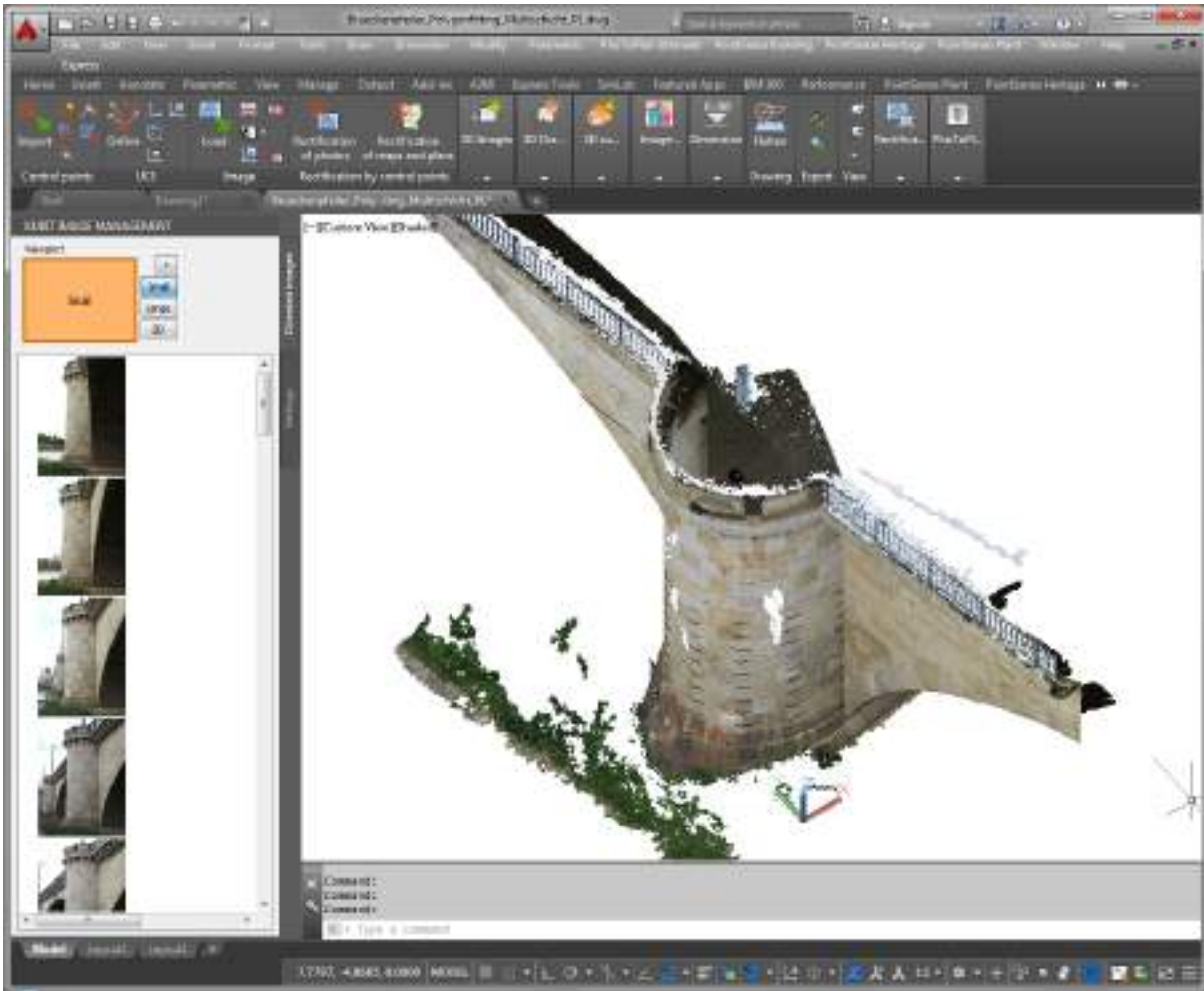
The import is now completed.

Oriented Images – Import ReCap Photo project

	Command name:		Menu:
	OIIMPORTRECAPPHOTO		As-Built Photo

You can with this command load oriented photos and point clouds of an Autodesk ReCap Photo project into your AutoCAD drawing.

What does ReCap Photo do?

ReCap Photo creates quickly and automatically from an object many oriented images, a meshed, textured 3D surface as well as a coloured point cloud. The only thing that you have to do is - following certain rules - take a number of photos and at least at one point measure a distance, to obtain scaled results.

To obtain good results from ReCap Photo we recommend that you take particular attention of the tips and rules of the manufacturer for taking the photographs! The quality of your ReCap Photo project is decisive for the quality of the further processing in As-Built Photo. Don't forget to scale your ReCap Photo project, before you process it with our software.

### How does Autodesk ReCap Photo work?

ReCap Photo is an internet based service from Autodesk, where you can transfer your data (photos) over the internet onto the Autodesk server, let them be computed there and then download the results over the internet onto your local computer.

Because of the extremely large amounts of data, you should have a fast internet connection, both for uploading and for downloading.

Your data are and remain your own property. Access is password protected.

Autodesk ReCap Photo – Getting Started

Start ReCap 360 from your desktop and click on the "photo project" icon:
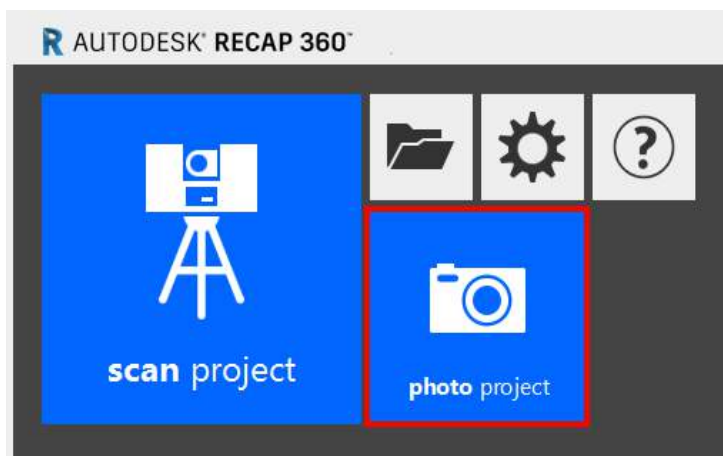
The internet browser opens (https://recap360.autodesk.com/) and after logging in to your Autodesk account you are on the landing page of the ReCap360 web service.

The user interface of ReCap 360 is very intuitive and easy to use. It is permanently being improved.

We strongly recommend that you watch the introduction videos and that you read the tutorials, thereby to obtain an insight into the mode of operation and the best way to use ReCap Photo.
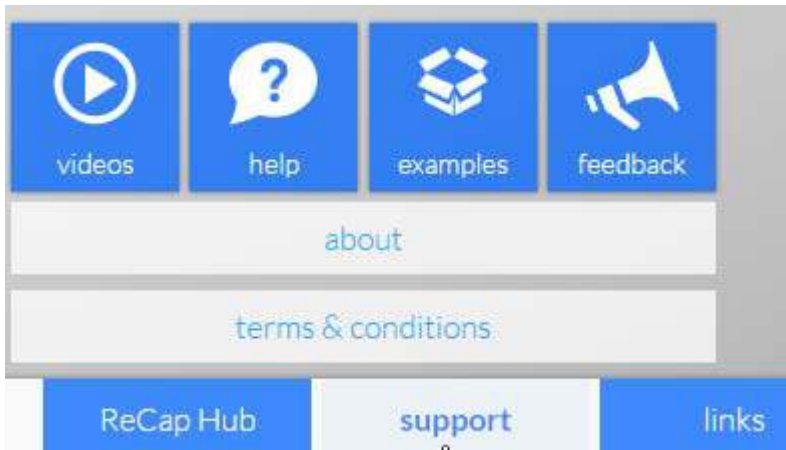

Please also read the (not quite up-todate) "ReCap Photo Getting Started Guide" (https://adsk-recap-public.s3.amazonaws.com/Getting_Started_Guide_ReCap_Photo.pdf). It contains valuable information on how to capture useful photos for your project.

After you have uploaded your images, the service requires, depending on the number of photos, up to several hours to carry out the computation. You will receive a notification by email when the computation is finished.

Downloading the completed ReCap Photo project

After your project has been successfully computed, download the complete project folder! from *Autodesk 360* onto your local hard drive. You can also connect over *Autodesk 360 Desktop* and directly access the project folder.
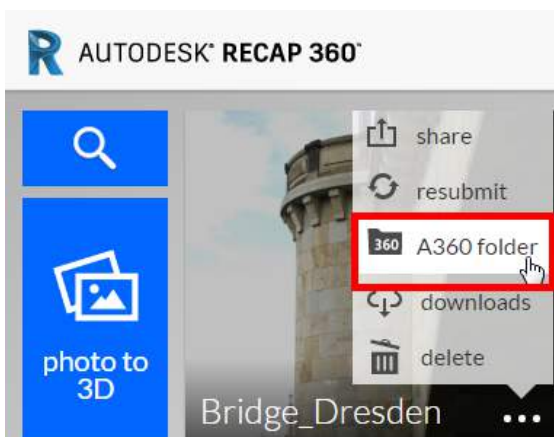
The downloaded ZIP file contains all data, including the oriented images, and may be a point cloud and/or a mesh:
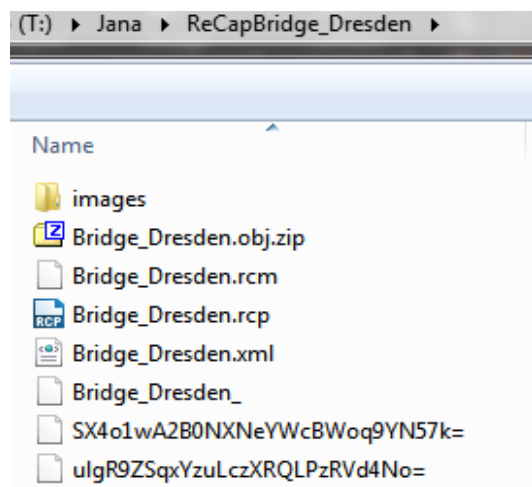
Import a ReCap Photo Project into an AutoCAD Drawing

Start AutoCAD and call the ReCap Photo import command:

Command: **OIIMPORTRECAPPHOTO**

A dialogue box appears to open a ReCap project file (*.rcp). Select the RCP file of your project.

In the next step you select the oriented images that are to be imported, that should be found in the sub folder "Images":

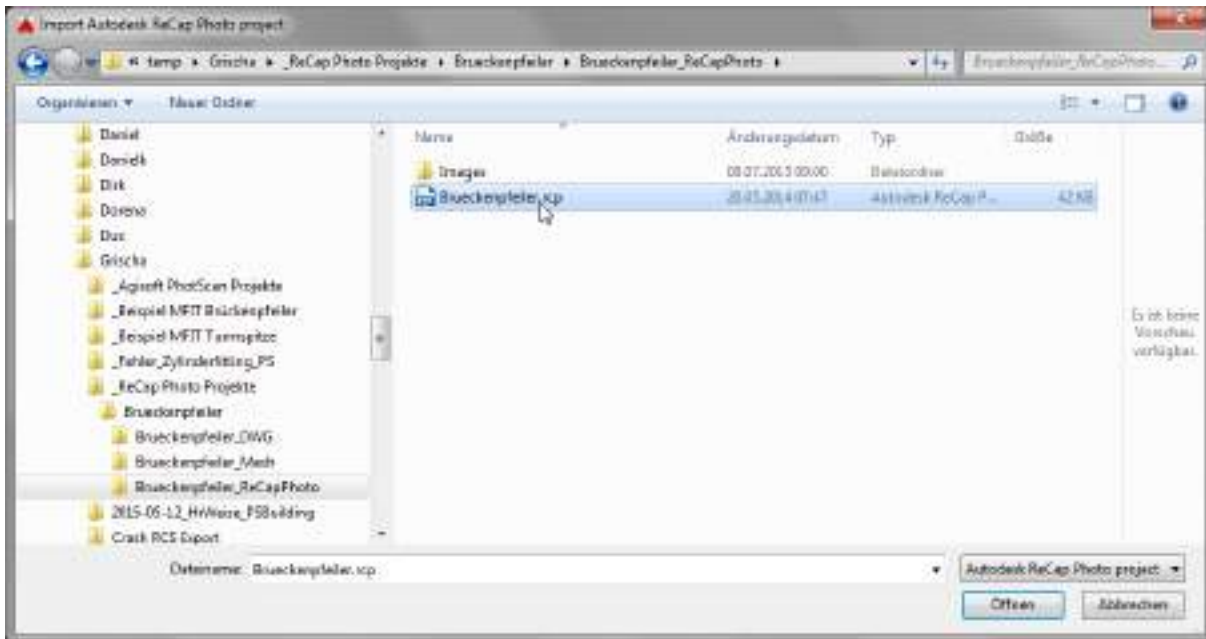In the subsequent dialogue box you can set the unit of length for the photo project and the drawing, and an offset when want to transfer from a national coordinates system to smaller local coordinates.

By default a folder will be created "_kubit_oriented_images_[project name]" as a sub folder of the folder of the images, in which the rectified images together with their orientation data are also saved. You can change the name of this sub folder. This is useful when you want, for example, to create multiple import variants with different units of length and offsets.

Hint: Remember or note the offset, in case the processing results have to be delivered with the original coordinates. Enter positive offset values. The software automatically subtracts them from the original coordinates. Care should be taken with respect to the offset, when inserting your project into a drawing that is not empty, but into a drawing that already contains some geometry.

The progress of the project import is displayed in the status bar:

When the import is completed and there is to be found the same folder as the RCP file (ReCap project) an RCS file (ReCap Scan) with the same name, you will be asked if this scan should also be loaded into the drawing as a point cloud (Attention: This functionality is **not** available in AutoCAD LT):

If everything is successfully completed you will be asked if the Image Management should be opened.
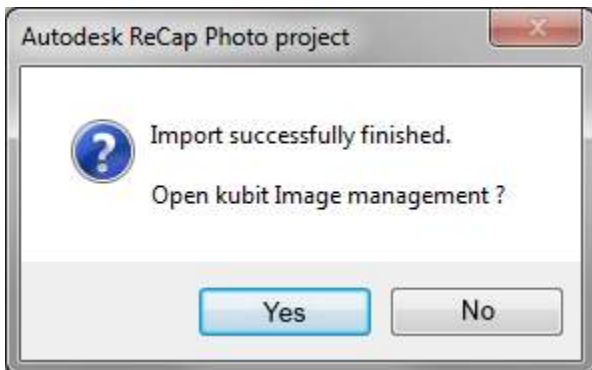
If you answer with yes, the image management palette will open on the left (→**Oriented Images – Image management**) and you will be looking, where applicable, at your loaded point cloud:
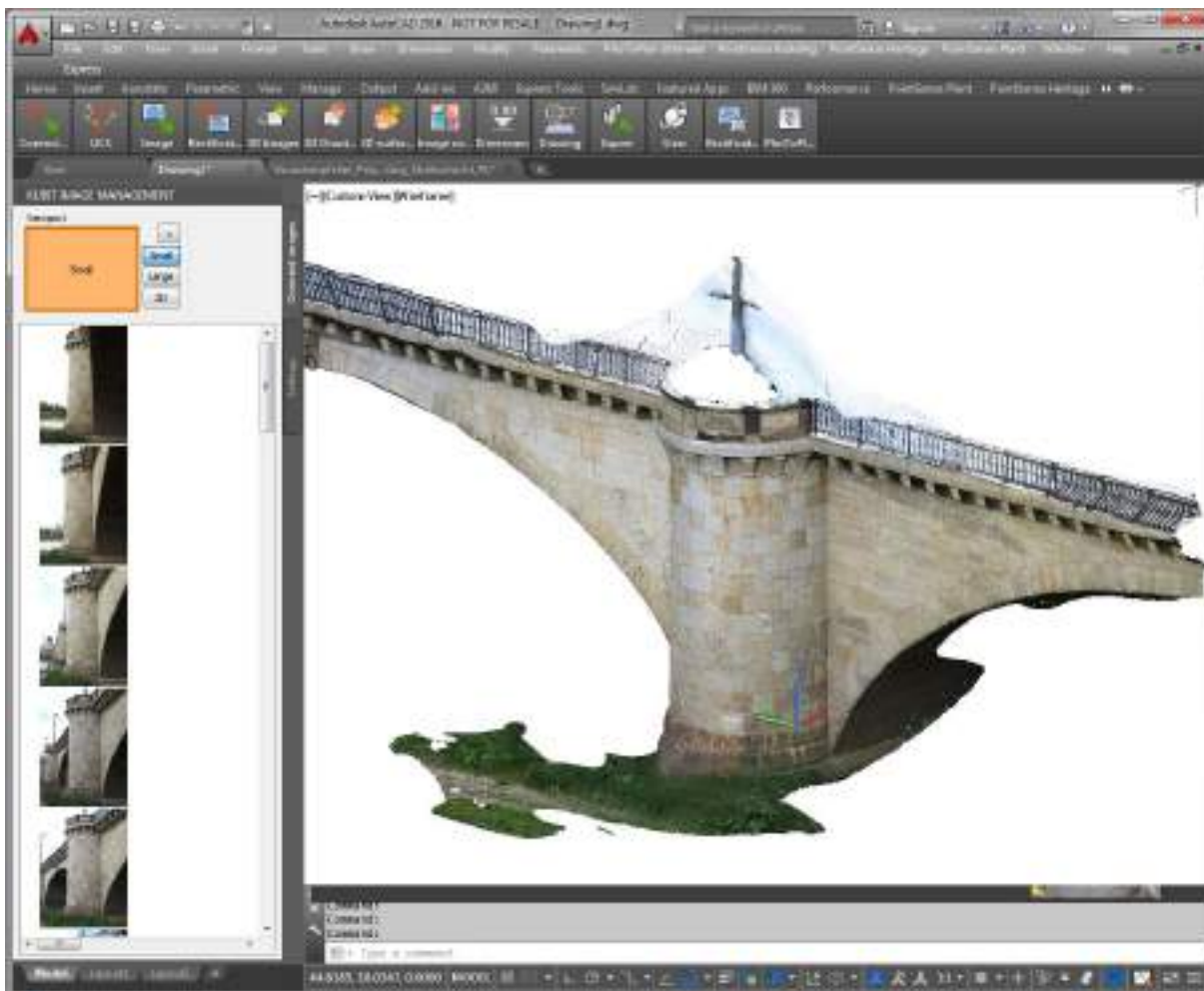
The import is now completed.
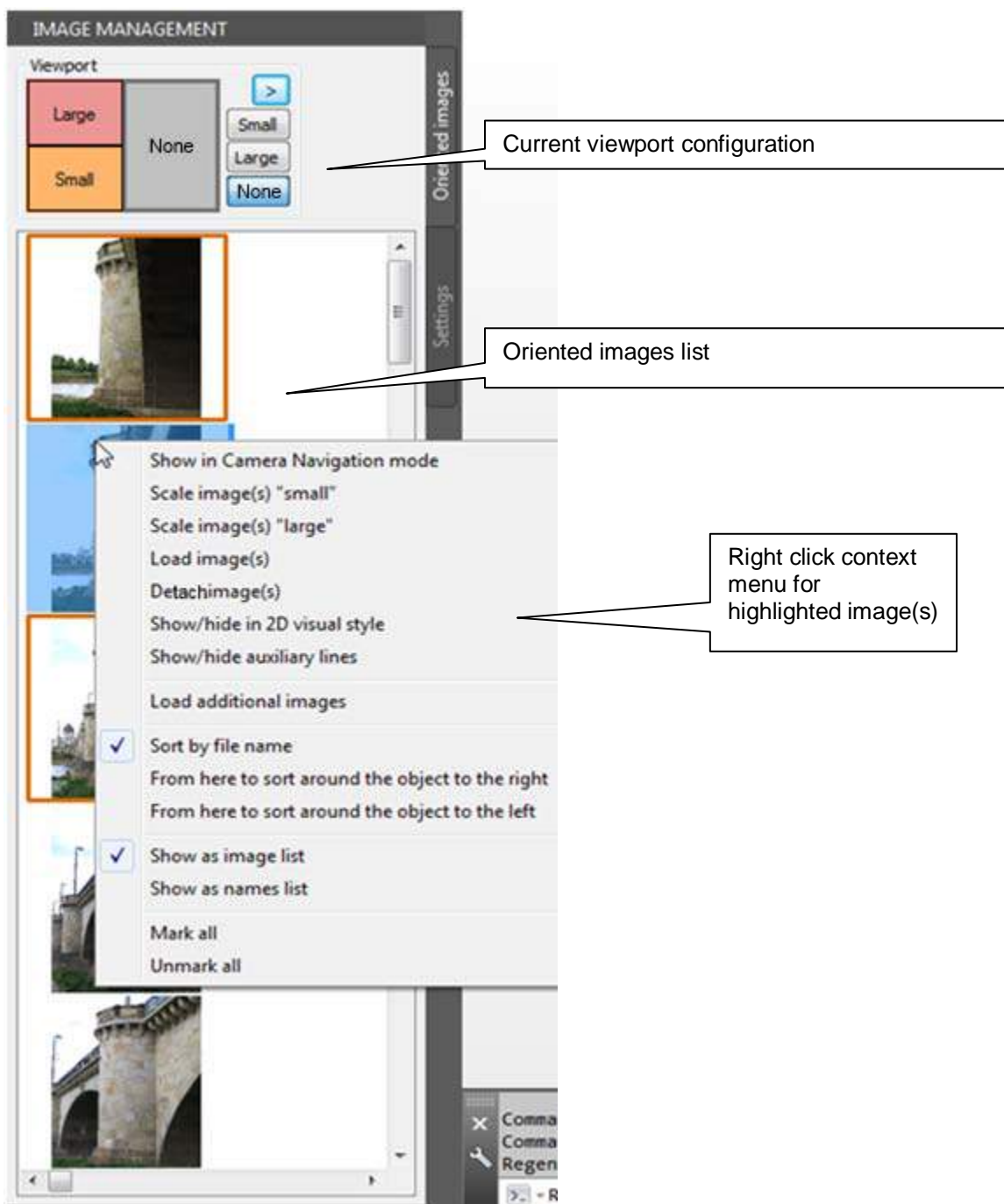
Oriented Images – Image management

	Command name:	Menu:
	OIIM	As-Built Photo

This command either opens or closes the As-Built Image Management for oriented images.

The image manager simplifies the handling of multiple oriented images and image processing with more than two images in an AutoCAD drawing. It has two tabs: "Oriented images" and "Settings".

Oriented images

Current viewport configuration

Oriented images list

Right click context menu for highlighted image(s)

Viewport:

The thumbnail shows how the current drawing is split in viewports. The current viewport has a thick border. To change the current viewport, either click in the viewport itself or on its thumbnail.

A small text and coloured highlighting shows how the oriented images in this viewport are displayed in the camera navigation mode:

Small (orange) – The image lies in front of the drawing geometry – it hides them.

Large (red) – The image lies behind the drawing geometry – the geometry is visible in front of the image. This scaling happens only if there is already is some geometry in the drawing. When you have later created some geometry, simply click again on the [Large] button for this viewport. The view is then refreshed.

None (grey) – no oriented images are displayed in this viewport. The geometry is displayed in 2D mode.

The properties for the active viewport can be changed by clicking the buttons [Small], [Large] or [None].

The button [>] opens the AutoCAD dialogue box to configure the viewports.

Image list:

Shows all of the available oriented images. These are those that are either to be found in the folder that has been selected in the tab "Settings" under "Additional directory for oriented images", or the oriented images that are already loaded into the drawing.

If the image has a thin border, it means that is loaded into the drawing.

If the image has a thick border, it means that is displayed in a viewport in camera navigation mode.

Images with a blue background are marked images. It is – when desired – possible to mark multiple images.

If the cursor hovers over an image, the file name of the image will be displayed in the view mode "Image list". Should you wish to display the full path, change (using the right click context menu) to the view mode "Names list".

If you right click on an image a context menu opens with more commands, that relate either to the highlighted image or are just normal commands:

- **Show in Camera Navigation mode (alternative: double-click the image)**

  Displays the highlighted image in camera navigation mode in the active viewport. The size is dependent on the viewport properties. Should there previously have been an image in the active viewport that was already in camera navigation mode, then the camera navigation mode for this image will be automatically ended.

- **Scale image(s) "small"**

  The image will be scaled "small". If the image is currently displayed in camera navigation mode, then the viewport properties will also be simultaneously changed.

- **Scale image(s) "large"**

  The image will be scaled "large", that means that the existing geometry will be hidden. If the image is currently displayed in camera navigation mode, then the viewport properties will also be simultaneously changed.

- **Load image(s)**

  The highlighted images will be loaded into the drawing and scaled "small".

- **Detach image(s)**

  The highlighted images will be fully removed (detached) from the drawing and memory.

- **Show/hide in 2D visual style**

  The highlighted image will be shown in 2D wire frame mode or hidden.

- **Show/hide auxiliary lines**

  The auxiliary lines from the image corners to the camera viewpoint will be shown/hidden for the highlighted images.

- **Load additional images**

  Load additional oriented images into the drawing. These will be scaled "small".

- **Sort by file name**

  Sorts the image list by file name, that means, in most cases by the order in which they were taken.

- **From here to sort around the object to the right**

  Sorts the image list geometrically around the photographed object. "Right" is to be understood as from the viewpoint of the photographer, so anticlockwise in relation to the object.

- **From here to sort around the object to the left**

Sorts the image list geometrically around the photographed object. "Left" is to be understood as from the viewpoint of the photographer, so clockwise in relation to the object.

- **Show as image list**

  Shows the image list with small preview images.

- **Show as names list**

  Shows the image list as the file names of the images.

- **Mark all (alternative: Ctrl+A)**

  Highlights all of the images in the image list.

- **Unmark all**

  Removes all of the highlighting in the image list.

Point information during image processing

When 3D points are calculated from two or more oriented images, the associated quality information is displayed on the bottom edge.
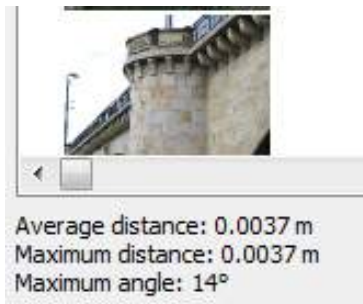
This information gives you a quick control of the quality of the calculated 3D point. Should the distance appear too large or the angle too small, then you can repeat the observation.

Settings

KUBIT IMAGE MANAGEMENT

Additional directory with oriented images:

K:\temp\Grischa_ReCap Photo Prc ▼ | ... | X

Here select a folder with oriented images.

Clears the folder with oriented images. And thereby removes the images from the image list.

☑ When swapping, unload the image previously shown in the viewport

☐ Image evaluation with two images

When you only want to pick points from **two** images to calculate the 3D points, when processing the images, then you should tick this box. Thereby the prompt "finish" is not displayed after picking the second point and the workflow is quicker.

Multi image evaluation

Maximum allowed distance of the image rays: 0.0500 m

Minimum allowed angle of the image rays: 10 °

| 3D protocol points on/off |

Here you can select the colour of the epipolar lines.

| Epipolar lines off | | Colour... |

Dock the image manager on the left, lower or right edge.

< | v | >

Details on how to use the image manager when processing multiple images can be found in sections **5.3** and **5.5** of this manual. Details on the meaning of distance and angle between the image rays can be found in Command Reference page 7-101 ff.

Note: When opening the image manager the system variables UCSVP and UCSFOLLOW are both set to 0 in all viewports of the current drawing, if at least one of the viewports is in camera navigation mode. The same applies when changing drawings and when the image manager is open, into a drawing with active camera navigation and by changing the viewport configuration through the image manager.

Oriented Images – CamNav on

	Command name:	Menu:
	OICAMNAV	As-Built Photo

This command switches the current AutoCAD view to the camera navigation mode.

This new way of navigation has been especially developed for the work with orientated images. In the camera navigation mode the position of the viewer is put into the projection centre of an orientated image and kept. The viewer sees the drawing with "the camera's eye".

Proceed as follows to switch on the camera navigation mode:

> Command: OICAMNAV
>
> Select image: (*Select an oriented image, which is to be place on the view*)

The camera navigation is activated in the current window.

You may use the command →**Oriented Images – CamNav off** to switch the camera navigation mode off.

Camera navigation

You may navigate (almost) as usual with the mouse or the camera navigation commands while in the camera navigation mode.

	mouse action	command
zoom	turn mouse wheel	**Oriented Images – CamNav - Zoom**
move the view	hold middle mouse key and move mouse	**Oriented Images – CamNav - Pan**
rotate the view around line of vision	CTRL + hold middle mouse key and move mouse up and down	**Oriented Images – CamNav - Twist**
change image size (move image forward or backwards)	CTRL + scrolling mouse wheel	"Scale" property of the oriented image

If the camera navigation is activated for a viewport, all other AutoCAD navigation commands (e.g. ZOOM, 3DORBIT, PAN,…) as well as commands which change the view, are deactivated for that viewport. The changing of all AutoCAD system variables that could possibly change the view incorrectly, is prevented. If you, by mistake, should leave the correct view, just set it again with this command.

Besides that, you may use the "Oriented Images – CamNav - Zoom" command with the option "image" any time in order to get back to the view.

Oriented Images – CamNav off

	Command name:	Menu:
	OICAMNAVOFF	As-Built Photo

This command switches the camera navigation mode of the current viewport off without any prompts.

Oriented Images – CamNav - Zoom

	Command name:	Menu:
	OICAMZOOM	As-Built Photo

With this command you can zoom when the camera navigation mode is enabled.

You may alternatively zoom with the mouse wheel.

> Command: OI**CAMZOOM**
>
> First point of [Image/Window/nX]:   (*Select the first corner of the zoom window*)
>
> Second point: (*Select second corner of the zoom window*)
>
>
> Command: OI**CAMZOOM**
>
> First point of [Image/Window/nX]: **I**   (*Select the "Image" option in order to zoom to the complete image*)
>
> Command: OI**CAMZOOM**
>
> First point of [Image/Window/nX]: **2x**   (*Enter a zoom factor, followed by an "x")*
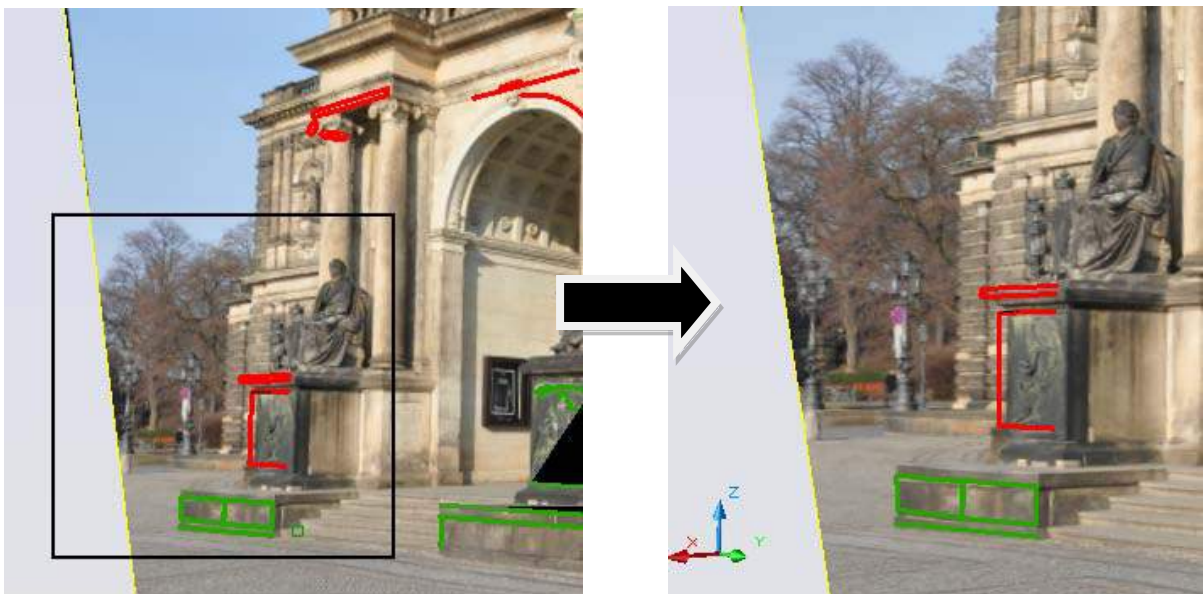
Oriented Images – CamNav - Pan

	Command name:	Menu:
	OICAMPAN	As-Built Photo

With this command you can pan the view when the camera navigation mode is enabled.

You may alternatively hold the middle mouse key and move the mouse – just like the common AutoCAD pan.

Command: OI**CAMPAN**

Press ESC or ENTER to exit!   *(Press the left mouse key, hold it and move the mouse.)*

(Press the ESC or ENTER key in order to end the command.)
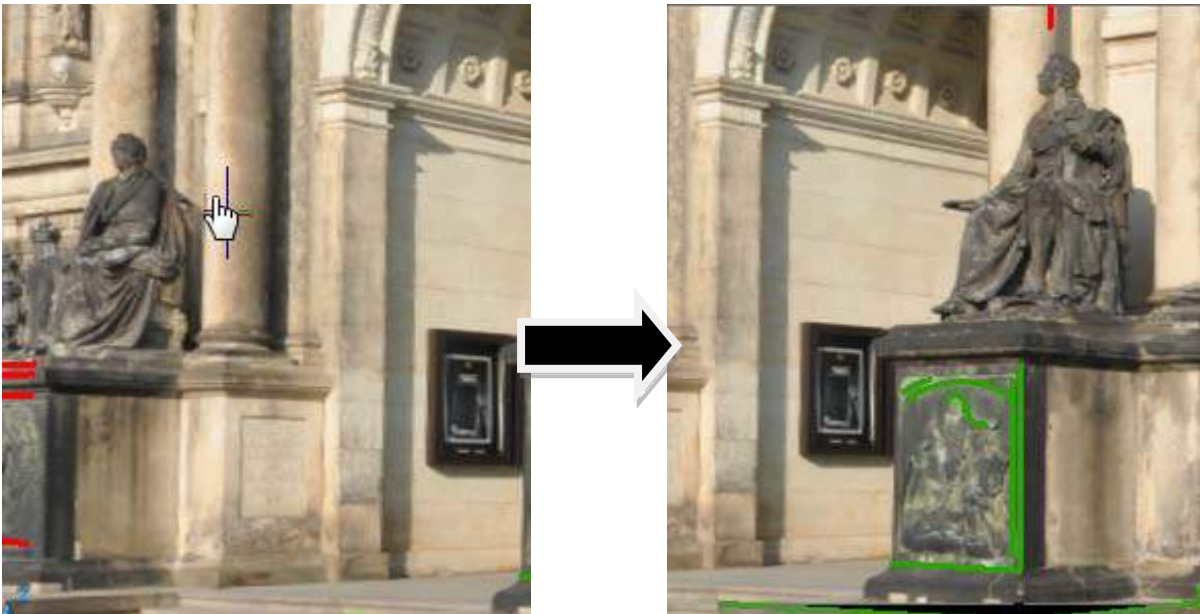
Oriented Images – CamNav - Twist

Command name:	Menu:
OICAMTWIST	As-Built Photo

With this command you can rotate the view around the viewing direction.

Alternatively you may rotate the view by pressing the CTRL key and holding the mouse wheel down while moving the mouse back and forth.

Command: OICAMTWIST

Select new twist angle <24>: **0**   *(An angle of 0 refers to the*

original orientation of the oriented image.)

Oriented Images – Set size

	Command name:	Menu:
	OISETSIZE	As-Built Photo

With this command you set the size in which one or more oriented images are to be displayed.

Command: **OISETSIZE**

Select oriented images <All>:   (*Select one or more oriented images*

or press the ENTER key in order to select all)

1 selected; display selected images large (in background) or small [Large/Small] <Small>:

(Select "Large" in order to display the selected

images behind all AutoCAD graphics and

"Small" or ENTER key in order to reduce the images.)

The selected images are displayed in the set size.

"Large" means:

The images are displayed large enough – seen from the camera – that they are placed behind all AutoCAD graphics (except the oriented images themselves). Therefore all AutoCAD graphics is displayed correct in position *in front of* the images, when working in the camera navigation mode.

"Small" means:

The images are scaled, so the distance of the centre of projection to the principal image point equals 20 times the focal length.

Hint:

You may also adapt the size of the images manually, e.g. in order to avoid overlapping of several oriented images.

- Within the camera navigation mode: by pressing CTRL + scrolling the mouse wheel. The scroll direction corresponds to the direction the image is moved to from the observers point of view.

- Changing the "scale" property within the AutoCAD properties window of the oriented image manually. The value is a manifold of the focal length. Therefore 3 means 3 times the focal length.

Example
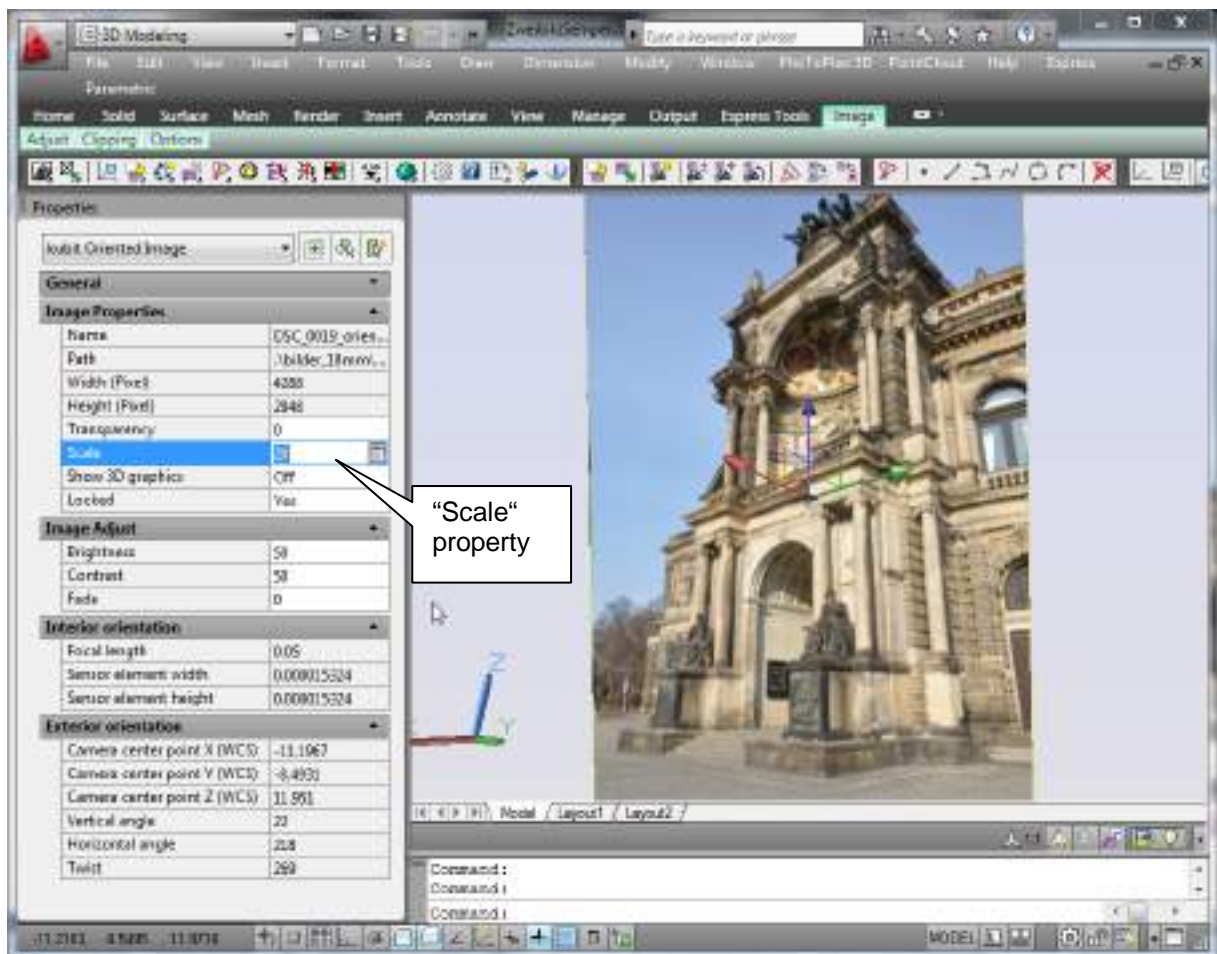
The oriented image – here in camera navigation mode (CamNav) - is small (size factor 20). It lies in front of the control points and therefore hides them.
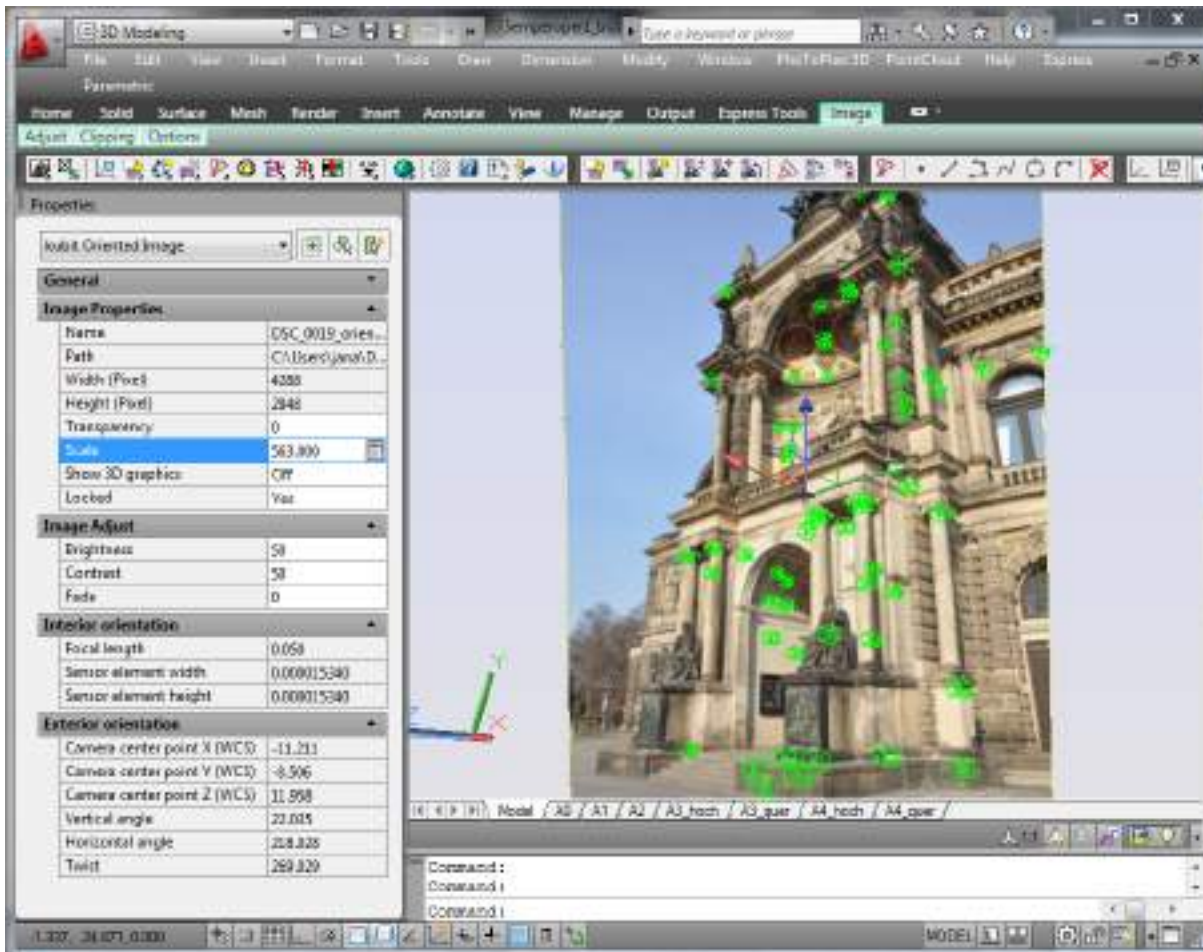
The oriented image – here in camera navigation mode (CamNav) - is large (size factor 563). It lies behind the control points so they are shown at correct position in front of the image.

Oriented Images – Show/hide in 2D visual style

	Command name:	Menu:
	OISHOWIN2D	As-Built Photo

With this command you set whether the oriented images are to be displayed in the AutoCAD visual style "2D wireframe" or not.

This is useful, when you have set an overview (like top view, isometric view, …) within an AutoCAD viewport, where the display of, possibly very large, oriented images would be interfering.

Command: **OISHOWIN2D**

Select oriented images <All>:   (*Select one or more oriented images*

or press the ENTER key in order to select all.)

1 selected. Show or hide oriented images in 2D visual style [Show/Hide] <Hide>:

(Select "Show" in order to show the images

in the visual 2D wireframe and select "Hide" or

press the ENTER key to hide the images)

Oriented Images – Show/hide auxiliary lines

	Command name:	Menu:
	OISHOWLINES	As-Built Photo

With this command you can turn the display of the auxiliary lines (pyramid from the center of projection to the image corners) on and off.

Command: **OISHOWLINES**

Select oriented images <All>:   (*Select one or more oriented images*

or press the ENTER key in order to select all.)

1 selected. Show or hide auxiliary lines [Show/Hide] <Hide>: **h**   (*Select "Show" in order*

to show the auxiliary lines of the selected images

or "Hide" or the ENTER key in order to hide the auxiliary lines.)
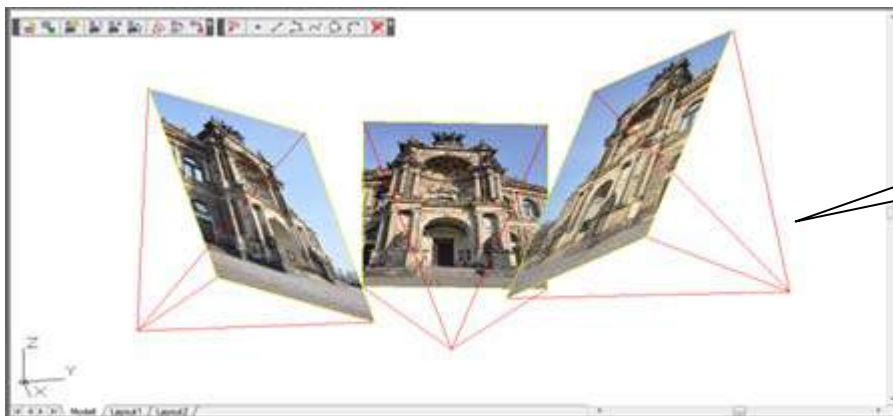
lines shown
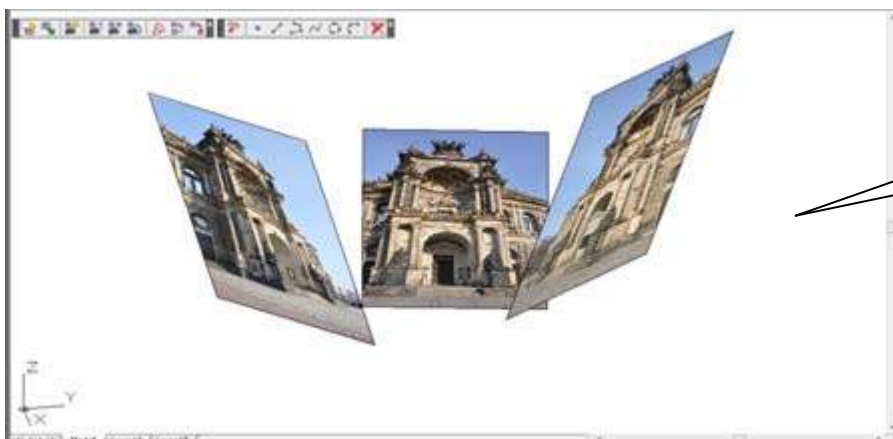
lines hidden

Image Modeling – 3D Drawing - Settings

	Command name:	Menu:
	IMDRAW3DCONFIG	As-Built Photo

With this command you select the objects and commands for which the 3D drawing is to be active.

3D Drawing - Settings

Objects | Commands

3D Drawing

3D drawing is available.

You can activate 3D Drawing by switching the button "3D Drawing" in the drawing status bar.

2 surfaces selected.

      1 kubit Plane(s)
      0 kubit Cylinder(s)
      1 AutoCAD surface(s)

2 oriented images selected.

> Two surfaces have been added, the 3D drawing is now activated.

You can activate 3D Drawing in AutoCAD's status bar.

[Add Surfaces...]
[Remove all]

[OK] [Cancel]

3D Drawing - Settings

Objects | Commands

Activate 3D Drawing for the following AutoCAD commands:

Available commands:

Command name	Command group

Active commands:

Command name	Command group
LINE	AutoCAD
POINT	AutoCAD
3DPOLY	AutoCAD
INSERT	AutoCAD
-INSERT	AutoCAD
UCS	AutoCAD

[>>]
[<<]

[Remove]

Add command

Global command name [   ]

Command group [   ]

[Add]

You can activate 3D Drawing in AutoCAD's drawing status bar.

> "active commands"
> If one of these commands is started, image rays will intersect with the selected surfaces and the calculated point is returned to AutoCAD.

[OK] [Cancel]

3D Drawing - Settings

Objects | **Commands**

Activate 3D Drawing for the following AutoCAD commands:

Available commands:

Command name	Command group
UCS	AutoCAD
INSERT	AutoCAD
-INSERT	AutoCAD

Active commands:

Command name	Command group
LINE	AutoCAD
POINT	AutoCAD
3DPOLY	AutoCAD

Remove

Add command

Global command name: 3DFACE

Command group: AutoCAD

Add

Move commands between the lists "available commands" and "active commands".

Here you may add further AutoCAD commands – even commands from AutoCAD applications – to the list of available commands.

You can activ[...] AutoCAD's drawing status [...]

OK   Cancel

3D Drawing - Settings

Objects | **Commands**

Activate 3D Drawing for the following AutoCAD commands:

Available commands:

Command name	Command group
UCS	AutoCAD
INSERT	AutoCAD
-INSERT	AutoCAD
MY_COMMAND	

Active commands:

Command name	Command group
LINE	AutoCAD
POINT	AutoCAD
3DPOLY	AutoCAD
3DFACE	AutoCAD

Remove

Add command

Global command name:

Command group:

Add

The "3DFACE" command has been added to the list of activated commands.
The "MY_COMMAND" command from an AutoCAD application has been added to the list of available commands.

You can activate 3D Draw[...] AutoCAD's drawing status [...]

OK   Cancel

The command lists (available and activated) are saved to the As-Built configuration file and apply to all drawings.

The selected objects and the current status of the 3D drawing are saved in the AutoCAD drawing.

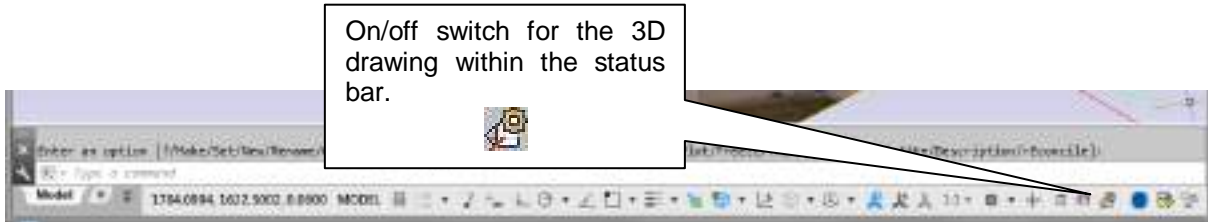Within the status bar you can turn the 3D drawing on and off.

On/off switch for the 3D drawing within the status bar.

Image Modeling – Prepare viewports

	Command name:	Menu:
	OISETVP	As-Built Photo

As already described in **chapter 5.3** of this manual at least two oriented images have to be loaded into the drawing in order to use the multiple image drawing. It is helpful to open at least two AutoCAD viewports for the images in which you alternately click corresponding points. Furthermore it is recommended for each viewport to set the camera navigation to the displayed image. Additionally the display size of the oriented images should be set in a way that the graphics to be generated are not covered by them (→Oriented Images – Set size) and the auxiliary lines should be turned off (→Oriented Images – Show/hide auxiliary lines). The manual preparation of viewports can make sense but it also is time consuming and quite an effort.

This command is a short cut for the preparation of the AutoCAD screen for the 3D drawing with multiple oriented images. You are prompted to select two oriented images:

Command: **OISETVP**
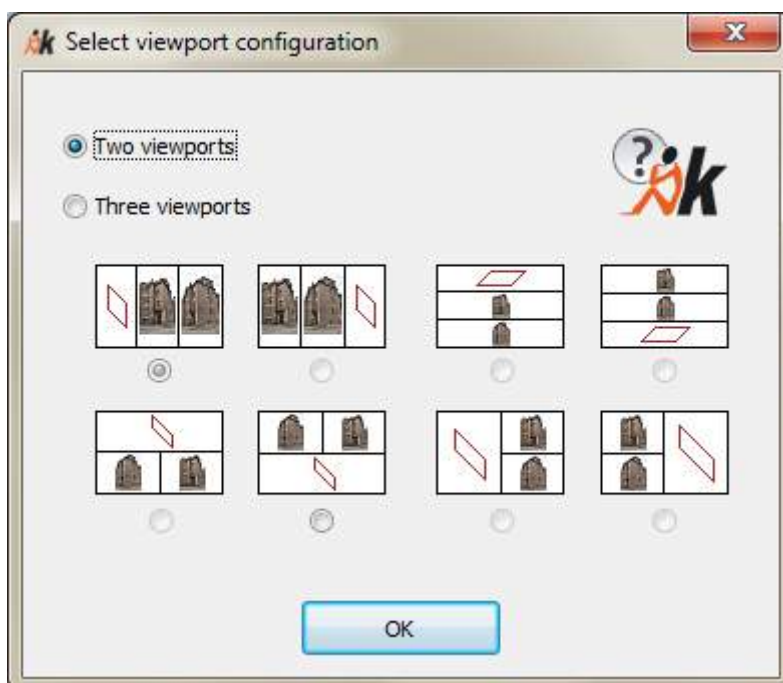
Select first oriented image: *(Click first oriented image.)*

Select second oriented image: *(Click second oriented image.)*

Please note that always in the **second** image the geometry is shown in front.

Following window for the definition of the alignment of the viewports opens after you selected the images:

After confirmation with **OK** As-Built automatically creates the viewports.

In the viewports with the oriented images the camera navigation mode is set to the respective image. The images are scaled in a way that at least in one viewport the three dimensional geometry drawn is displayed in front of the oriented image. The auxiliary lines of both images are turned off and in the three-viewports-mode an

additional viewport is generated, where the development of the geometry can be observed and checked. In this viewport the 2D Wireframe style is automatically turn on and the oriented images are hidden in order to keep the view on the geometry clear.

You may now use the commands for the multiple image drawing which are described in the following sections. You find further information in chapters 5.3 and 5.5 of the manual.

Hint: Use the →**Image Modeling – Reset viewports** command in order to restore the original view status.

If you have changed the UCS during the multiple image evaluation it is better you first activate the viewport with the geometry and then use the AutoCAD command from the menu 'View' → 'Viewports' →'1 Viewport'.

Image Modeling – Reset viewports

	Command name:	Menu:
	OIRESETVP	As-Built Photo

If you used the command →**Image Modeling – Prepare viewports** for the preparation of the AutoCAD screen, you may reset the screen to the state it had before you ran →**Image Modeling – Prepare viewports** by using this command.

Of course you may also reset the AutoCAD screen manually by means of the AutoCAD commands for viewports. This task can be quite time consuming though, since you have to turn off the camera navigation, turn the auxiliary lines of the oriented images on again (→Oriented Images – Show/hide auxiliary lines) and, where applicable, adapt the image size manually (→Oriented Images – Set size).

If you did not use the command →**Image Modeling – Prepare viewports** for the preparation of the viewport this command does not have any effect.
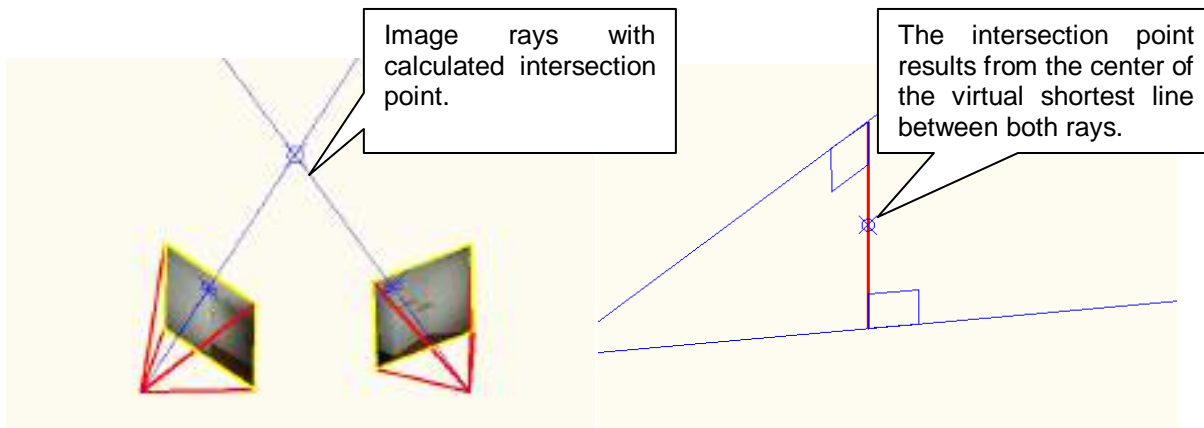

Caution!

If you added further viewports manually after you used the command →**Image Modeling – Prepare viewports** these viewports get lost if you run this command. If you changed the UCS during the multiple image evaluation, this new UCS does not stay current.

Image Modeling – 3D point

	Command name:	Menu:
▫	'IMPT2P	As-Built Photo

This command returns a 3D point to the AutoCAD command line. This 3D point results from the intersection point of image rays which were clicked within two or more oriented images.


> Image rays with calculated intersection point.

> The intersection point results from the center of the virtual shortest line between both rays.

There have to be at least two oriented images within the drawing or the image management has to be open so the function can be called up. Otherwise a warning message pops up.

It is recommended to work with viewports and for each view port set the camera navigation to the corresponding image (→**Oriented Images – CamNav on**). To prepare the screen the →**Oriented Images – Image management** command is very helpful.

Example

A drawing with two oriented images, which show the same object and which were taken from different camera positions.
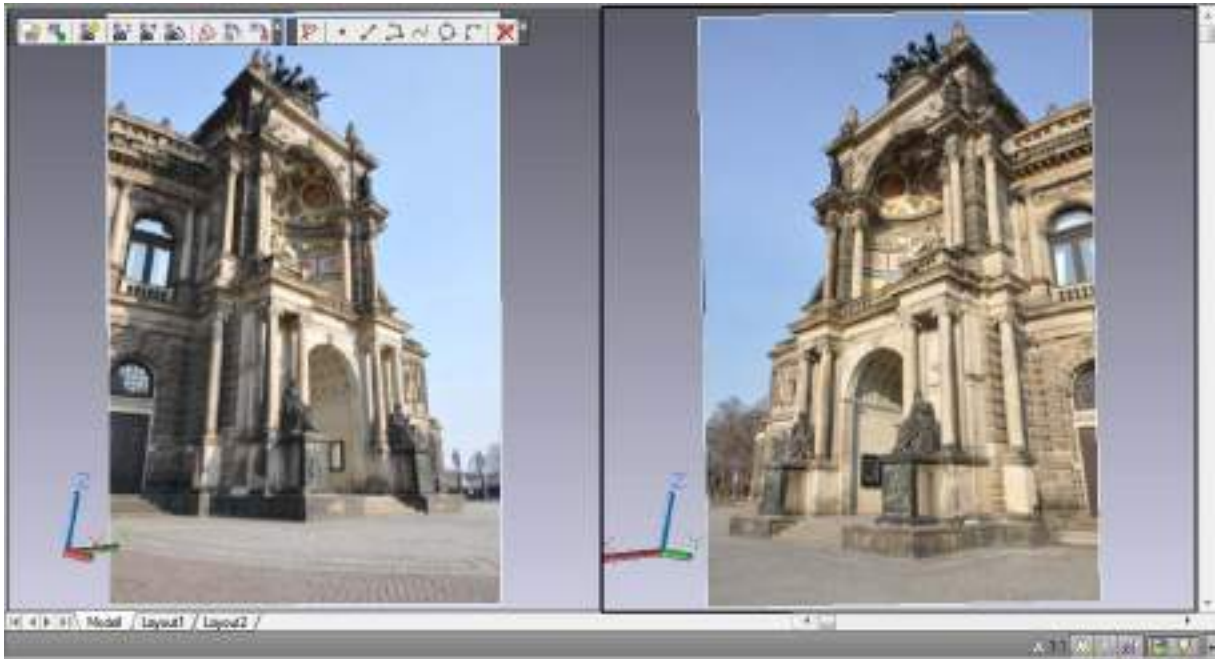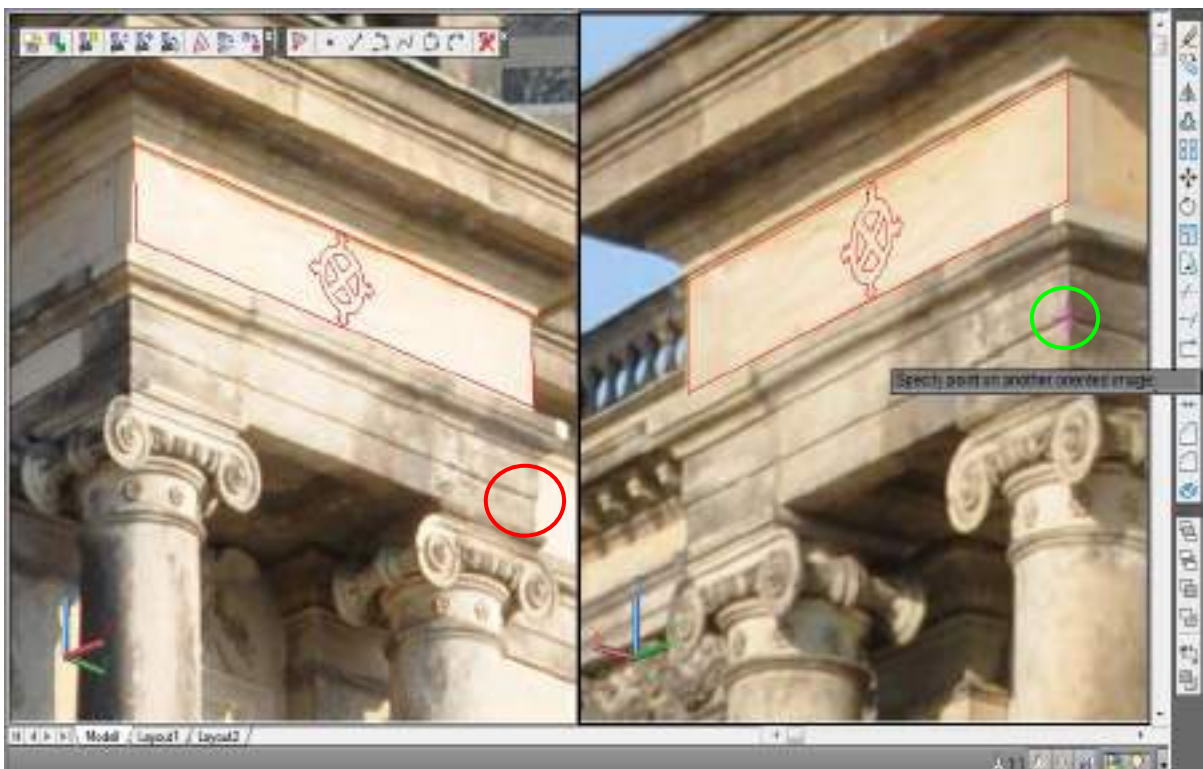

Now call up an AutoCAD command, e.g. "LINE"

Command: **LINE**

State first point: 'IMPT2P

(When ever AutoCAD expects a point you may enter it directly or use the function I'MPT2P *to calculate the spatial intersection.)*

>>> Specify point on oriented image or [Cancel] <Cancel>:

(*Click a point in one of the oriented images; green circle in the right image. The click point in the first image is always highlighted by a magenta coloured cross. This is meant as aid to memory. It disappears after clicking in the second oriented image.*)

>>> Specify point on another oriented image or [Back] <Back>:

(Click a point in another oriented image; red circle in the left image)

Now do the same for the other points of the line. The displayed plane has been generated by clicking points within both images by using the →**As-Built Modeler – Modeling – Fit Plane** command. You may also use the command '**IMPT2P** to insert AutoCAD blocks for instance.

If you have not enabled the option "Image evaluation with two images" in the image management, the command IMPT2P finishes not automatically after you clicked in the second image. Instead you may click the same point in further oriented images and thus improve the accuracy.

>>> Specify point on another oriented image or [Finish/Back] <Finish>:

After having clicked in further image you finish the command line prompt by pressing ENTER.
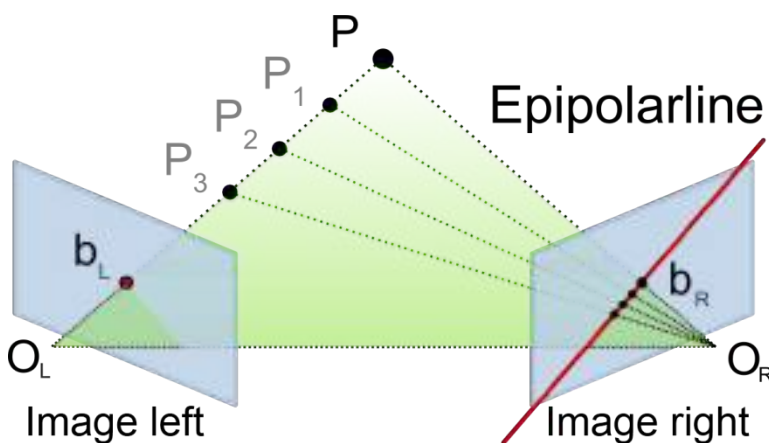
The epiplolar line helps you finding the corresponding point in the second image. It always lies on the epiplolar line. This fact is especially useful when you want to digitize linear or curved objects that have no exactly distinguishable single points.
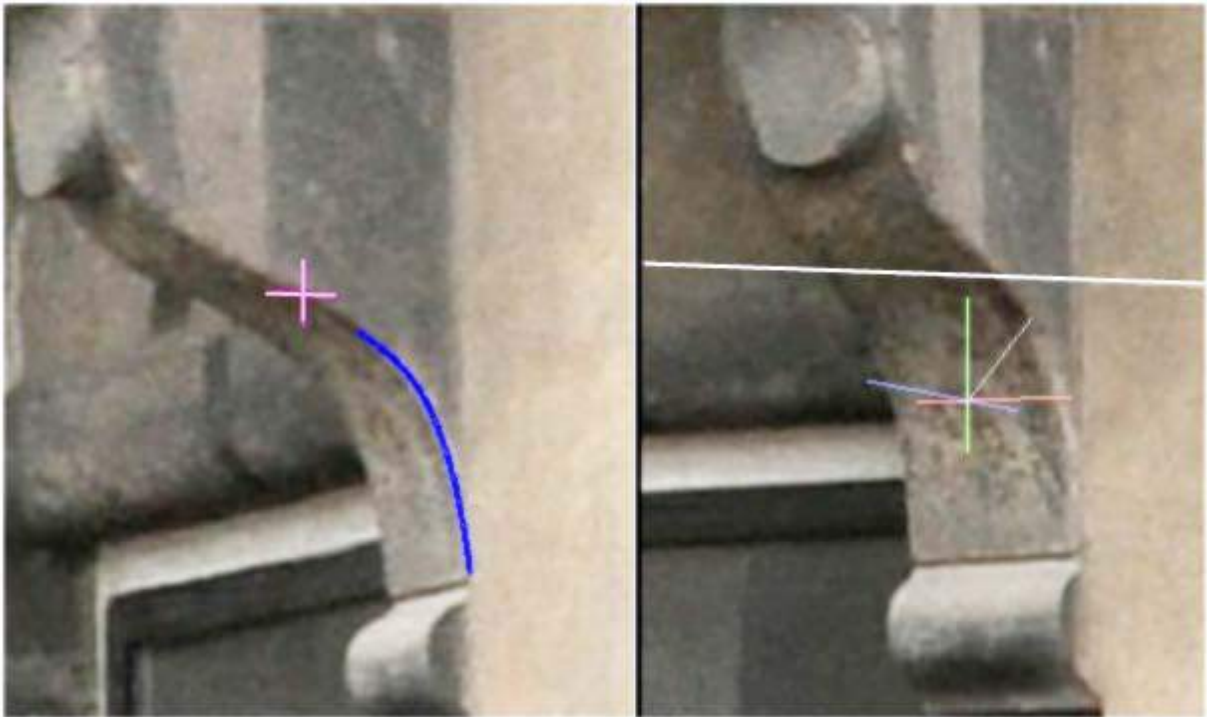
You may toggle the visualization of the epipolar line on/off by using the button ⬚ in the lower right of the AutoCAD statusbar or by clicking the according button on the "Settings" tab of the image management. If you use more than two images in addition to the epipolar line a circle is displayed after you clicked in the second image. The point clicked in the next oriented image has to lie inside this circle.

To avoid inaccuracy and errors when assigning the image points you may set thresholds for the maximum distance and for the minimum spatial angle between the image rays. This is done on the "Settings" tab of the image management (→**Oriented Images – Image management**).
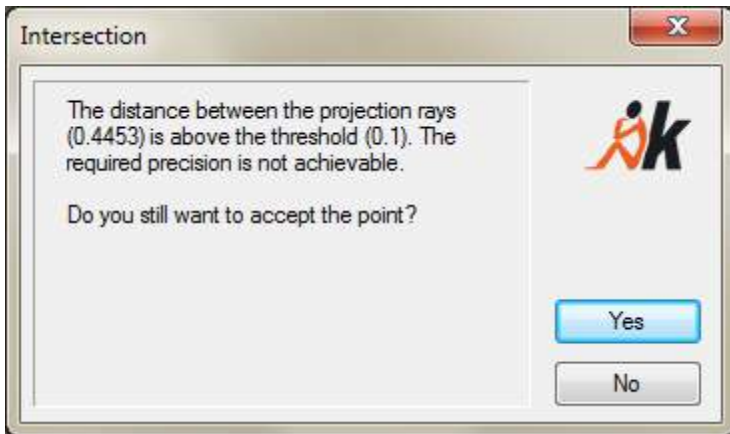
The distance and the angle between the image rays are explained in the following paragraphs.

Distance between the image rays

shortest line (=**Distance**) between two image rays
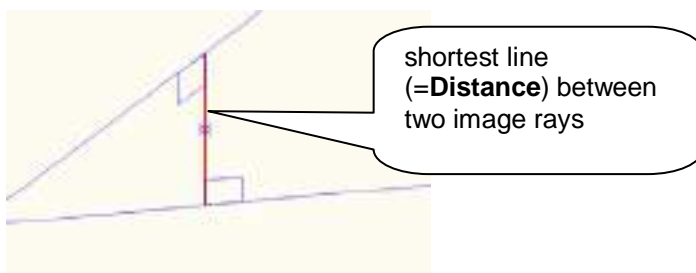
The threshold for the maximum allowed length of the shortest line applies for a distance of 10 metres from the camera position.

Following warning pops up if the maximum distance is exceeded:

Here the distance values refer to the drawing unit which is set within the As-Built settings under "System". This warning message does not appear if the second point was click on or close to the epipolar line.

Depending on the project it might be necessary to change the threshold (unit meters). An aerial photo or a satellite image need other tolerances than a detailed photo of a façade element.

Spatial angle between the image rays

The second tolerance value refers to this angle. It is given in decimal degrees.
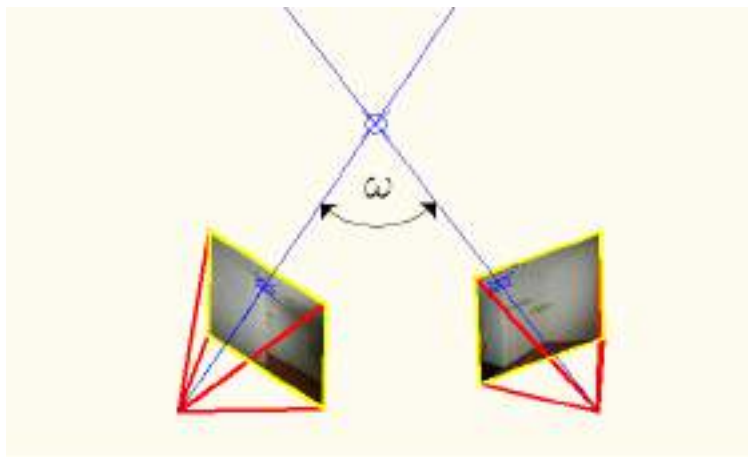
If the angle w falls below the default minimum angle w_{min}, you receive following warning:
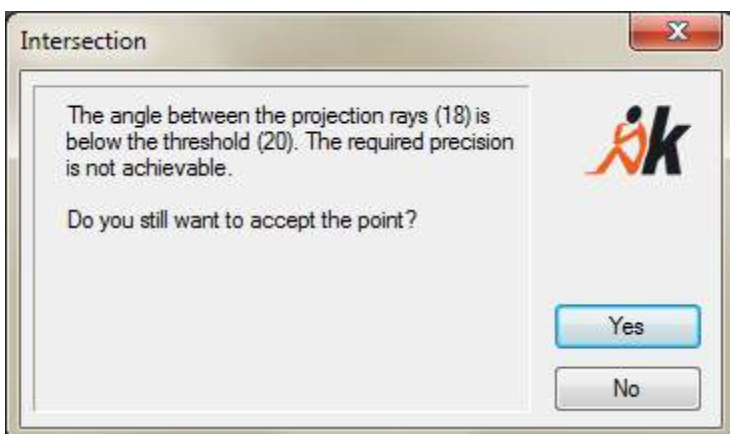
The angle values of the message are given in the angle units currently set in AutoCAD.

As-Built draws a protocol block for every point that is created by multiple image evaluation. The blocks are drawn on a specific layer which is hidden by defaul.

The upper attribute of the block is the maximum distance between the image rays while the lower attribute shows the minimum angle between them.

You may show/hide the protocol block by pressing the button on the "Settings" tab of the image management (→**Oriented Images – Image management**). In the →**Settings** in the section „Layer" you may define the name of the layer the software puts the protocol blocks on. The name of the variable is "Layer3DMultiImgPoint" and its default value is „3DMULTIIMGPOINTS".

Hints:

(1) If you cannot see the drawn graphic within the images, this most likely results from the fact that the images are in the front. Use the [Large] button of the image management in order to place an image behind the AutoCAD graphic.

(2) If both images overlap adapt the image size using the properties window or the mouse (CTRL + scrolling the mouse wheel) manually.

(3) There are native FARO commands available for the 3D drawing of geometry like lines, 3D polylines, 3D splines, 3D circles, and 3D circle arcs. Those commands help you to draw easier and faster than using the transparent 3D point command. They are described in the following sections.

You find further information on 3D drawing with two oriented images in **chapter 5.3** of this manual.

Image Modeling – 3D line

	Command name:	Menu:
	IMDRAW3DLINE	As-Built Photo

This command facilitates the drawing of a 3D line by means of oriented images. For every point of the line you consecutively have to click corresponding points in two or more different oriented images. It does not matter in which image you click the first point of the pair. To finish the command press ESC:

Command: **IMDRAW3DLINE**

Specify first point for line:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back]<Cancel>:

>>> Specify point on another oriented image or [Finish/Cancel/Back]<Finish>: F

Specify point for line:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back]<Cancel>:

>>> Specify point on another oriented image or [Finish/Cancel/Back]<Finish>: F

Specify point for line:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back]<Cancel>:

>>> Specify point on another oriented image or [Finish/Cancel/Back]<Finish>:

>>> Specify point on another oriented image or [Finish/Cancel/Back]<Finish>: F

Specify point for line:

>>> Specify point on oriented image or [Cancel/Back/cLose/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back]<Cancel>:

>>> Specify point on another oriented image or [Finish/Cancel/Back]<Finish>: F

Specify point for line:

>>> Specify point on oriented image or [Cancel/Back/cLose/Point snap] <Cancel>: L

You also have the option to snap points of existing AutoCAD objects and use them for the line.

>>> Specify point on oriented image or [Cancel/Back/cLose/Point snap] <Cancel>: **P**

>>> Specify or snap 3D point:

        (the object snap is now enabled and you may snap for instance an existing line end)

For closing the line run use the [cLose] option.

There have to be at least two oriented images within the drawing or the image management has to be open so the function can be called up. Otherwise a warning message pops up.

To avoid inaccuracy and errors when assigning the image points you may set thresholds for the maximum distance and for the minimum spatial angle between the image rays. This is done on the "Settings" tab of the image management (→**Oriented Images – Image management**). The distance and the angle between the image rays are explained more detailed on page 7-101 of this command reference.

Hints:

(1) It is advisable to work with viewports where camera navigation is set to the respective image (→Oriented Images – CamNav on).

(2) If you cannot see the drawn graphic within the images, this most likely results from the fact that the images are in the front. Use the [Large] button of the image management in order to place an images behind the AutoCAD graphic.

(3) If both images overlap adapt the image size using the properties window or the mouse (CTRL + scrolling the mouse wheel) manually.

(4) The command →**Oriented Images – Image management** is very helpful for preparing the screen.

You find further information on 3D drawing with two oriented images in **chapter 5.3** of this manual.

Image Modeling – 3D polyline

	Command name:	Menu:
	IMDRAW3DPOLY	As-Built Photo

This command facilitates the drawing of 3D polylines by means of oriented images. It works the same way as the command →**Image Modeling – 3D line**.

Image Modeling – 3D spline

	Command name:	Menu:
	IMDRAW3DSPLINE	As-Built Photo

This command facilitates the drawing of 3D splines by means of oriented images. It works the same way as the command →**Image Modeling – 3D line**.

Please note, that the starting tangent and the end tangent correspond the spatial direction in the start point respectively the end point. During the command the lines of the tangents are shown. The spline is only displayed after the command is finished.

Possibly you have to edit the spline later.

Image Modeling – 3D circle

	Command name:	Menu:
	IMDRAW3DCIRCLE	As-Built Photo

This command facilitates the drawing of a 3D circle via exactly three points that lie on its perimeter by using oriented images. The points should – if possible – have a distance of 120° in relation to the circle centre.

It works the same way as the command →**Image Modeling – 3D line**. But there is no visualization of the circle during the point inquiry.

Image Modeling – 3D circle arc

	Command name:	Menu:
	IMDRAW3DCIRCLEARC	As-Built Photo

This command facilitates the drawing of a 3D circle via exactly three points that lie on its perimeter by using oriented images. The first and the last point define the start and the end of the arc.
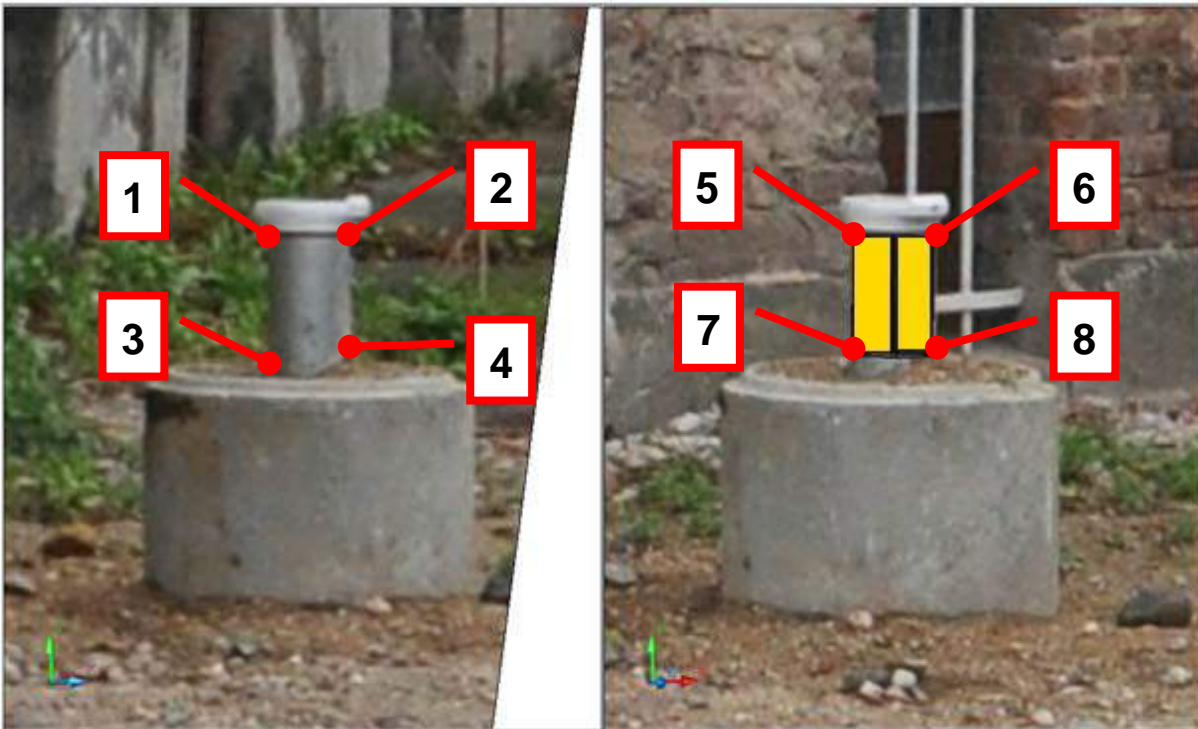
It works the same way as the command →**Image Modeling – 3D line**. But there is no visualization of the circle during the point inquiry.

Image Modeling – 3D cylinder

	Command name:	Menu:
	IMDRAW3DCYLINDER	As-Built Photo

This command helps measuring a cylinder without the cylinder needing to have distinctive surface structures.

An Example:

Command: IM_DRAW3DCYLINDER

First image - Point for cylinder top left:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

First image - Point for cylinder top right:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

First image - Point for cylinder end left:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

First image - Point for cylinder end right:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

Second image - Point for cylinder top left:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

Second image - Point for cylinder top right:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

Second image - Point for cylinder end left:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

Second image - Point for cylinder end right:

>>> Specify point on oriented image or [Visualisation/Back] <Back>:   *(click image point)*

It is important that you hit the rim of the cylinder as exactly as possible. But it does not matter if you do not get the start or the end of the cylinder as accurate – those values are averaged. The extend of the cylinder can be edited easily after the cylinder has been created. Ensure that the cylinder axis is fixed when changing its length.

Of course this method is limited. If the cylinder broader than it is long or if its beginning and its end lie close to each other then the direction of the cylinder axis becomes less definite.

Image Modeling – Define UCS with minimum 3 points

	Command name:	Menu:
	IMSETUCS	As-Built Photo

If you want to digitize objects on planar surfaces (e.g. flat façades) during the multiple image evaluation, it can be beneficial to chose a different strategy. Therefore you define a UCS with its XY plane in the plane of the façade. Now you may use native AutoCAD commands like LINE or RECTANGLE to draw on this façade.

Of course you do not draw on the façade itself but on the XY plane of the new UCS with Z value zero.

The As-Built command IMSETUCS helps you to create such a UCS very easily. The sequence of points which is prompted in the command line is shown here with an example.
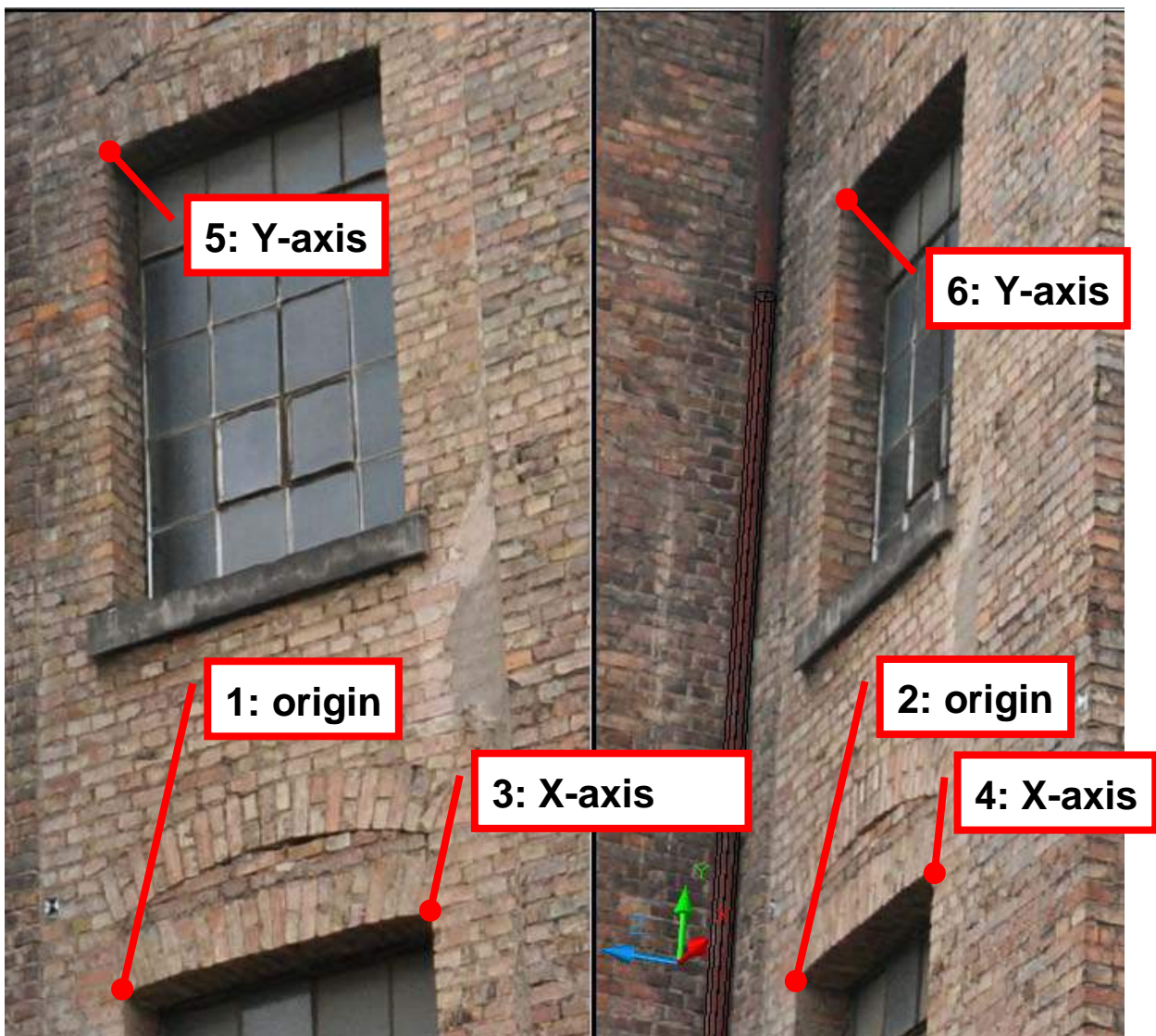
Command: IM_SETUCS

Point for origin:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

(click image point)

>>> Specify point on another oriented image or [Cancel/Back] <Cancel>:

(click image point)

Point on positive X axis:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

(click image point)

>>> Specify point on another oriented image or [Cancel/Back] <Cancel>:

(click image point)

Point with positive Y co-ordinate in XY plane of UCS:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

(click image point)

>>> Specify point on another oriented image or [Cancel/Back] <Cancel>:

(click image point)

Further point:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>: *Cancel*

ELEVATION was set to 0.

For the definition of the new UCS you simply have to state three points in the image which lie on the new drawing plane (façade). You do it in two oriented images. Thus you have to click six times. To improve the accuracy you may of course state more points. The drawing plane is then computed as average plane.

The meaning of the values for the angle and the distance is explained in more detail on page 7-101 of this command reference.

You find an introduction to the creation of 2D plans of structured façade using oriented images in chapter 5.5 of this manual.

Note: When running this command the system variables UCSVP and UCSFOLLOW are set to 0 in all viewports of the current drawing.

Image Modeling – Set drawing elevation to XY plane UCS

	Command name:	Menu:
	IMSETELEVATION	As-Built Photo

Like already described for the command **Image Modeling – Define UCS with minimum 3 points** it sometimes is helpful to draw directly on the XY plane of the UCS during multiple image evaluation.

There is another trick to speed up drawing. If there are for instance parts of a façade which are parallel to the main façade (like windows, doors, ledges) you do not have to define a new UCS for digitizing those parts. You simply set the drawing ELEVATION to a value which corresponds with the distance to the main façade.

As-Built provides the command IMSETELEVATION which makes it easy to set the elevation during the multiple image evaluation. The sequence which is prompted in the command line is shown here with an example.
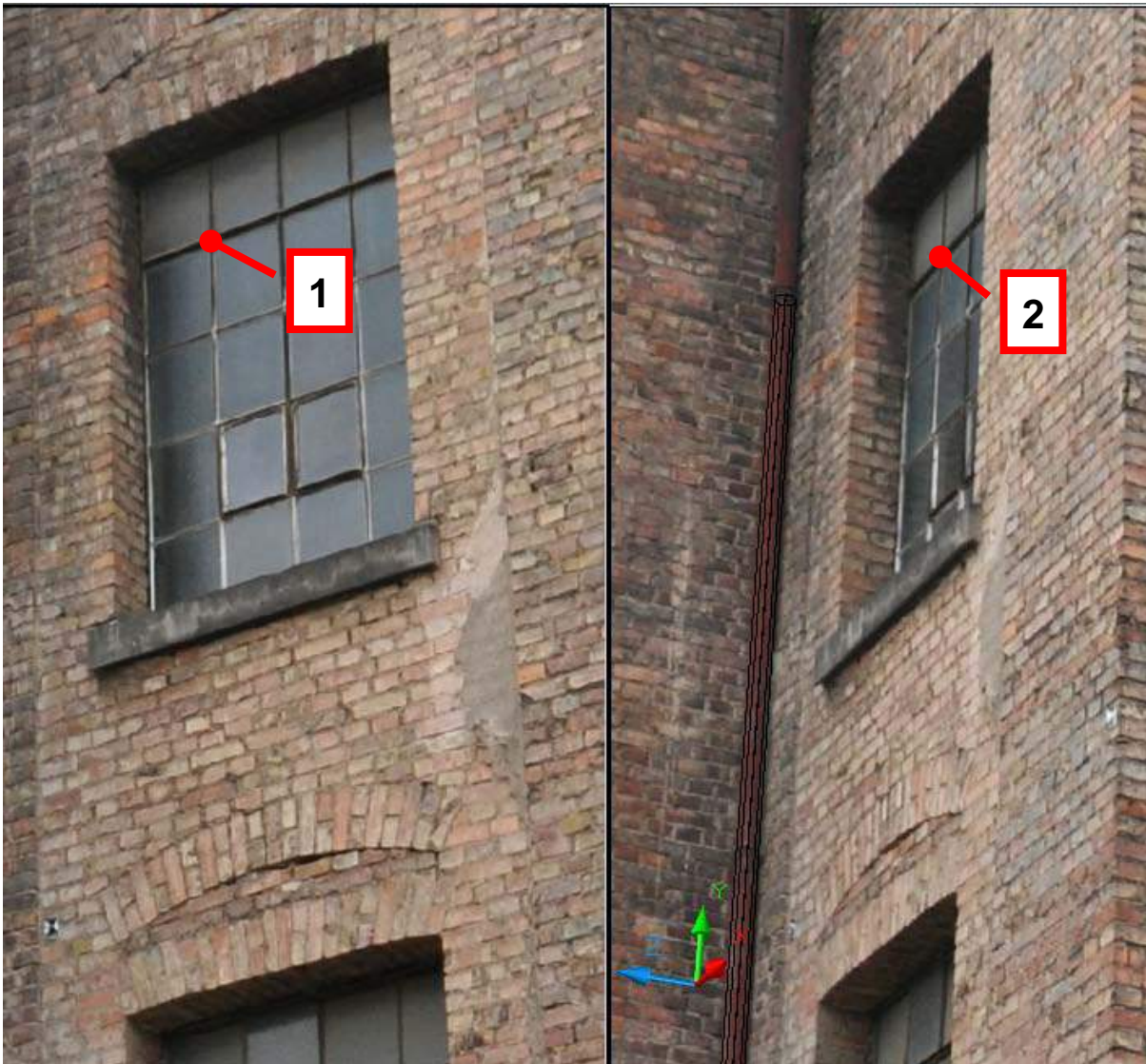
Command: 'IMSETELEVATION

Point for ELEVATION (Z co-ordinate in UCS):

>>> Specify point on oriented image or Elevation [Cancel/Reset] <Cancel>:

(click image point)

>>> Specify point on another oriented image or [Cancel] <Cancel>:

(click image point)

ELEVATION was set to -0.2625.

You merely click one and the same point in the new drawing plane in both oriented images.

The meaning of the values for the angle and the distance is explained in more detail on page 7-101 of this command reference.

You find an introduction to the creation of 2D plans of structured façade using oriented images in chapter 5.5 of this manual.

Note: When running this command the system variables UCSVP and UCSFOLLOW are set to 0 in all viewports of the current drawing.

Image Modeling – 3D dimension

	Command name:	Menu:
	IMDRAW3DDIMENSION	As-Built Photo

With this command you can determine and dimension the spatial distance between two points. The 3D dimension will always be aligned with the current view and thus will be readable.

First point for dimension:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back] <Cancel>:

Second point for dimension:

>>> Specify point on oriented image or [Cancel/Back/Point snap] <Cancel>:

>>> Specify point on another oriented image or [Cancel/Back] <Cancel>:

The 3D dimension is meant for quick determination of distances and the presentation of spatial situations.

It is always displayed in the current text style and with the current As-Built dimension size. The latter depends on the settings for the drawing unit and the block size factor under →**Settings** section "System".

The 3D dimension is by default put on the layer "3DDIMENSIONS". But you may change the layer under →**Settings** section "Layer ".

Hint: You may print the 3D dimension infront of the oriented image in camera navigation mode using the AutoCAD command. Doing so it is important that you enable the suitable viewport and that you ensure the visual style of the viewport is no wireframe.

Image computations – Merging of images…

	Command name:	Menu:
	KUBT_PC_MONTAGE	As-Built Photo

This command serves for melting more than one separate image to one complete image. It is used for combining more than one single rectification to one image plan. The projection plane is always the XY plane of the current UCS.
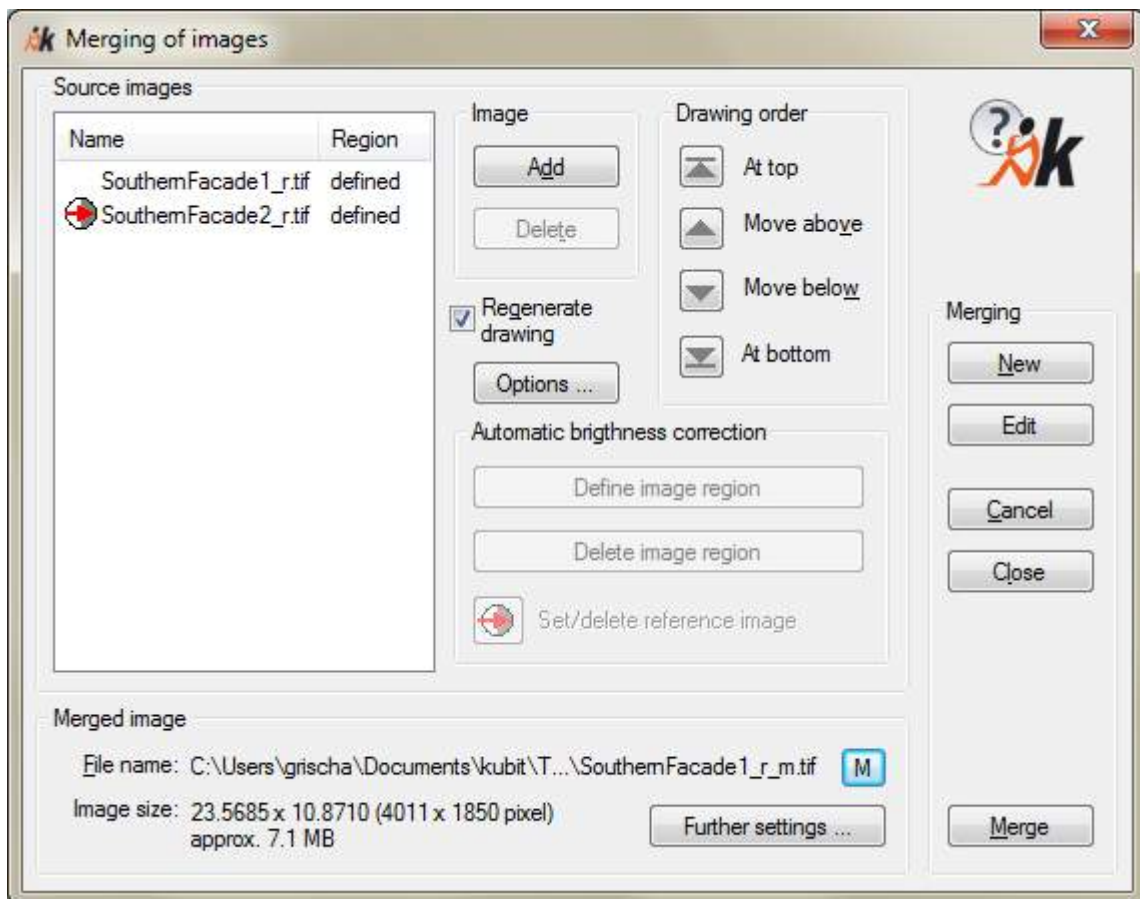
Heading "Merging"

- With [**New**] you define a new merging. A previously existing image selection is discarded.

- With [**Edit**] you can call up the montage settings of a previously merged image. After a security check you can also switch to the UCS of the selected image montage.

- With [**Cancel**] you leave the dialogue. All alterations are discarded. With [**Close**] they are stored.

- With [**Merge**] you will start the assembling process. This button is only activated if all requirements for image merging are fulfilled: at least one image has to be selected in order to merge and all statements concerning the assembled image have to be complete.

Images to be merged

Here all images to be merged are entered. With [**Add**] or [**Delete**]**,** respectively, you may set up the list. The following call appears in the command line when you click on [**Add**]:

>   Choose source image or <Cancel>:   *(click on image's periphery)*

In the drawing the software will draw a rectangular frame around all selected images. It will represent the size of the merged image.

Order of display

The images to be merged will be displayed in the drawing as they are listed in the image list of the montage dialogue. The image on top in the list will also be the image on top in the drawing. If you mark (select) an image in the list, it will also be highlighted in the drawing.

You can change the order of display by selecting an image from the list and "to top", "to bottom" etc. With overlapping image areas only the upper image will become visible.

Options

Under Options you can enable a number of further functions for merging images.

- If you click the check box '**Create separate images**' for each image to be merged an extra image with the image size of the complete merging is generated. You may overlay these separate images as a layer in an external image processing program and design the cutting edges and transitions by hand (see chapter 4.11). The image name of a separate image will be:
  'ImageNameMergedImage_Image NameSourceImage'.

- '**Remove source images from drawing**' removes these images from the AutoCAD-drawing but does not delete them from your hard disk.

- '**Hide merged image(s)**' removes this/these image(s) immediately after the assembling from your AutoCAD-drawing but does not delete it/them from your hard disk.

- **'Fade over images'** merges images through partial overlapping. In contrast to picture a) a softer merging, which can compensate global differences in brightness (b), is achieved. Satisfactory results can only be achieved as long as

the image content of the overlapping areas coincide. Otherwise the result will appear blurry or double exposed. You should only decide for this option when it is impossible to adjust overlapping areas through brightness adjustments of the individual pictures. For brightness and contrast adjustments of an entire image, you can use the AutoCAD function '**Adjust image'**. Picture c) shows the result without 'Fade over' option. This result was achieved with '**Adjust image'**. However, this process demands a great deal of computer performance. Thus the merging process requires more time than without 'Fade over'.

a)   b)   c)

- **Automatic brightness correction** adjusts the mean brightness and colour level of all images to be merged. In the main dialogue there will be a separate area for the definition of the image regions that are needed for the adjustment.

With this button you can access the image, where you will be asked to define an image region with a polygon.

With this button you can delete a previously defined image region.

With this option you may select one of the images as reference. The image region of this image is decisive for the brightness of the whole resulting merged image. If you do not set a reference image an average value for the brightness is calculated.

A new column that shows whether an image has already been selected will appear in the list of the images to be merged.

Different brightness and colour levels of images of one and the same object are very common in praxis. Only changing the angle of the lens relative to the projected surface leads to different brightness and colour levels. If there is also a different position of the sun or overcast skies, the brightness and colour levels are bound to deviate. The same is true when using different devices.

The automatic correction function can only be used for the same or very similar objects. These can be images of e.g. facade plaster-surfaces, brick work or road surfaces - all objects with a relatively homogeneous surface (texture). However, trying to adjust brightness and colour levels of a meadow with flowers and a piece of brick work seems less sensible.

As images to be merged usually contain not only areas of the surfaces that are to be merged (e.g. brick work) but often also pieces of a meadow, the sky or a

window opening, you have to indicate which regions should be considered when the program runs the automatic brightness and colour correction. You have to define a piece of reference structure (e.g. brick work) on every individual image. If you do not define such an image region, the whole image will be used as reference region.

You can, of course, also try to adapt the brightness manually. Either you use an external image processing program or the As-Built function "Adapt image". However, with very large sets of images or a high degree of exactness, this process may become time consuming and tiresome. Therefore, we have developed the automatic brightness correction.
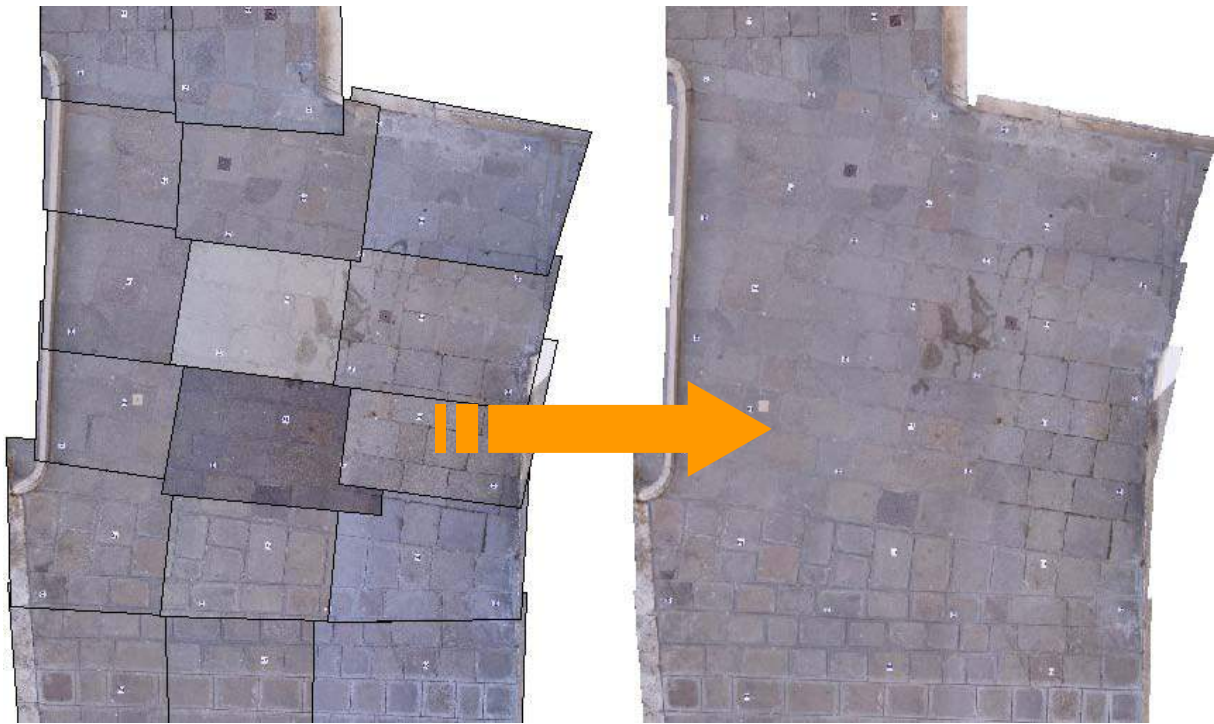
Example with individual images, all of which show almost the same surface structure (cobblestones) – without defined reference regions: (Source: GS Rilievi, Project Pavimenti, Italy)

Two rectified images that have different levels of brightness due to different conditions when taken.

Montage **with** automatic brightness correction but **without** defined image regions.
Due to the different character of the objects, the brightness correction fails.

Montage **with** automatic brightness correction and with defined image regions (marked red in the left image). The brightness correction works almost perfectly for the cobblestones.

Example with images that show different surface structures (street surface, curbs, doors, people etc.) without defined image regions (Source: GS Rilievi, Project Pavimenti, Italy)

Merged image

- **File names**

  Before you can start the rectification process, you have to enter a file name for the rectified image. Use the buttons [...] or [M] to enter name and path manually. BMP, TIFF, JPEG and PNG are at your disposal as are file formats for the rectified image. With the button [A] you enable the automatic naming. You may determine where the merged images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

- **Extended settings**

  With the button "**Further settings...**" you can adjust the properties of the rectified image. You will be shown the optimal values for the **number of pixels**, **image size** and **pixel size/resolution**. Optimal means that the image to be created contains exactly so many pixels that a maximum of image information is available without wasting memory at the same time. If necessary, you can also adapt values to your individual needs. For further details on this dialog please refer to

Image size

Here you see the information on an image in a compressed way:
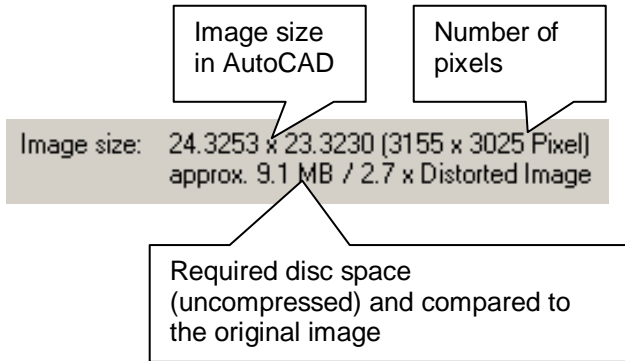
In addition to each assembled image a file 'FileNameAssembledImage_FileExtension.ppb', in which the image position information is stored, is stored in the same directory. If you have deleted the merged image from your drawing by mistake you may restore it with 'Load Image'.

For the peripheral sections that come into being during the image merging the same rules as for the rectification are valid: They will be filled with the currently set background color of the AutoCAD drawing area.

An Example:

The merging of two images X.jpg and Y.png to Merged.tif with the option 'Create Separate Images' leads to the following files in your target directory:

Merged_X.tif

Merged_X_tif.ppb   (image information file)

Merged_Y.tif

Merged_Y_tif.ppb   (image information file)

If you process Merged _X.tif and Merged _Y.tif in an external image processing program (e.g. Photoshop) and generate an image Processed.tif from them with the same size you may position it exactly again in AutoCAD. In order to do so you will have to rename the image information file Merged_X_tif.ppb or Merged_Y_tif.ppb into Processed_tif.ppb.

The image that is created during the merging is always laid into the XY-plane of the current UCS. The selected images that do not lie in this plane are projected perpendicular on it and thus probably displayed shortened. The merged image looks thus exactly like the top view of the current UCS.

Note: If you merge images that stand at a very wide angle to the UCS and they will appear strongly shortened, the number of pixels suggested automatically and thus the required disc space will increase immensely. In this case reduce the number of pixels manually.

Hint: Once you have clipped parts of an image you might use this command to calculate a new image out of this. The hidden parts of the image are then deleted. The parts without photo information are filled with the background colour currently set

in AutoCAD. In order to do so accomplish an image merging with only one image. . Please do NOT activate the merging option "Create separate images".

Note: The merged image will automatically be placed on the layer which you have defined with the command →**Settings** under Layer "LayerMergedImages". If no layer is stated (default) the image will be placed on the current layer.

Hint: You may also use the →**Image computations – Merging of images…** command for merging scanned maps and plans. If you have bitonal images (one color and white or transparent background) of plans of different content for the same object – e.g. layout plans from different times or at different conditions – you may superpose these plans by merging them. Please also refer to the information given in chapter **2 Supported Image Formats**

Image computations – Edit prismatic surface

	Command name:	Menu:
	PCEDITUNWRAPSURFACE	As-Built Photo

Using this command you may define the extend of a prismatic surface in extrusion direction.

> Command: KUBT_PP_EDITUNWRAPSURFACE
>
> Select prismatic surface (2D polyline, line, circle, circle arc):
>
> Lower boundary of surface:
>
> Point in drawing or [in oriented Image] <in oriented Image>:
>
> Upper boundary of surface:
>
> Point in drawing or [in oriented Image] <in oriented Image>:

The selected prismatic surface does not have to have a "thickness". Optionally you may also click points in oriented images:
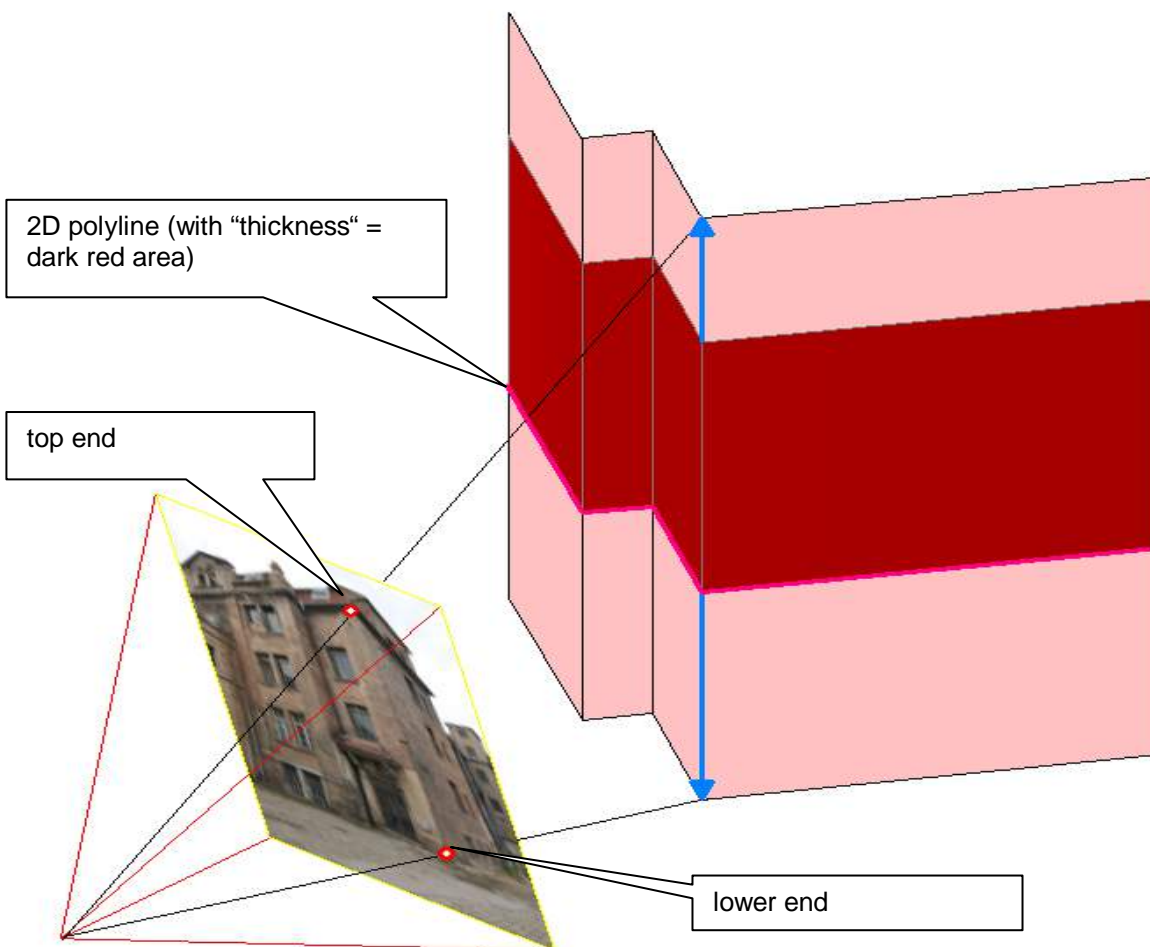
For more detail on the application of this command please refer to chapter **6.2 Unwrap prismatic surfaces** of this manual.

Image computations – Unwrap cylinder

	Command:	Menu:
	PCCU	As-Built Photo

This command is for the unwinding of photos of cylindrical surfaces into the plane, mainly for the generation of 2D image plans. Additionally already existing CAD graphic, lying on the cylinder, can be unwound.

Please refer to chapter 6 of this manual for the requirements and inputs for this command.

When you start the command for unwrapping cylinders the following dialogue opens:
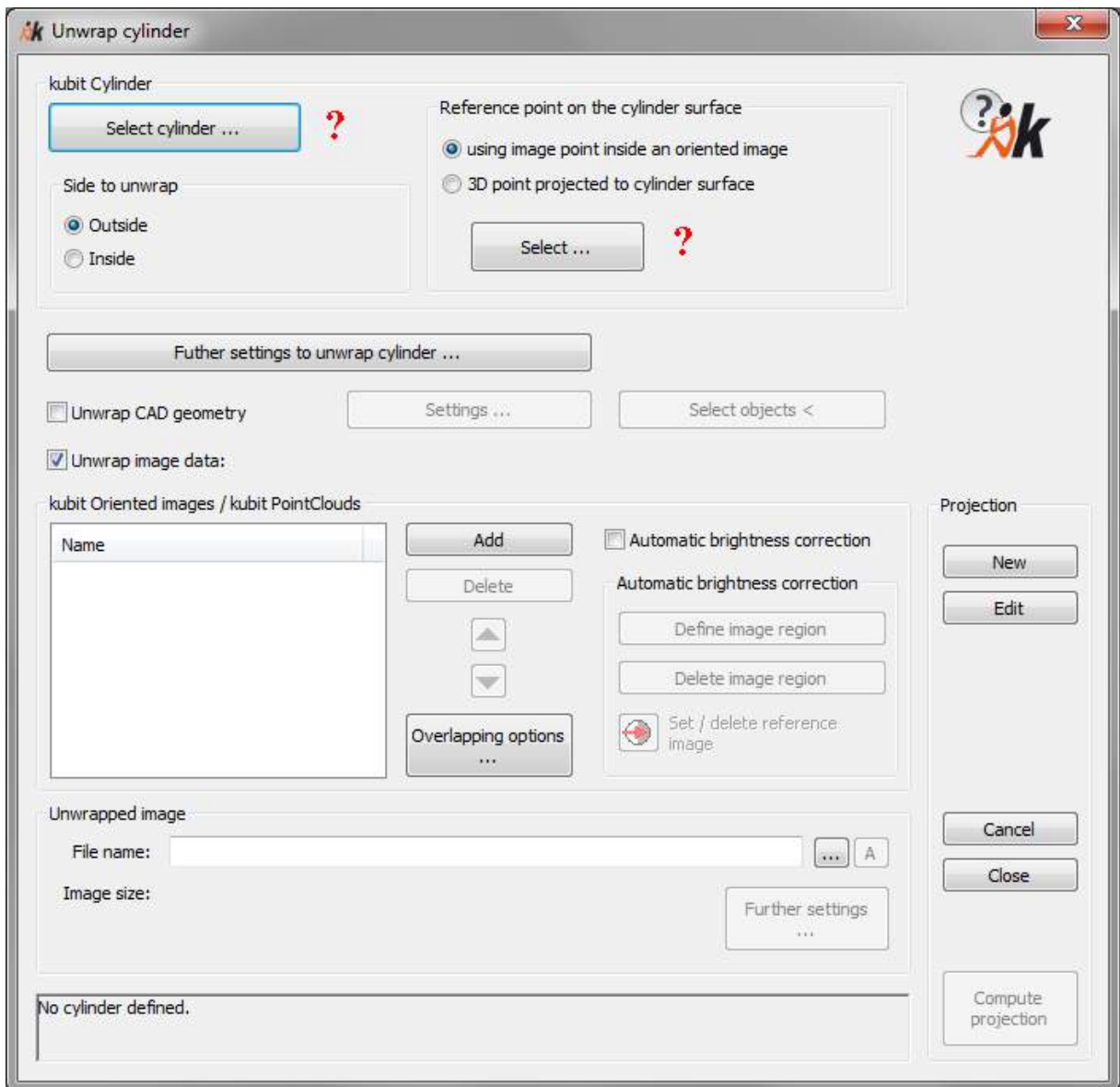
Heading "Projection"

Here you can state what to do next.

- With [**New**] you start a new unwinding of cylinders. A possibly existing image selection and other inputs will be dropped.

- With [**Edit**] you can recall an existing unwinding of cylinders and you can then change and/or process it again. The following prompt appears in the command line:

  Select unwrapped image or <Cancel>:   *(Click image on frame.)*

  The previous settings are displayed. An image unwinding can only be edited, when the respective unwound image and the underlying oriented image still exist in the drawing.

- You exit the dialogue with [**Cancel**]. All changes are dropped. If you exit using the [**Close**] button the changes will be saved.

- With [**Unwrap**] you start the calculation of the unwound image and/or the unwound CAD geometry. The button is only active, if all conditions for an unwinding are complied with: A kubit cylinder has to be selected and the reference point has to be stated.

Heading "kubit Cylinder"

Select a kubit cylinder from your drawing. It represents the cylindrical lateral surface to be unwound. You may also generate a kubit cylinder by using for example the →**As-Built Modeler – Modeling – Cylinder** command.

Side to unwrap:

Here you state, which side of the cylinder barrel has been photographed.
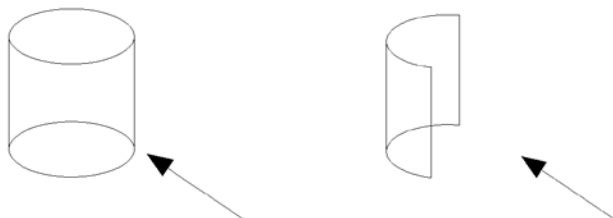
outside   **inside**

Reference point on the cylinder surface:

The reference point states that point on the cylinder barrel, at which the unwound image will be positioned. Opposite of the reference point the lateral surface of the cylinder will be split open and unwound into the image plane.
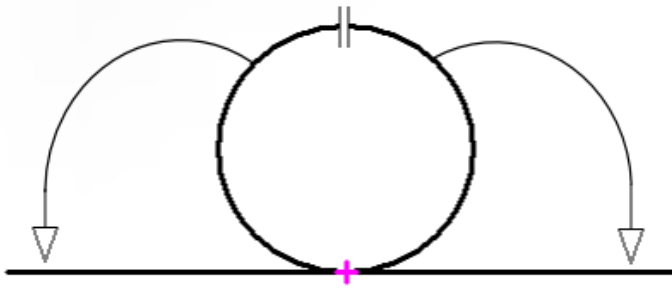
The reference point can be defined in two different ways:
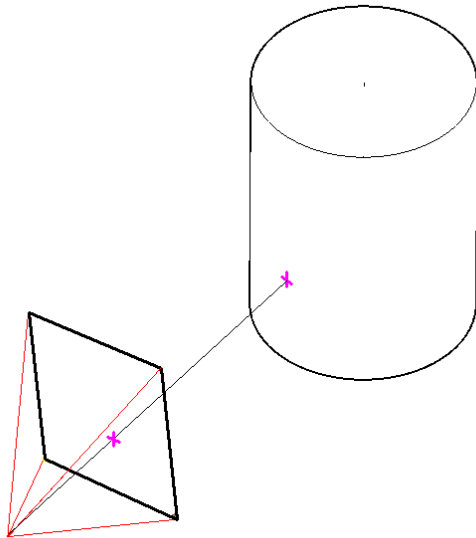
Using image point inside an oriented image. This is the easiest and most natural way. With AutoCAD orbit you turn the drawing, so you are looking at an oriented image, which pictures the cylinder. Now, within the image, you simply click on the point of the displayed cylinder that is to serve as reference point. You do not have to run the camera navigation mode.
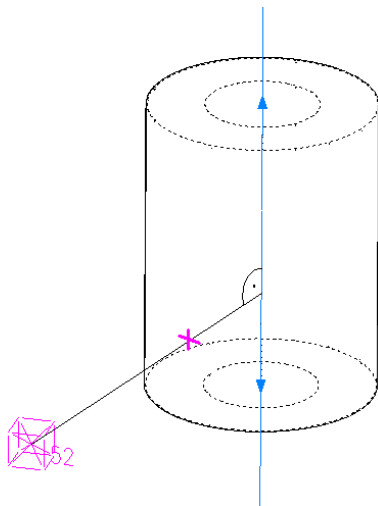
3D point projected to cylinder surface. In order to do so you snap a point or select a control point alternatively. That point will now orthogonally be projected onto the cylinder axis. The piercing point on the lateral surface of the cylinder is the reference point.

[Further settings to unwrap cylinder]

Following window opens when you click that button. Here you can determine the position and alignment as well as the width of the unwrapped result.
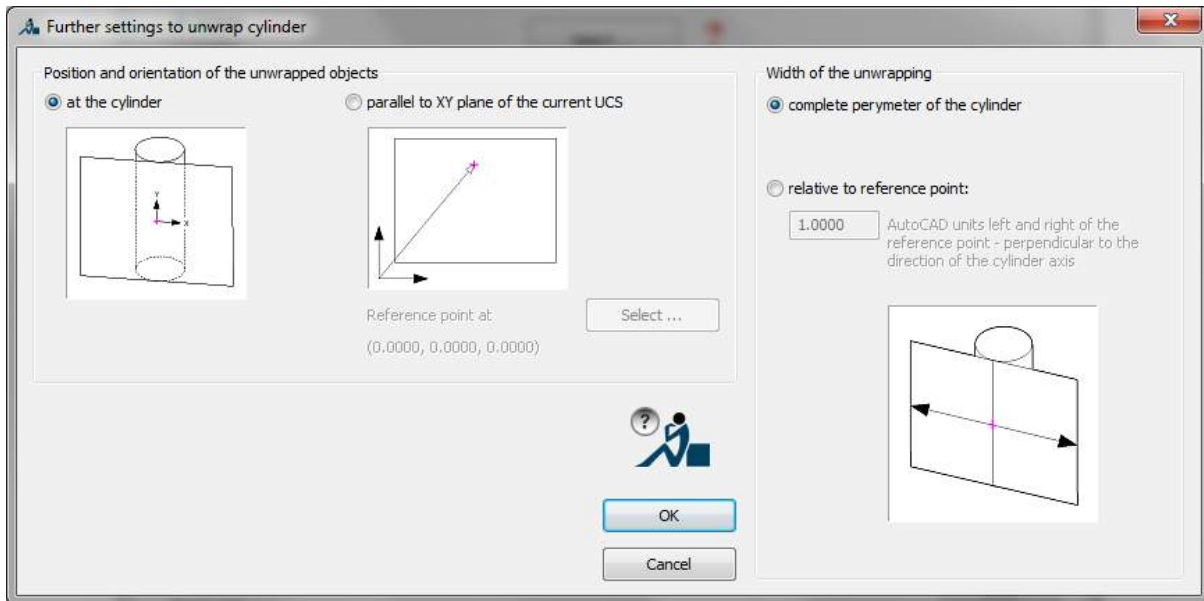
The unwrapped result can be aligned and positioned *at the cylinder*. A new UCS will be set, the origin of which will be in the previously defined reference point. The Y-axis runs parallel to the cylinder axis through this point on the barrel, the X-axis perpendicular to it, as shown in the sketch. With this, the image plane has been defined.

Alternatively the unwinding result can be generated within the drawing *parallel to the XY plane of the current UCS*. The unwound image (and where applicable also unwound CAD geometry) will be shifted, so that the previously defined reference point will be at the position within the current UCS, that has been selected here.

Furthermore, the *width of the unwrapping* is determined within this window. By default always the complete cylinder circumference will be unwound. But since this is not necessary or wanted for many applications, it is possible to set the unwinding width manually. The basis for this information is the reference point on the cylinder barrel.

"Unwrap CAD geometry"

When you enable this option, you can hit the [Select objects] button and select CAD geometry to be unwound like AutoCAD points and lines or curve-like objects. These are scanned, according to the scan width defined under [Settings…], projected to the cylinder barrel and then exactly unwound into the image plane.
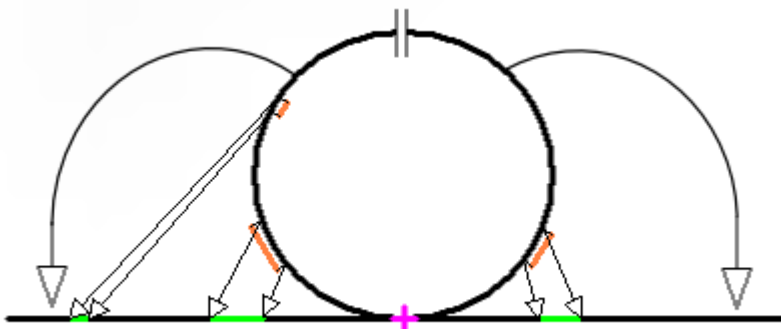
Click on [Settings...] in order to set the scan width for curve-like objects and in order to state, if the initial geometry is to be deleted after the unwinding.
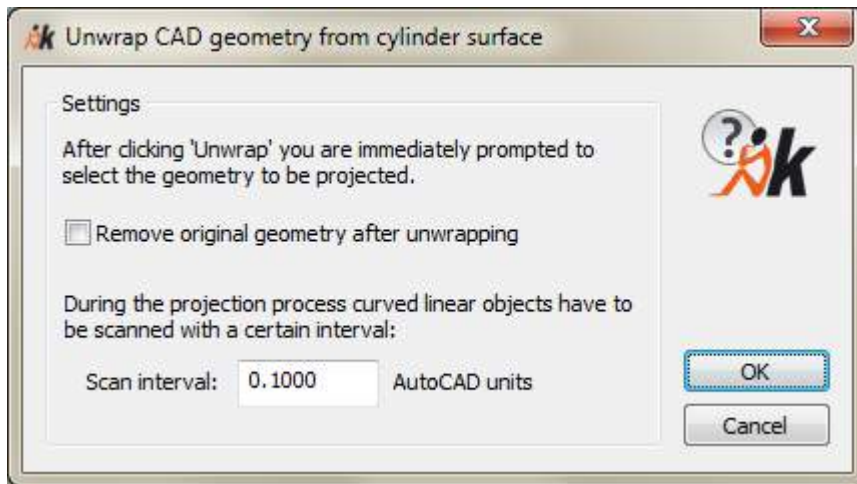
"Unwrap image data"

Enable this option, if you want to generate an unwound image (enabled by default). The unwound photo gets the image information from one or several oriented images, on which the cylindrical surface is shown.
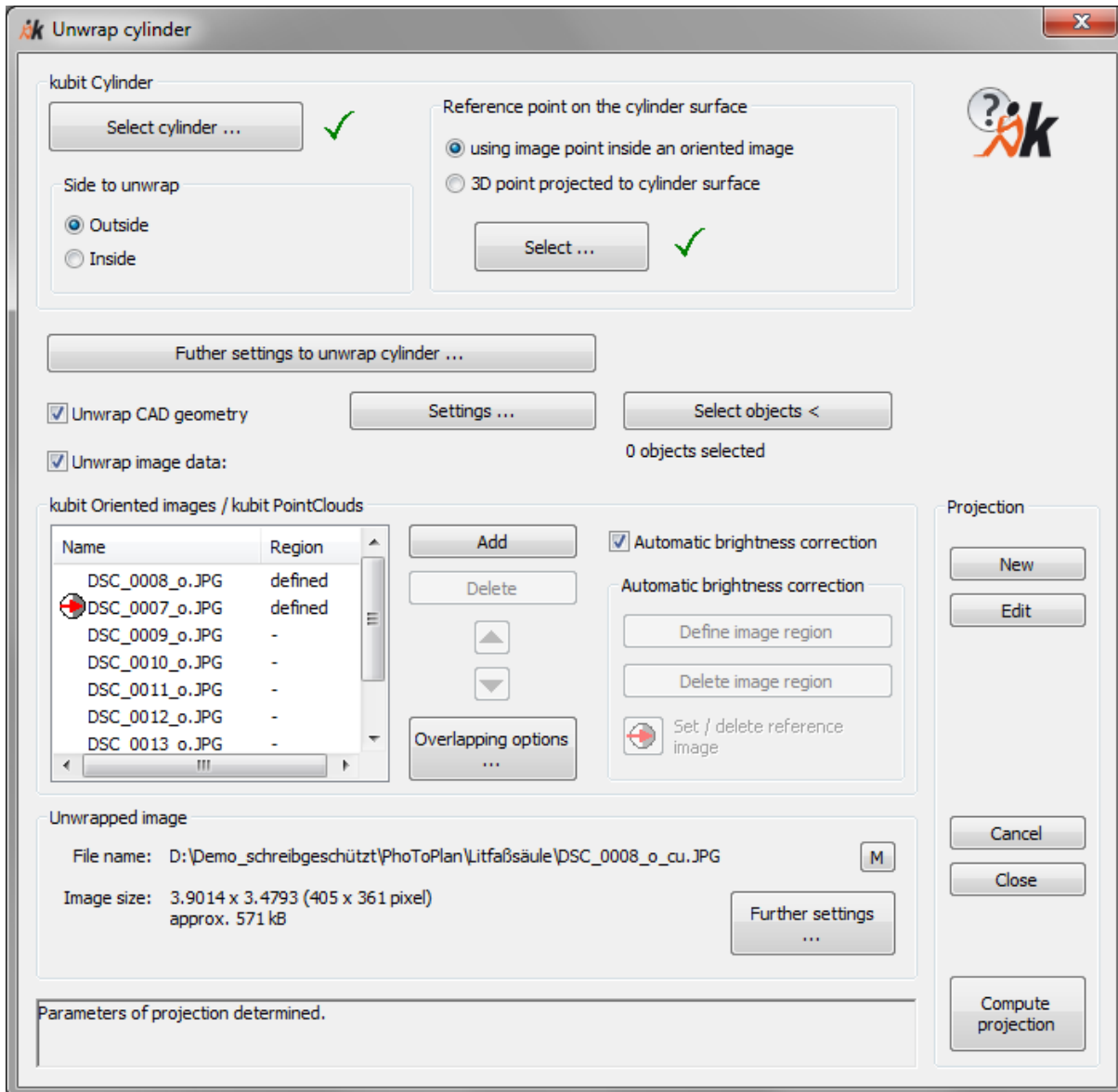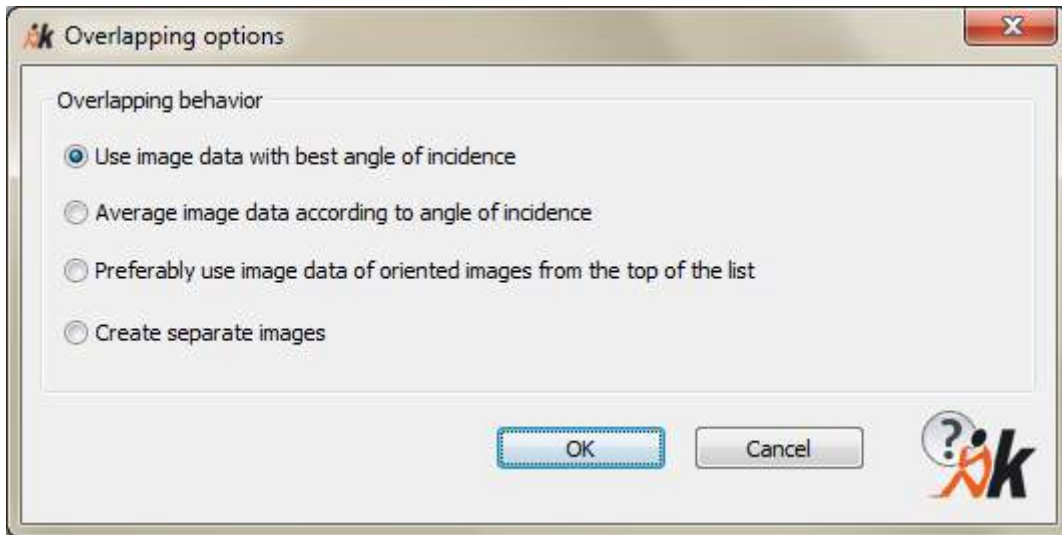

Heading "kubit Oriented Images"

This heading contains the list of the oriented images, which are to be used as source data for the developing unwound image. In addition to the buttons "Add" and "Delete" you can use the arrow keys to change the order of the entries.

Hint: Use the command "Clip image" to cut out unneeded or "bad" image parts from the oriented images before the unwinding. For cylindrical surfaces this is necessary in many cases, since very different illumination and reflexes are more likely to occur, than for a plane.

The currently set background colour of the AutoCAD drawing area is used for those area of the unwound image, which have no colour information from an oriented image.

Overlapping options:

A point on the cylinder barrel can be shown in several oriented images. With the help of the overlapping options you determine, how to handle the different image data.

Let's take a closer look at the meaning of the single overlapping options.

O_1 and O_2 are two oriented images in the above picture. η is the surface normal, which builds the angles ω_1 and ω_2 with the two view rays of the oriented images.

Option "Use image data with best angle of incidence ":

The image data with the smallest angle ω is used. For this as well as for the following options it is assumed, that the oriented images have a similar shooting distance and about the same resolution.

Option "Average image data according to angle of incidence ":

The image data is averaged according to their angle of incidence ω. A smaller angle gets a higher importance.

Option: "Preferably use image data of oriented images from the top of the list":

The image data of oriented images which are at the topmost position in the list, are used for the resulting image. That way you can determine, which images are to be preferred as source for the colour information.

Option "Create separate images":

One unwound output image is generated per oriented image. All output images lie at the same position and have the same size. They may now be put on top of each other as image planes and be merged manually using with an external image editing software (see chapter 4.11). The file names for the individual images are defined as follows:

{path and file name of the unwound image}_{file name of the oriented image}.{file extension of the unwound image}

Automatic brightness correction

Activate this option, when colour and brightness of the used oriented images are to be adapted to one another.

Please read the part "Automatic brightness correction" from the command "Image computations – Merging of images… " (page 7-119ff)

Heading "Unwrapped image"

- **File name**

  Before you can start the unwrap process, you have to enter a file name for the unwrapped image. Use the buttons [...] or [M] to enter name and path manually. BMP, TIFF, JPEG and PNG are at your disposal as file formats for the unwrapped image. With the button [A] you enable the automatic naming. You may determine where the unwrapped images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

- **Further settings**

  With the [**Further settings..**]" button you can adjust the properties of the unwound image. The optimal values for the **number of pixels**, **image size** and **pixel size/image resolution** will be displayed. Optimal means that the image to be created contains exactly as many pixels that a maximum of image information is available without wasting memory at the same time. If needed it is possible to adapt the values to your requirements. You can find further information regarding

the individual settings under Rectification by control points - Rectification of photos (Projective Transformation) (page 7-37).

- **Image size**

  Here the information regarding the unwrapped image is summarized:

  Image size in AutoCAD units (image size in pixels)

  Demand of memory space (uncompressed)

The status bar

The status bar is at the bottom of the window. It displays information about the current calculation status of the unwinding and if applicable missing input.

Hints:

The unwound image will automatically be placed on the layer, which you have defined with the command "Settings..." under Layer "UnwrappedImages". If no layer is stated (default) the image will be placed on the current layer.

The unwrapped geometry will by default be placed on the same layer as the source geometry. With the →**Settings** command under Layer →"Layer suffix for unwrapped geometry" you may state a layer name extension. The software will then create a copy of the source layer to put the unwrapped geometry on. The name of the new layer is the name of the source layer plus the suffix.

Additionally to every unwound image a file "FilenameUnwrappedImage-_FileExtension.PRK will be generated in the same directory. This protocol file in ASCII format contains all important information for every unwinding of a cylinder like information regarding the used cylinder, the names and paths of the used oriented images, set options as well as name, size, resolution and measurements of the unwound image.

The computation of the unwrapped image may take a few minutes. The time depends on:

- the number of used oriented images,
- the clipping of these images,
- the size of the unwrapped image,
- the processor power of your computer.

Image computations – Unwrap surface

	Command:	Menu:
	PCPU	As-Built Photo

This command is for the unwinding of photos of prismatic surfaces into the plane, mainly for the generation of 2D image plans. Additionally already existing CAD graphic, lying on the surface, can be unwound.

What are „prismatic surfaces"?
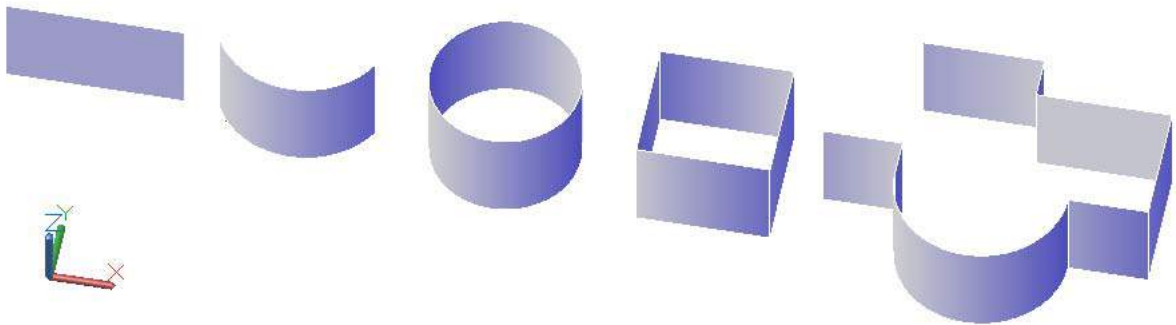
Prismatic surfaces have a baseline (AutoCAD elements: line, arc, circle, rectangle, 2D polyline) with a thickness (object height). These 2D elements are usually drawn on or parallel to the XY plane of the current UCS. This way the XY plane is the datum plane of our object while the Z axis is the extrusion direction. The extents of such a surface in Z direction are defined by the thickness property.
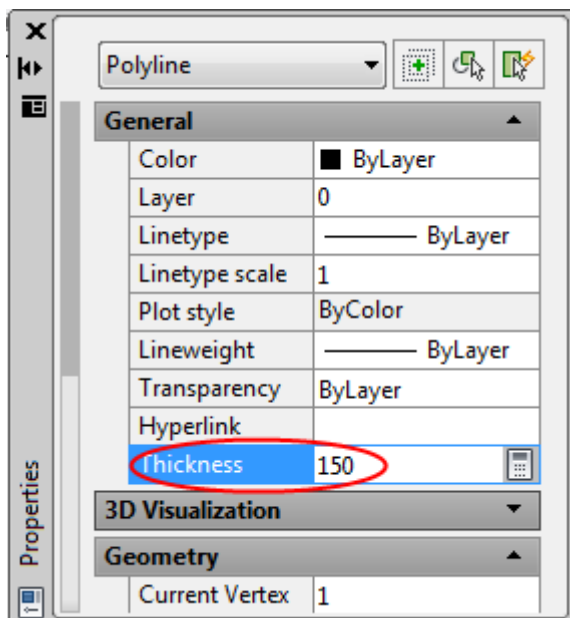
The 2D polyline is the most universal object. It may contain a combination of straight und curved segments or may also be completely fitted as curve or spline. With a 2D polyline almost all prismatic surface shapes can be represented or at least approximated with sufficient accuracy.

The unwrap command refers to such "prismatic surfaces" as **Projection surface**.

Please refer to chapter 6.2 of this manual for the requirements and inputs for this command.

When you start the command for unwrapping prismatic surfaces the following dialogue opens:
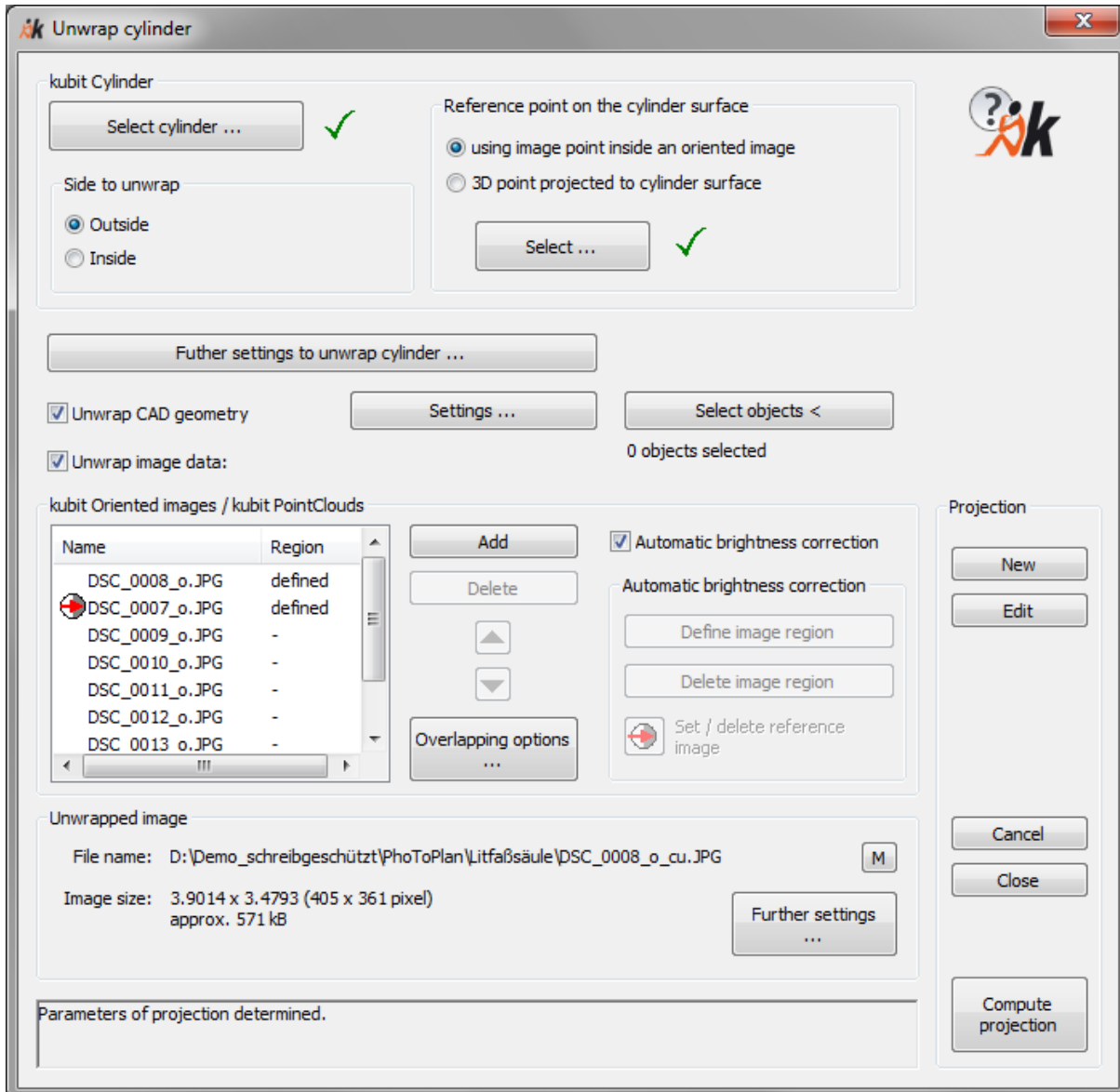
Heading "Unwrap surface"

Here you can state what to do next.

- With [**New**] you start a new unwinding. A possibly existing image selection and other inputs will be dropped.

- With [**Edit**] you can recall an existing unwinding and you can then change and/or process it again. The following prompt appears in the command line:

    Select unwrapped image or <Cancel>:   *(Click image on frame.)*

    The previous settings are displayed. An image unwinding can only be edited, when the respective unwound image and the underlying oriented image still exist in the drawing.

- You exit the dialogue with [**Cancel**]. All changes are dropped. If you exit using the [**Close**] button the changes will be saved.

- With [**Compute projection**] you start the calculation of the unwound image and/or the unwound CAD geometry. The button is only active, if all conditions for an unwinding are complied with: A prismatic projection surface has to be selected and the reference point has to be stated.
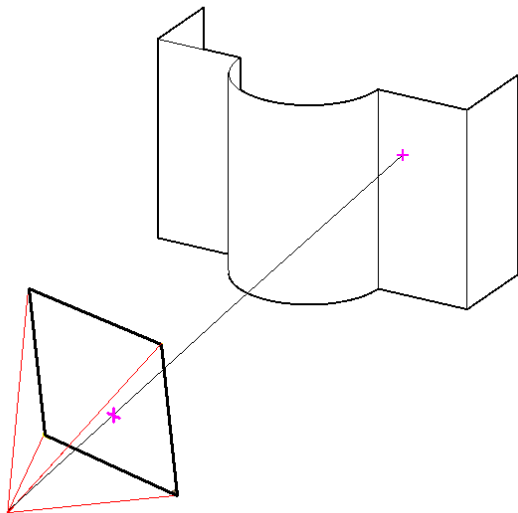

Heading "Projection surface"

Via the **[Select projection surface]** button you select one of the above described projection surfaces from your drawing.

Reference point on projection surface:

The reference point defines the point on the projection surface at which the unwrapped image will be tied.

The reference point can be defined in two different ways:

Using image point inside an oriented image. This is the easiest and most natural way. With AutoCAD orbit you turn the drawing, so you are looking at an oriented image, which pictures the projection surface. Now, within the image, you simply click on the point of the displayed projection surface that is to serve as reference point. You do not have to run the camera navigation mode.
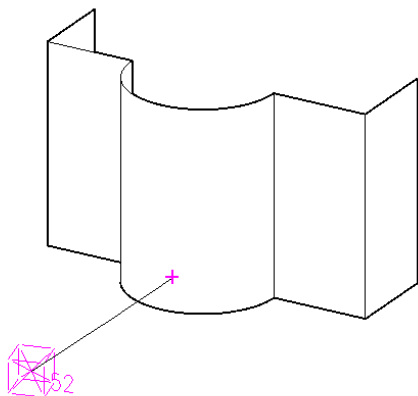
3D point projected to surface. In order to do so you snap a point or select a control point alternatively. The point on the surface with the shortest distance to this point is the reference point.

[Further settings to unwrap surface]

Following window opens when you click that button. Here you can determine the position and alignment of the unwrapped result.
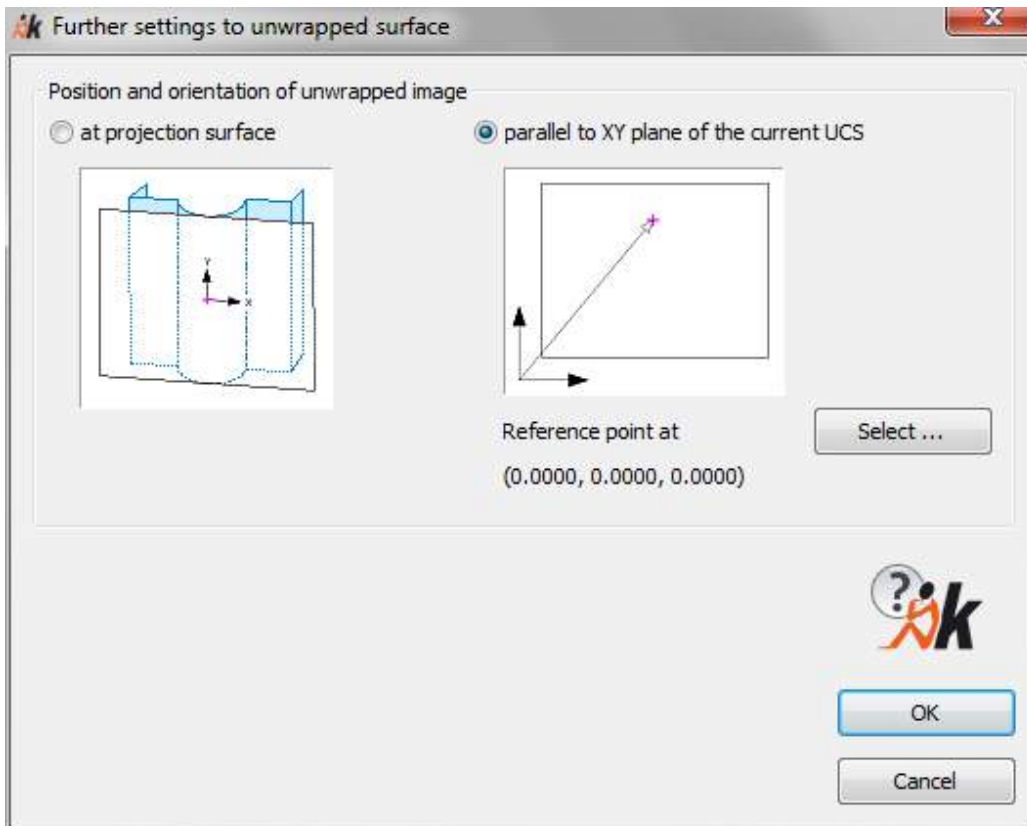

The unwrapped result can be aligned and positioned *at the projection surface.* A new UCS will be set, the origin of which will be in the previously defined reference point. The Y-axis runs parallel to the extrusion direction.

Alternatively the unwinding result can be generated within the drawing *parallel to the XY plane of the current UCS.* The unwound image (and where applicable also unwound CAD geometry) will be shifted, so that the previously defined reference point will be at the position within the current UCS, that has been selected here.

"Unwrap CAD geometry"

When you enable this option, you can hit the [Select objects] button and select CAD geometry to be unwound like AutoCAD points and lines or curve-like objects. These are scanned, according to the scan width defined under [Settings…], projected to the projection surface and then exactly unwound into the image plane.
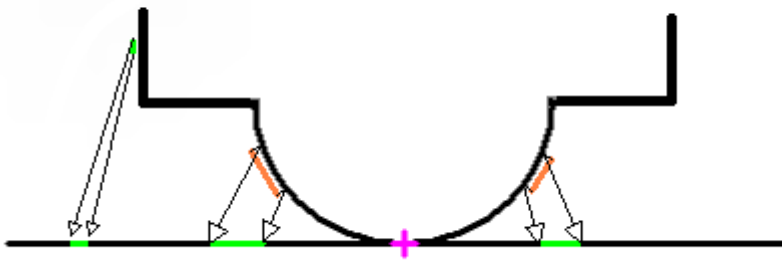
Click on [Settings...] in order to set the scan width for curve-like objects and in order to state, if the initial geometry is to be deleted after the unwinding.
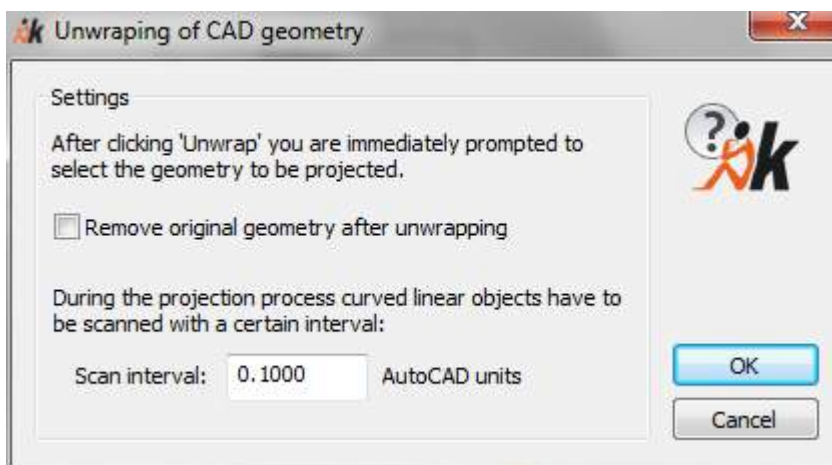
"Unwrap image data"

Enable this option, if you want to generate an unwound image (enabled by default). The unwound photo gets the image information from one or several oriented images, on which the prismatic surface is shown.
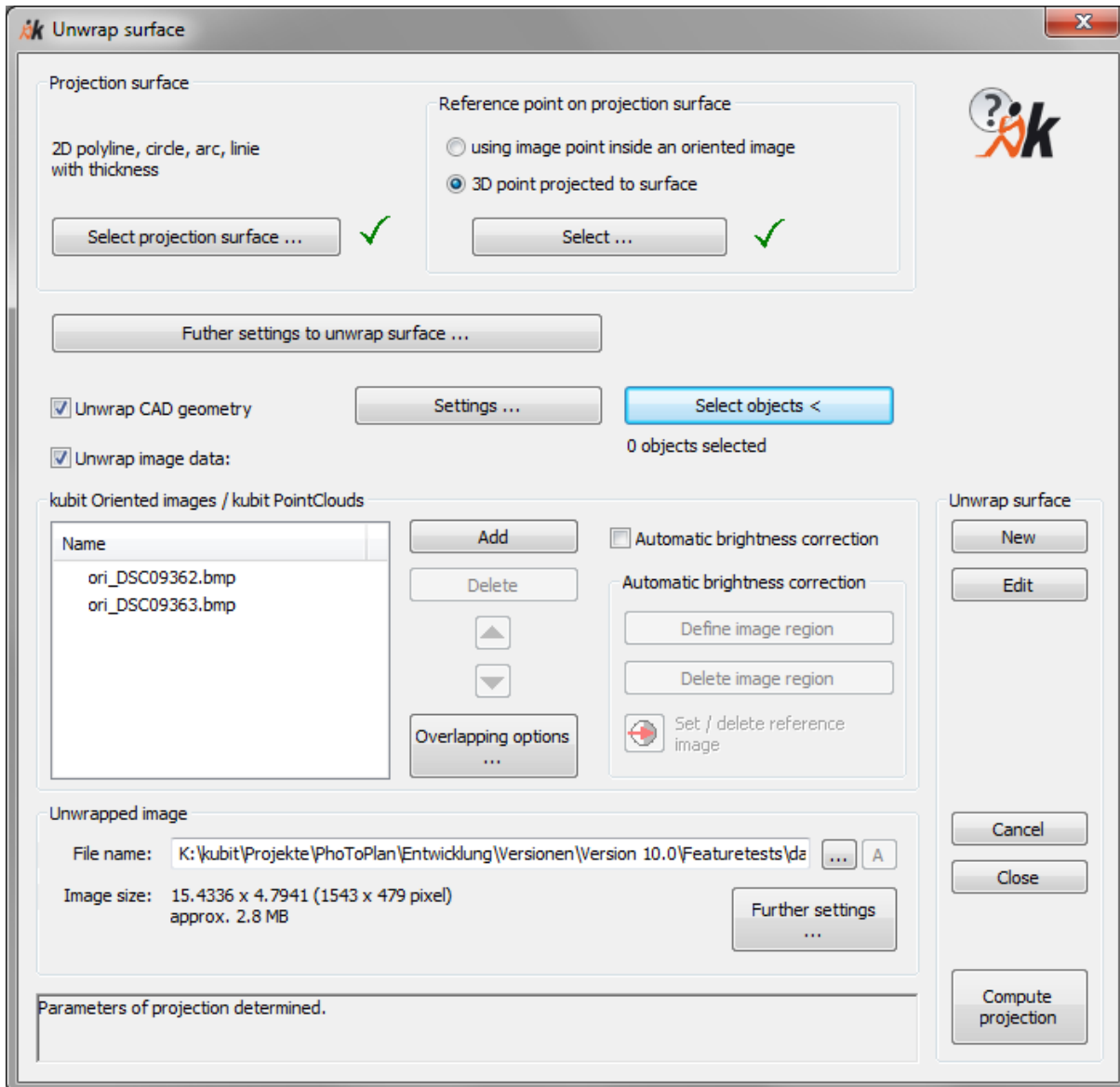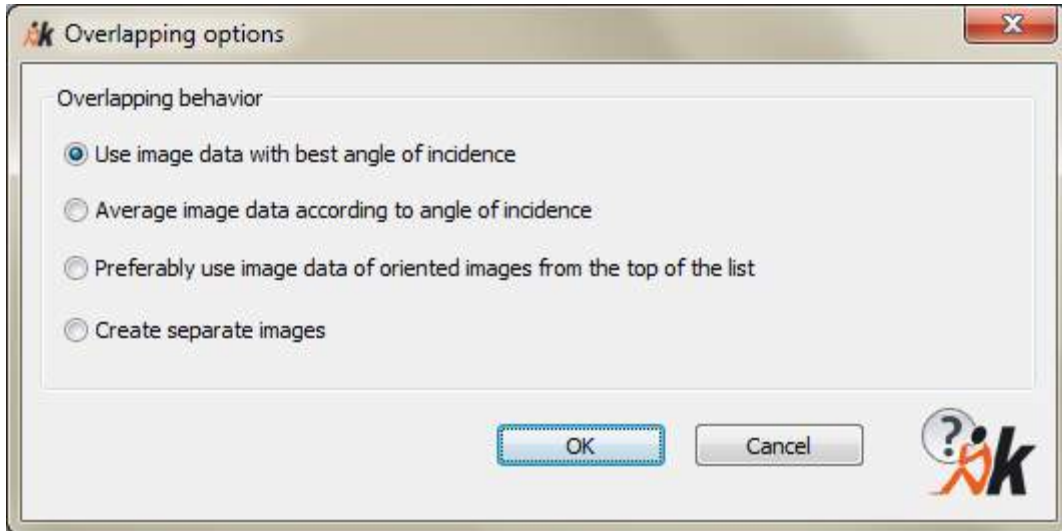
Heading "kubit Oriented images"

This heading contains the list of the oriented images, which are to be used as source data for the resulting unwound image. In addition to the buttons [Add] and [Delete] you can use the arrow keys to change the order of the entries.

Hint: Use the command "Clip image" to cut out unneeded or "bad" image parts from the oriented images before the unwinding. For prismatic surfaces this is necessary in many cases, since very different illumination and reflexes are more likely to occur, than for a plane.
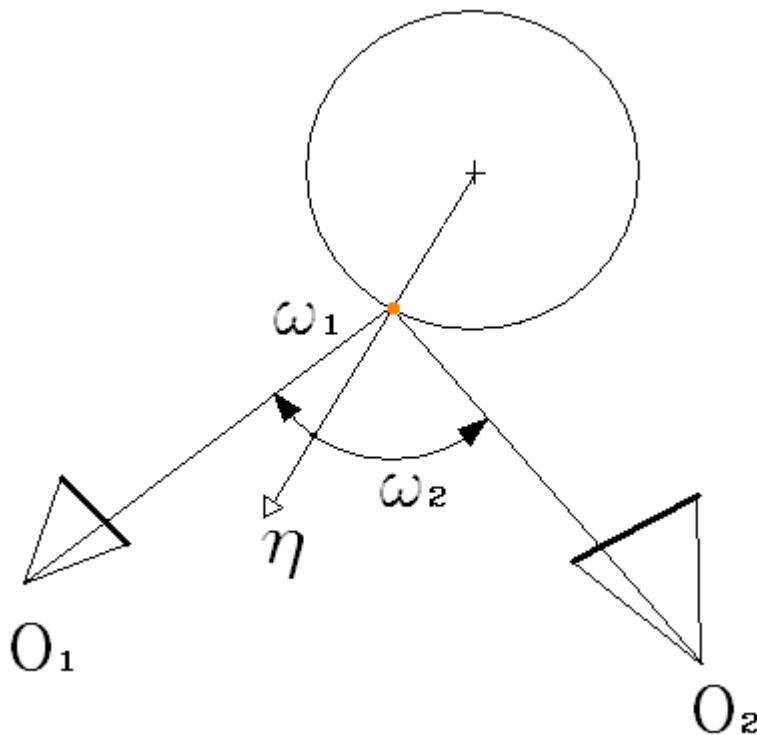
The currently set background colour of the AutoCAD drawing area is used for those area of the unwound image, which have no colour information from an oriented image.

Overlapping options:

A point on the projection surface can be shown in several oriented images. With the help of the overlapping options you determine, how to handle the different image data.

Let's take a closer look at the meaning of the single overlapping options.

O_1 and O_2 are two oriented images in the above picture. η is the surface normal, which builds the angles ω_1 and ω_2 with the two view rays of the oriented images.

Option "Use image data with best angle of incidence ":

The image data with the smallest angle ω is used. For this as well as for the following options it is assumed, that the oriented images have a similar shooting distance and about the same resolution.

Option "Average image data according to angle of incidence ":

The image data is averaged according to their angle of incidence ω. A smaller angle gets a higher importance.

Option: "Preferably use image data of oriented images from the top of the list":

The image data of oriented images which are at the topmost position in the list, are used for the resulting image. That way you can determine, which images are to be preferred as source for the colour information.

Option "Create separate images":

One unwound output image is generated per oriented image. All output images lie at the same position and have the same size. They may now be put on top of each other as image planes and be merged manually using with an external image editing software (see chapter 4.11). The file names for the individual images are defined as follows:

{path and file name of the unwound image}_{file name of the oriented image}.{file extension of the unwound image}

Automatic brightness correction

Activate this option, when colour and brightness of the used oriented images are to be adapted to one another.

Please read the part "Automatic brightness correction" from the command "Image computations – Merging of images… " (page 7-119ff)

Heading "Unwrapped image"

- **File name**

  Before you can start the unwrap process, you have to enter a file name for the unwrapped image. Use the buttons [...] or [M] to enter name and path manually. BMP, TIFF, JPEG and PNG are at your disposal as file formats for the unwrapped image. With the button [A] you enable the automatic naming. You may determine where the unwrapped images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

- **Further settings**

  With the [**Further settings...**] button you can adjust the properties of the unwound image. The optimal values for the **number of pixels**, **image size** and **pixel size/image resolution** will be displayed. Optimal means that the image to be created contains exactly as many pixels that a maximum of image information is available without wasting memory at the same time. If needed it is possible to adapt the values to your requirements. You can find further information regarding

the individual settings under Rectification by control points - Rectification of photos (Projective Transformation) (page 7-37).

- **Image size**

  Here the information regarding the unwrapped image is summarized:

  Image size in AutoCAD units (image size in pixels)

  Demand of memory space (uncompressed)

The status bar

The status bar is at the bottom of the window. It displays information about the current calculation status of the unwinding and if applicable missing input.

Hints:

The unwound image will automatically be placed on the layer, which you have defined with the command "Settings..." under Layer "LayerUnwrappedImages". If no layer is stated (default) the image will be placed on the current layer.

The unwrapped geometry will by default be placed on the same layer as the source geometry. With the →**Settings** command under Layer →"Layer suffix for unwrapped geometry" you may state a layer name extension. The software will then create a copy of the source layer to put the unwrapped geometry on. The name of the new layer is the name of the source layer plus the suffix.

Additionally to every unwound image a file "FilenameUnwrappedImage-_FileExtension.PRK will be generated in the same directory. This protocol file in ASCII format contains all important information for every unwinding like information regarding the reference, the names and paths of the used oriented images, set options as well as name, size, resolution and dimensions of the unwound image.

The computation of the unwrapped image may take a few minutes. The time depends on:

- the number of used oriented images,
- the clipping of these images,
- the size of the unwrapped image,
- the processor power of your computer.

Image computations – Compute orthophoto

	Command:	Menu:
	PCOF	As-Built Photo

With this command you can compute orthophotos of any 3D scene, which are mainly used for documentation reasons and for the generation of 2D image plans.

Concerning the requirements and inputs for this command please refer to chapter 6 of this manual.

The following window opens, when you run the orthophoto command:
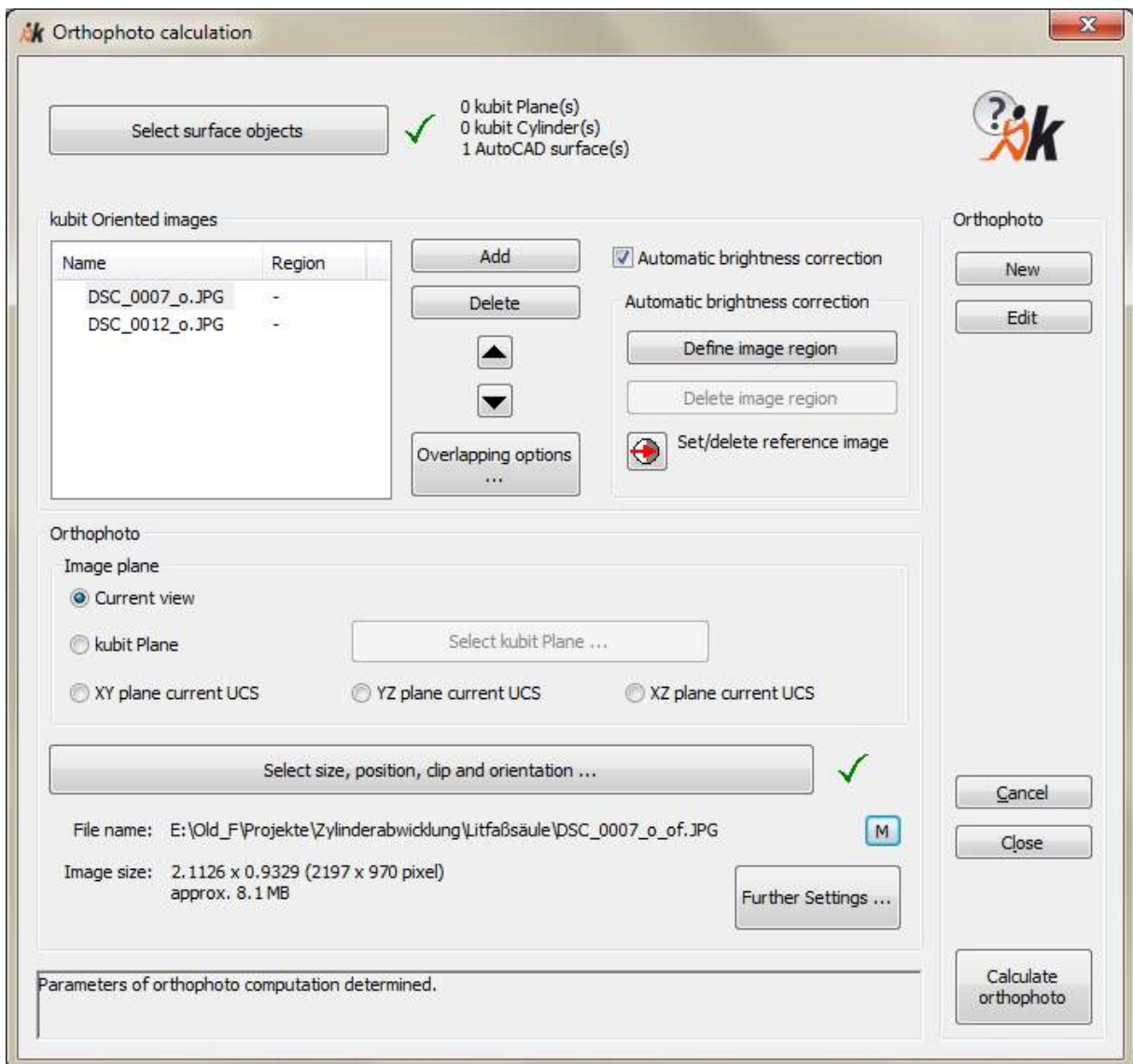
Heading "Orthophoto"

Here you can state what to do next.

- With [**New**] you start a new orthophoto calculation. A possibly existing image selection and other inputs are dropped.

- With [**Edit**] you can recall an existing orthophoto calculation and you can then change and/or process it again. The following is prompted in the command line:

  Select orthophoto or <Cancel>:   *(Click image at frame)*

  The previous settings will be displayed after selection of the image. An orthophoto calculation can only be processed, if the respective orthophoto and the underlying oriented images still exist in the drawing.

- You exit the window with [**Cancel**]. All changes are dropped. The changes are saved when you click the [**Close**] button.

- With [**Calculate orthophoto**] you start the calculation of the orthophoto. The button is only enabled, if all conditions for the calculation are complied with: At least one oriented image and one surface object have to be selected. Image size, position and alignment as well as the name of the orthophoto have to be stated.

Button "Select surface objects"

In your drawing select all surface objects belonging to the scene. The following are accepted as surface objects:

- o   kubit planes (caution: have to be limited to their boundaries)
- o   kubit cylinders
- o   AutoCAD surfaces (solids, meshes)

The number of the objects selected of the respective surface type is displayed as status behind the button.

Important! AutoCAD solids and meshes are not supported in AutoCAD LT.

Due to an AutoCAD error, at the moment the use of AutoCAD solids results in a memory overflow. Until Autodesk has solved this problem we advice you **not to select solids** as surface. But it is possible, to convert all 3D solids as well as poly-face networks (As-Built Total Station Interface →intermeshing) into AutoCAD meshes (convert to mesh, AutoCAD command MESHSMOOTH).

When using AutoCAD meshes as surface, please make sure, that the value for the 'Smoothness' property is set to 'None'.
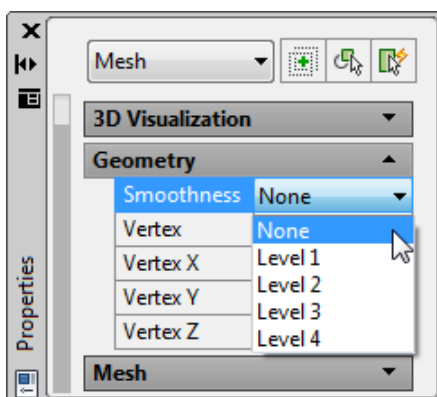
Hint:

If you want to use a smoother mesh as surface anyhow, it is possible to set the wanted smoothness level (level 1 to 4) and then use the AutoCAD command 'MESHREFINE'. The mesh will be refined accordingly. The resulting mesh is denser,

but has the smoothness level 'NONE'. The higher the smoothness level or the denser the mesh, the longer the calculation time for the orthophoto will be.

For even more smoothness especially for Mesh Primitives like cones, spheres etc. You may use the AutoCAD command _MESHOPTIONS with its Tesselation options. Please refer to the AutoCAD help file for a detailed description of the above stated AutoCAD commands.

Heading "kubit Oriented Images"

This heading contains the list of oriented images, which are to be used as source data for the orthophoto. Besides the buttons "Add" and "Delete", you may use the arrow keys to change the order of the entries. Please refer to the respective section under →Image computations – Unwrap cylinder (page 7-130) for more information about further functions within this heading.

Heading "Orthophoto"

Image plane

Define the image plane of the orthophoto. The latter may lie in exactly one of the three principal planes of the current UCS, on a kubit plane which you have defined previously or simply on the current view plane. For the last option, the plane will automatically be placed in front of all selected surfaces.

Button "Select size, position, clip and orientation"

After clicking this button you will leave this window. The view of the drawing changes to the selected plane with focus on all selected surface objects. Now outline the area of the new orthophoto polygonal, in order to define the clipping of the orthophoto.

> State position or <Cancel>:
>
> State next point or [Close/Cancel] <Close>:
>
> State next point or [Close/Cancel] <Close>:
>
> …

Hint: If you want a rectangular clipping, use the ortho mode of AutoCAD.

File name

Before you can start the calculation of orthophotos, you have to enter a file name for the image. Use the buttons 	or 	to enter name and path manually. BMP, TIFF, JPEG and PNG are available as file formats for the orthophoto. By clicking the 	button, you enable the automatic naming. With the →Settings command you can determine, where to save the orthophotos when using this mode. Further more you may determine the image format (e.g. TIFF) and have an automatic prefix or suffix assigned to the name.

Button "Further settings"

With the [**Further settings...**] button you can adjust the properties of the orthophoto. The optimal values for the **number of pixels**, **image size** and **pixel size/image resolution** will be displayed. Optimal means that the image to be created contains exactly as many pixels that a maximum of image information is available without wasting memory at the same time. If needed it is possible to adapt the values to your requirements. You can find further information regarding the individual settings under Rectification by control points - Rectification of photos (Projective Transformation) (page 7-37).

Image size

Here the information regarding the image is displayed summarized:

Image size in AutoCAD units (image size in pixels)

Demand of memory space (uncompressed)

The status bar

The status bar is at the bottom of the window. It displays information about the current calculation status of the orthophoto calculation and if applicable missing input.

Hints:

The orthophoto will automatically be placed on the layer, which you have defined with the command →**Settings** under Layer 'LayerOrthophotos'. If no layer is defined (default) the image will be placed on the current layer.

In addition to every orthophoto a file 'FilenameOrthophoto_Fileextension.PRK' will be generated in the same directory. This protocol file in ASCII format contains all important information for every orthophoto calculation like information regarding the used surface objects, the names and paths of the used oriented images, set options as well as name, size, resolution and measurements of the orthophoto.

The computation of the orthophoto may take quite a while. The time depends on:

- the number of used oriented images,
- the clipping of these images,
- the number and complexity of the used surfaces,
- the size of the unwrapped image,
- the processor power of your computer.

Dimension - Reference height dimension

	Command name:	Menu:
	KUBT_PC_HP0	As-Built Photo

In order to put spot heights on a rectified image at first a height reference has to be created. This command serves for that purpose. At the corresponding place a symbol is inserted that marks the reference height.

▼ Reference height: 0.00

All following height measurements refer to this value.

When you call up the command 'reference height dimension' the following dialogue will appear.
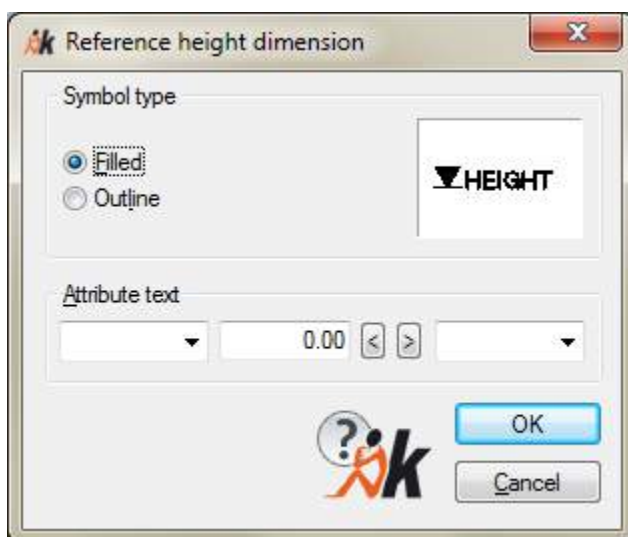
Under 'Symbol Type' you may select whether the symbol is to be solid or just outlined. On the right you can see a display window in which you may check your selection.

The frame 'Attribute text' allows for various options concerning the design of the object labelling. In the middle you see a grey text window with 0.00. This is the value of the reference height. If you want, you can change this value for instance to a given height over sea level. With the two arrow switch keys on its right-hand side you may state how many digits behind the decimal point are to appear. In the left-hand side text window you may determine the prefix. You either select one of the default terms ('Reference height:' or 'Ref.H.:') with a click on the arrow key or fill in a self-chosen term. In the right-hand side text window you may determine a suffix in the same way. Various units are offered as defaults here.

With **OK** you will return to the drawing. In the command line this message will appear:

Point for reference height:

Determine the height reference point with a click.

With **Cancel** you exit the command early.

Dimension - Height dimension

2.41 ▽	Command name:	Menu:
	KUBT_PC_HP	As-Built Photo

This command serves for putting spot heights on a rectified image. A symbol with the corresponding height value is inserted at the desired place.

Zero as determined using the previous command 'reference height dimension' is used as reference height. If no reference height was determined the zero of the current UCS serves as a reference point. **The height always orients on the Y-axis of the current user coordinate system (UCS)**.

When you call up the command the following dialogue will appear:
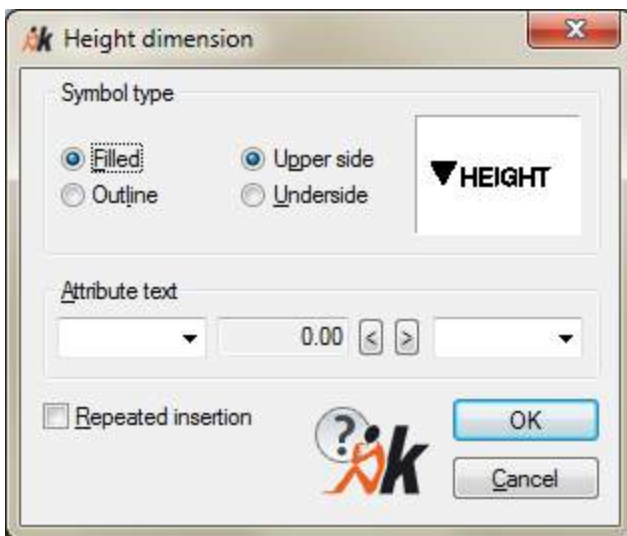
Under 'Symbol Type' you may select whether the symbol is to be solid or just outlined and whether it represents an upper side (point shows down) or an underside (point to the top). On the right you can see a display window in which you may check your selection.

The frame 'Attribute text' allows for various options concerning the design of the object labelling. In the middle you see a grey text window with 0.00. This symbolizes the height value. With the two arrow switch keys on its right-hand side you may state how many digits behind the decimal point are to appear. In the left-hand side text window you may determine a prefix. You either select the default term 'Height:' with a click on the arrow key or fill in a self-chosen term. In the right-hand side text window you may determine a suffix in the same way. Various units are offered as defaults here.

If you put a hook into the box 'Repeated Insertion" you may insert more than one height point one after another without having to call up the command anew.

With **OK** you will come back to the drawing. In the command line this message will appear:

> Select point for height dimension:

Determine the height point with a click. With **Cancel** you cancel the command early.

Dimension - Area dimension

	Command name:	Menu:
	KUBT_PC_AREA	As-Built Photo

The command 'KUBT_PC_AREA' serves for putting measurements on areas in the rectified image. After selecting a boundary line its area and circumference will be calculated. These are inserted together with additional information, into the drawing in the form of an area stamp.

Before calling up the command 'KUBT_PC_AREA' the areas to be calculated have to be defined with AutoCAD-drawing elements (e.g. lines, polylines).

The following dialogue belongs to the command:
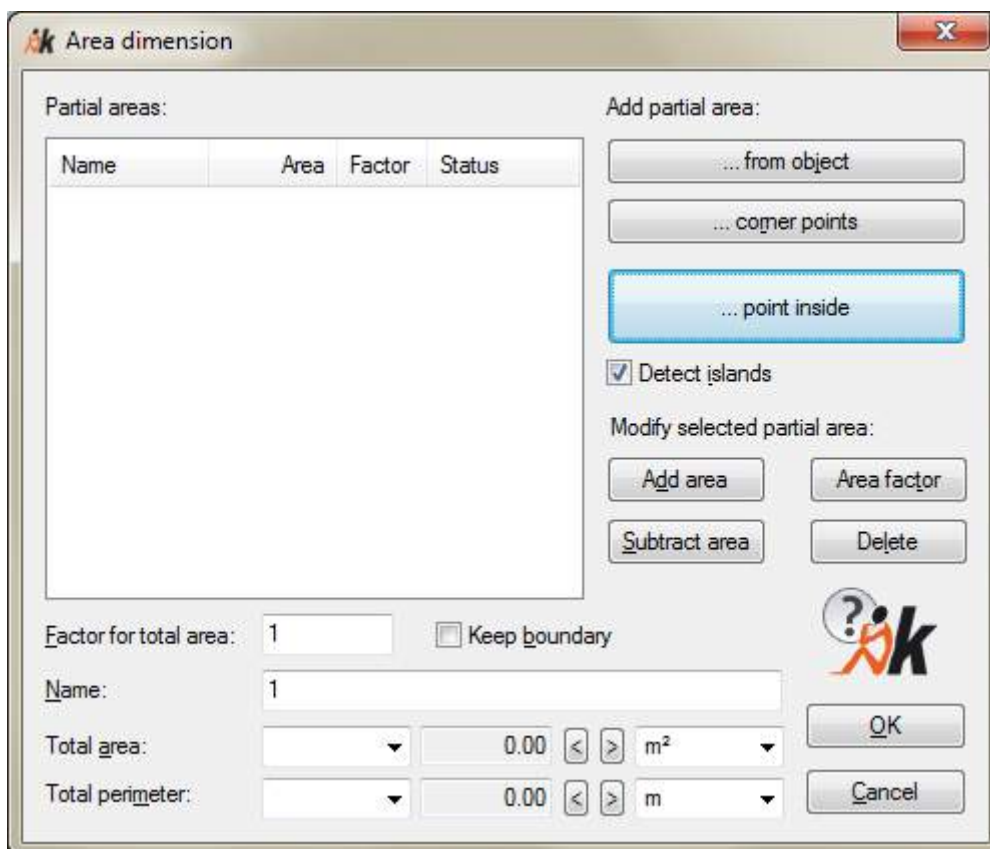
An area can be put together including multiple partial areas. They are listed in the chart on the left-hand side in the dialogue. In order to select the boundary lines of the areas to be measured there are various possibilities:

- **Add partial area...from object**

   With a click on this button you will come to the drawing and the following call will appear in the command line:

   Choose a closed object:

   Click on a closed object e.g. a polyline, circle, ellipse or a region. The selected area is hatched immediately in colours. You may select as many partial areas as you want to. With **Return** you will come back to the dialogue.

- **Add partial area...corner points**

  Here you are asked directly for the corner points of the area boundary. Follow the command line text:

Start point:	*(click first point of the boundary)*
Next point or [Close] <Close>:	*(click first point of the boundary)*
Next point or [Close] <Close>:	*(click second point of the boundary)*

  ...

  If you want to close the boundary then enter the option 'C' into the command line and press **Return**.

- **Add partial area...Point inside**

  Here you only have to click inside the area to be supplied with measurements. The software picks out the area's boundary line automatically and marks it with a hatch. A previously drawn closed boundary is a pre-condition for this. It may be a combination of various objects, e.g. lines, poly lines, arches, circles etc. If If no boundary line can be found the following error message will appear:
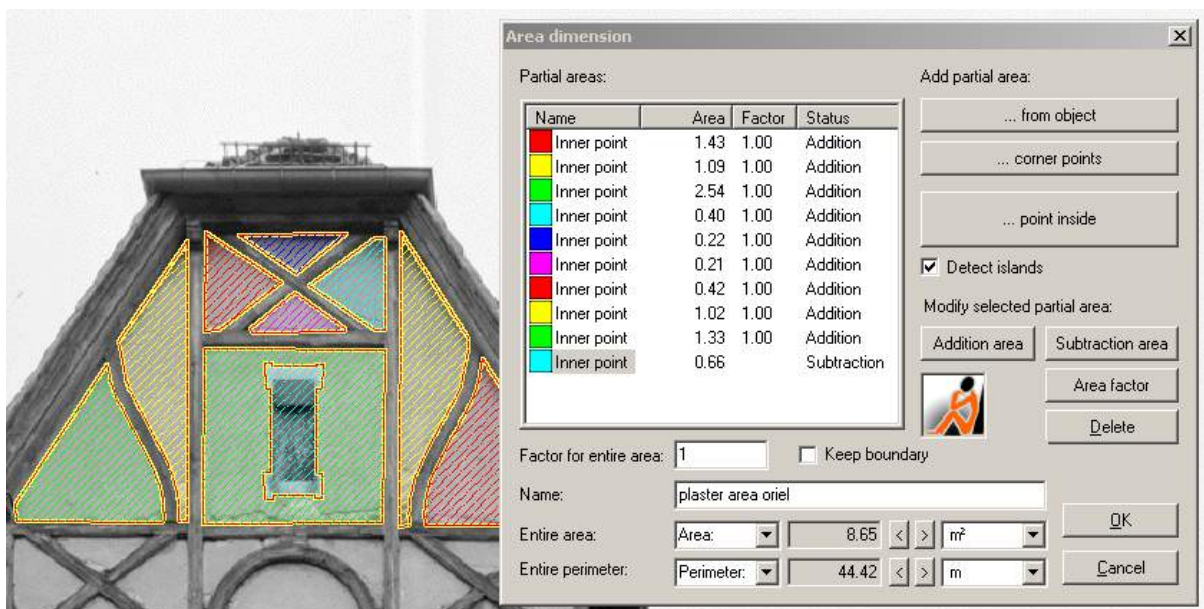
  Valid hatch boundary not found.

  0 loops extracted. 0 Regions created.

  No closed region found!

  You may select as many partial areas as you want to. With **Return** you will come back to the dialogue window. If you activate the option 'Detect Islands' then holes that lie within the area are separated from the calculation.

The result of an area selection could look like this:

You may assign a factor to each partial area with which the area value is to be multiplied. In order to do so mark the corresponding line in the list and click on **Area Factor**. An input field for the factor will appear.

With the buttons '**Addition area**' and '**Subtraction area**' you may determine whether the corresponding area is added to or subtracted from the complete area. Subtracted

areas always have the highest priority, they represent 'holes' throughout all partial areas.

With **Delete** you remove a partial area.

The determined complete area can be multiplied with a **factor for entire area.** This factor is 1 as a standard but you may alter it in the corresponding text field.

The final values are displayed under '**entire area**' and '**entire perimeter**', respectively. The figures are in the grey text field in the middle. With the two corresponding arrow keys you may state how many digits behind the decimal point are to be displayed. On the right and on the left input fields are set in which you may determine optionally a suffix or prefix, respectively, in the area stamp. You may either select one of the default terms or enter something yourself.

With **OK** you will cancel the dialogue. An area stamp with an area name, area value and circumference is now 'attached" to the mouse which you may position with a click in the desired place.

plaster area oriel
Area: 8.65 m^2
Perimeter: 44.42 m

To write area dimensions into a text file in tabular form, use the AutoCAD command "Tools – attribute extraction" (**eattext)**.

Dimension - Align dimension symbols

	Command name:	Menu:
	PCROTATECP	As-Built Photo

This command serves for aligning dimension symbols or other AutoCAD blocks with the XY plane of the current UCS. After that all selected As-Built dimensions or other blocks are brought to front in the display order.

> Command: PCROTATECP
>
> Align all control points or
>
> [Control points/dimension Symbols] <Control points>: **S**
>
> Select dimension symbols to be aligned: *(Select blocks to be aligned and confirm with ENTER)*
>
> Select objects: 1 found
>
> Select objects:
>
> Align with [Ucs/current View] <Ucs>:

A typical application for this command is the change into another UCS. The As-Built dimensions are possibly not visible anymore as they may lie e.g. rectangular to the top view.
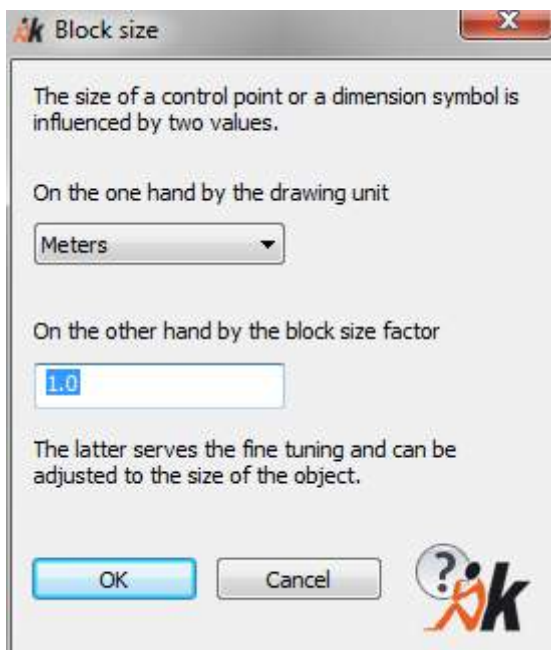
Dimension - Change size of dimension symbols

	Command name:	Menu:
	PCRESIZECP	As-Built Photo

This command allows you to adjust the size of As-Built blocks (control points or dimension symbols) to your individual needs.

Different projects often differ in depicted images of the world. The standard setting of As-Built uses symbol (block) sizes (e.g. Control and Image point blocks) which are adjusted to facades between 5–20 m (AutoCAD units). If you want to rectify smaller objects e.g. a painting control points may be too large. You can change these settings by using the command 'PCRESIZECP.

When running the command a dialogue appears, in which you change the scale factor which relates to the AutoCAD drawing unit.
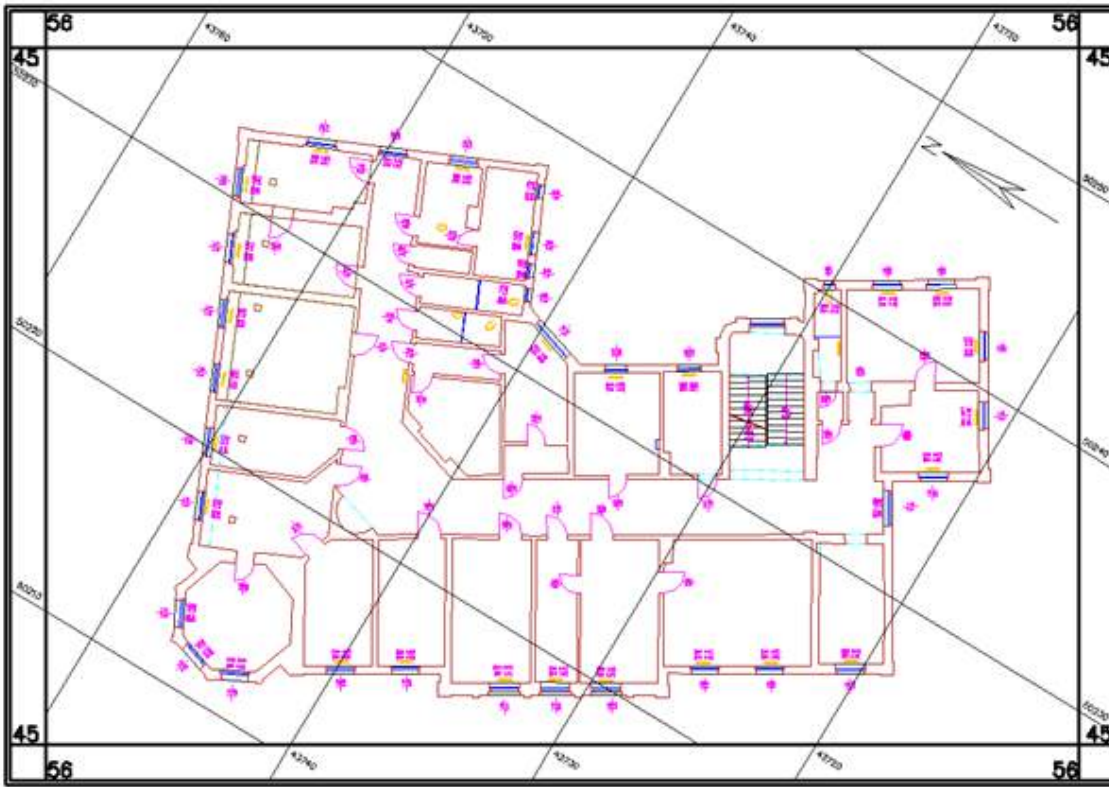

Afterwards all control points, area and height blocks in the drawing will be adjusted.

Dimension - Insert coordinate frame

	Command name:	Menu:
	KUBT_PC_COORDRASTER	As-Built Photo

This command allows you to insert a coordinate frame with coordinate dimensioning and grid for any perpendicular section into the drawing.
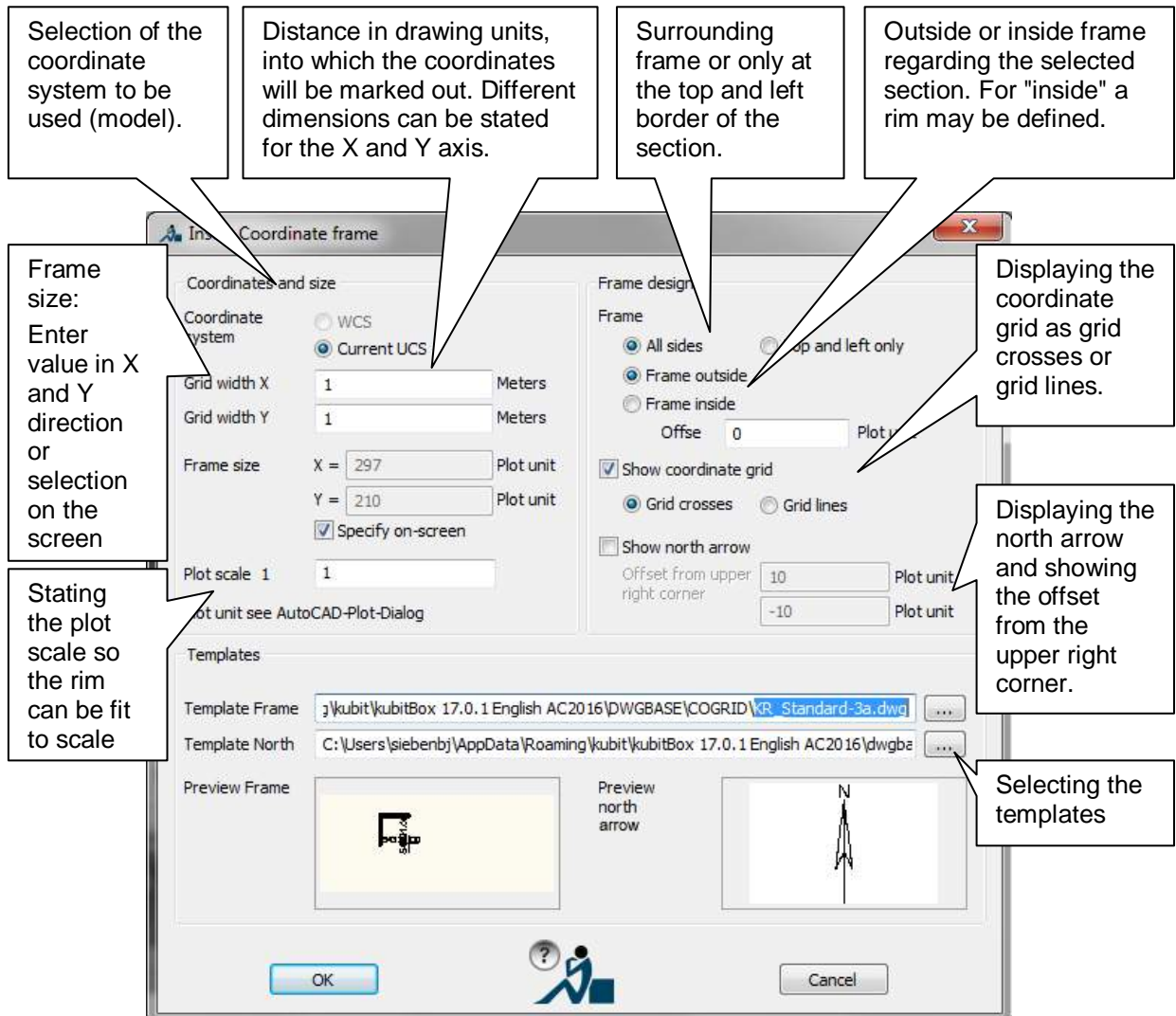
An example:

The coordinate frame may be featured variably by individually designed templates. But a number of ready to go templates will be provided.

The frame may be inserted into the drawing within the model or the paper area. The coordinate dimensioning is always based on the model coordinates though. The WCS or the UCS may serve as basis. The top view has to be set for the underlying coordinate system.

Command run

After calling up the command a window will open where all essential settings can be set. If the layout area is active, you will have to select the relevant view first.

Selection of the coordinate system to be used (model).

Distance in drawing units, into which the coordinates will be marked out. Different dimensions can be stated for the X and Y axis.

Surrounding frame or only at the top and left border of the section.

Outside or inside frame regarding the selected section. For "inside" a rim may be defined.

Frame size:

Enter value in X and Y direction or selection on the screen

Displaying the coordinate grid as grid crosses or grid lines.

Stating the plot scale so the rim can be fit to scale

Displaying the north arrow and showing the offset from the upper right corner.

Selecting the templates

Settings

Coordinate system: Either the WCS or the current UCS (if existing) can be used as basis for the dimensioning of the coordinates. In order to be able to insert the coordinate frame, the top view of the according coordinate system (view parallel to the XY plane of the relevant UCS or WCS) has to be selected within the drawing view. If the coordinate system is twisted regarding its XY plane, the entry cannot be selected.

Grid width X and Y: Distance in drawing units in which the coordinates will be marked out. You may state different units for the X axis and the Y axis.

Frame size: You may state a definite dimension for constant frame sizes, so only the lower left corner of the wanted section has to be stated. You will more often use the option to draw a perpendicular section on the screen in order to specify the frame size. In order to be able to do, so activate the "Specify on-screen" option.

Plot scale: The selection of the correct plot scale is important, so the frame layout, like width and font size, is always the same within the plot. The plot scale to be stated (ratio plot unit in mm to drawing unit) should match the plot scale within the AutoCAD dialog "Plot".

Example model area: A drawing (drawing unit meter) is to be plotted in the map scale 1 : 100. The plot scale then has to be set to 1 : 0.1. Reason: The plot units in AutoCAD are always in millimeters (for metric paper formats). Therefore the wanted map scale 1 : 100 has to be multiplied with the ratio of drawing to plot unit (1 meter / 1.000 millimeters = 0.001) in order to get the matching plot scale or 1 : 0.1

Example paper area: Here it is easier. Since the plan scale is controlled via the view window, you will have, in general, to set plot scale 1 : 1, unless the paper format is to be reduced or enlarged. In that case you will have to adapt the plot scale as well.

Frame design:

- "All sides" The frame will be drawn circular.

- "Top and left only": The frame will only be drawn on the top left rim of the selected section.

- "Frame outside": If this option is selected, the frame will be drawn directly outside of the selected section.

- "Frame inside ": The frame will be drawn within the selected section.

- When selecting "Rim", you can state an offset in order to separate the frame from a drawing frame for example.
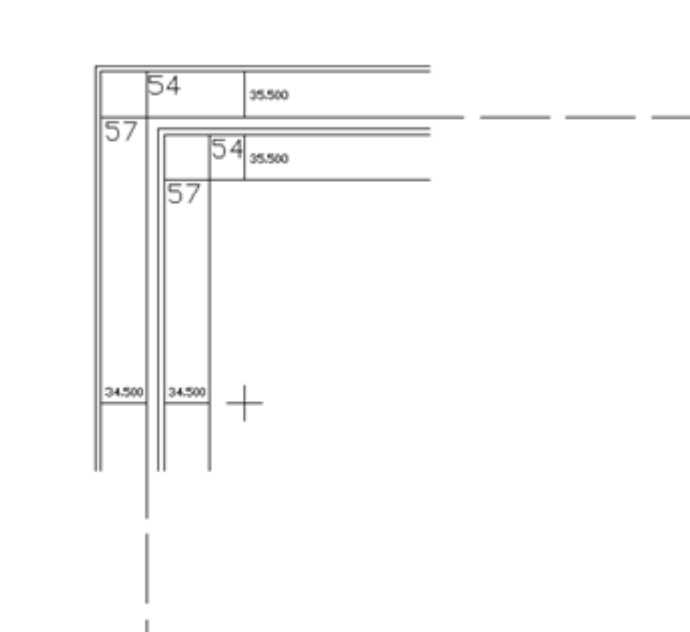
Show coordinate grid:

- Grid crosses: The elements (lines, circles, points, etc.) from the template will be drawn at the grid points.

- Grid lines: A grid with continuous lines will be drawn. The template has to contain lines as cross elements for this.

Show north arrow: As block the north arrow will be inserted into the selected template. The X and Y measure for the insertion position of the north arrow refers to the top left corner of the selected section.

Templates: Here you select the templates for the frame and the north arrow. A small selection of templates will be provided. You will find those within the As-Built program directory in the sub folder \DWGBASE\COGRID. It is also possible to create your own templates.

Further command run

After you have adjusted all wanted settings, close the dialog with OK. Next you will be prompted to select the section.

For the model area you will always have to select a perpendicular section by selecting two opposite points. For the layout area, the section may match the dimensions of a view (no further selection) or you may select a section that is different from the view.

After you have selected the section the coordinate frame will be drawn. The frame will be inserted as block reference. In order to change the frame afterwards, you will have to use the block editor or use the AutoCAD command "Explode".

Within the paper area the view window is locked by the command execution, so it is impossible to change the view, because this could lead to invalidity of the coordinate frame. You may unlock the window manually (Click window and call up context menu with the right mouse key. Select "No" at "Display locked")

Hint: If the view is twisted, the coordinates will change to the right or left when aligning in north direction. That means, the northing (Y-values) will marked out to the top and the easting will be marked out to the left.

Information regarding the templates:

Next to the provided templates and their individual adaptation like changing the line color and width, font size, etc. you may create your own templates.

The templates for the coordinate frames are AutoCAD drawings, which contain the basic elements of a frame, like frame line, coordinate labeling, crosses or grids.

According drawing objects have been assigned to these elements. Via this assignment the individual drawing elements will be used when creating a frame.

The following elements will be differentiated according to the following figure (grid size = 10):
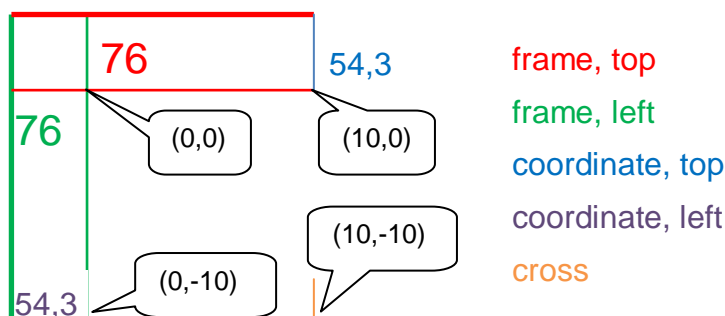
The template drawing shows the top left corner of the coordinate frame. The dimensions of the frame (width, font size) refer to plot units (mm). The origin 0,0 has

to be defined at the inner corner. For further elements a square grid of the size x is valid. That means, the top coordinate is at x,0, the left coordinate is at 0,x and the cross at -x,-x. In order to determine the grid measure by the program, at least one object has to be defined as cross element.

Only lines (no polylines) and text objects are allowed as drawing objects for frame and coordinate elements. You may use circles or points for the crosses though. For the "Frame" element you may use text as leading coordinate digit, so it does not have to be named for every coordinate labeling.

The drawing objects of the template have to be assigned to the individual frame elements separately. You will do this with extended data (xData). In order to do so enter the command KUBT_PC_COORDRASTEREDITTEMPLATE into the command line. Select the drawing objects belonging to the elements within the opening window. In order to show the assignment on the screen use the "Show" buttons.

The formatting of the coordinate labeling will be done via statement of the position of the location to be shown. That means, the text "76" puts out the 7th and 6th place before the comma of the coordinate (matches the first two digits for Gauß-Krüger).

The text for the coordinate labeling should generally be aligned centered.

The center or pivotal of the north arrow has to be inserted at 0,0 within a template drawing for the north arrow. The size has to be stated in plot units.
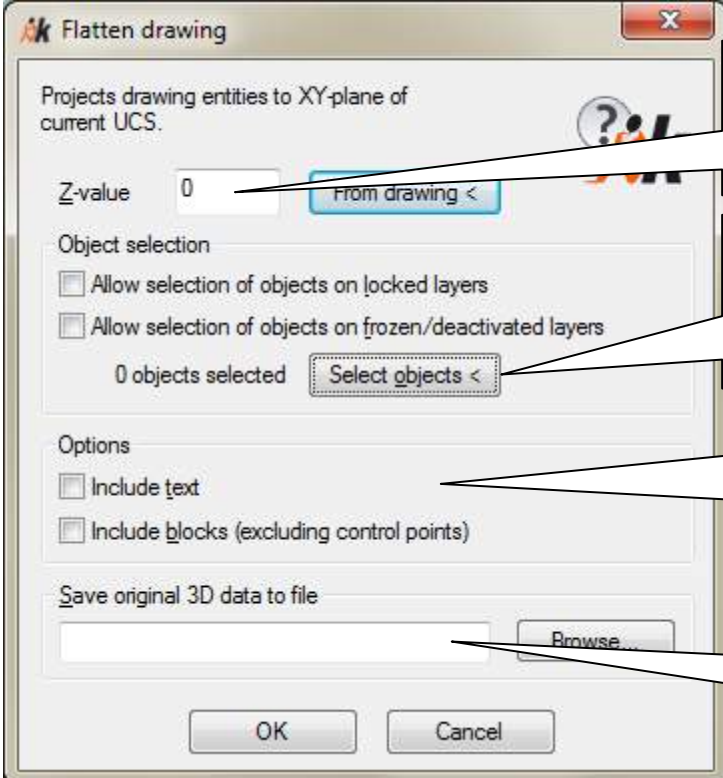
Flatten drawing

	Command name:	Menu:
	KFFLATTEN	As-Built Photo

The command 'KFFLATTEN' is used to orthogonal project line-like 3D drawing elements into a plane. Thus, elements that have been measured in the 3D mode can be processed to a 2D plan in AutoCAD.

The projection plane is defined parallel to the XY plane of the current UCS with the Z value that has been entered in the field 'Z-value'.

Following types of elements are flattened:

Points, circles, lines, all poly lines, ellipses, arcs, beams, straight lines and dimensions.

All elements are projected to this Z value of the UCS. Via the button you can pick a value from the drawing.

Via the button you can select the objects to be flattened in the drawing. Furthermore you can enable the selection of objects for locked or frozen layers.

Tick these options if you like to flatten text and blocks as well. Note that control points and instrument stations cannot be flattened.

If necessary, all elements can be saved in an external file before the flattening process.

If the options 'include text' and 'include blocks' are activated, texts and blocks too will be shifted to the defined Z value. However, the inner geometry of a block is kept.

Dimensions are only flattened if measurement lines and texts are parallel to the UCS. It makes sense to dimension the plan after having flattened the drawing.

The blocks for control points are not flattened. Flattening does not make sense here, since the 3D positions are absolutely valuable for image rectification and image orientation.

Export - Create ESRI World Files

	Command name:	Menu:
	KUBT_PC_WORLDFILEEXPORT	As-Built Photo

This command serves for creating an image position file in ESRI format.

If you want to import correctly positioned and scaled images of your As-Built drawing into another System (e.g. GIS), a world file will serve for storing the required position data. This step is called geo-referencing.

The world file format for geo-referencing of raster images was established by the ESRI company. It became a quasi-standard, because of its easy appliance.

A world file has following properties:

- For each image a separate world file in the same folder like the corresponding image has to exist. There are guidelines for the naming. The file name equates to filename of the corresponding image with a special file extension. The extension consists of the first and third letter of the image file extension followed by "w", e.g.:

    Image: aerialview.TIF → World file: aerialview.TFW

    Image: map.JPG → World file: map.JGW

- The world file as an ASCII File is readable with any text editor.
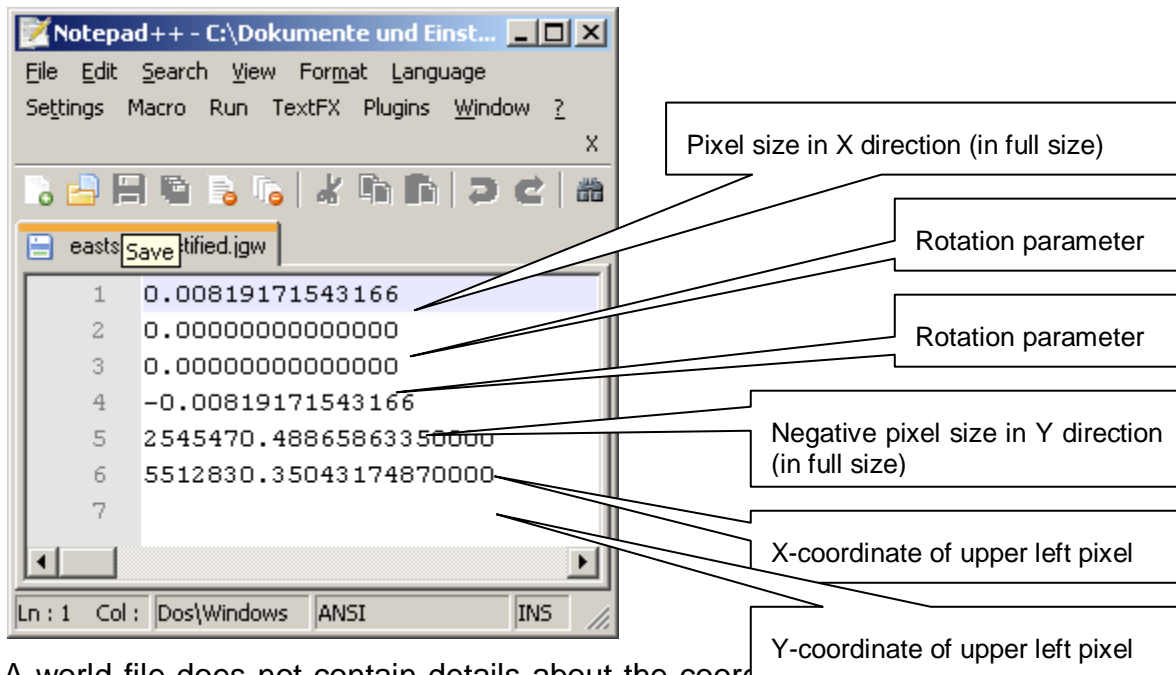
- A world file does not contain details about the coordinate system. Users have to take care to use the correct system for creating these files. Further details you will find below.

After calling up the command you are asked to select one ore more images:

    Command: KUBT_PC_WORLDFILEEXPORT

    Select image(s):

Confirm the selection with Return. As-Built now creates a separate world file for each selected image.

The correct coordinate system

World files contain no information about the kind of coordinate system. This means neither the origin of coordinates nor kind of projection are saved in world file.

You have to take care that coordinate systems are identical in AutoCAD and your final system. A world file with e.g. Gauss Kruger Coordinates cannot be positioned correctly in a GIS which expects longitude and latitude.

As-Built always uses the just current UCS. Before creating world files you have to select the correct UCS as the current one. Furthermore selected images have to lie in the XY plane of the current UCS or have to be parallel to this. Otherwise As-Built cannot create a world file and the following message appears:

    Error saving "ESRI World File" for "C:\…\IMAGE_NAME.jpg".

    0 "ESRI World Files" of 1 image(s) created.

Loading images with world files

Conversely As-Built allows you to load any images, which are geo-referenced by world files. They will be placed in the correct position. See further details in this command reference under → **Image - Load image**.

Export - Export to VRML

	Command name:	Menu:
	PPEXPORTVRML	As-Built Photo

This command saves the geometry of certain images in a VRML 2 format (*wrl). VRML files can describe 3D scenes independent of the system. VRML allows you to move virtually in a 3D room. The images are only referenced if possible with their relative path to their VRML file.

You can download a free Viewer for your Web browser from http://www.parallelgraphics.com

After running the command you are prompted to select the images to export. Afterwarts following dialog opens:
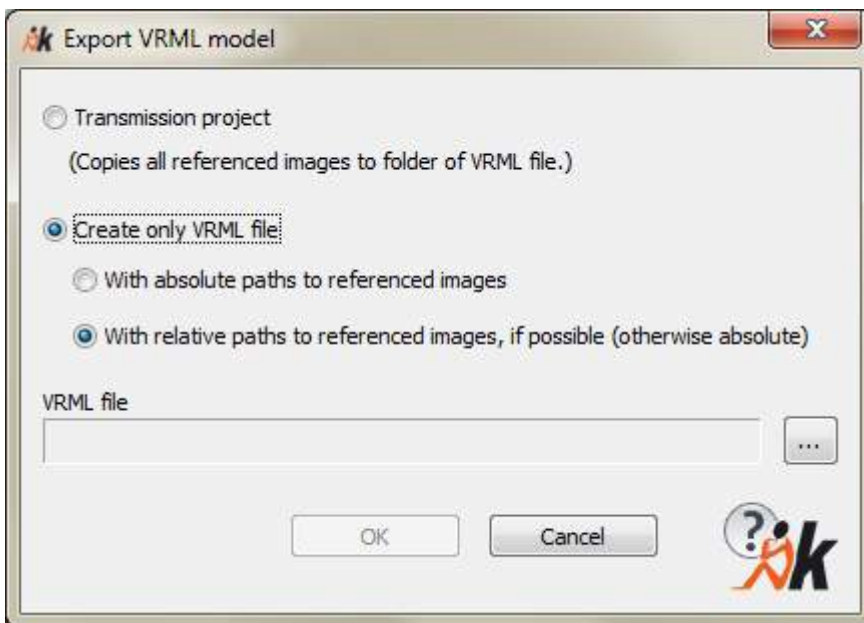
Select the desired option, path and name of the VRML file and confirm with [OK].

View – 3D Orbit

	Command name:	Menu:
	PP3DORBIT	As-Built Photo

This command is especially meant for users of AutoCAD LT. The full version of AutoCAD does contain 3D orbit as native feature anyway.

Using 3D orbit you can rotate and move a drawing freely in 3D space. Thus, the spatial position of objects can be made clearer you can get a better view on the scene.
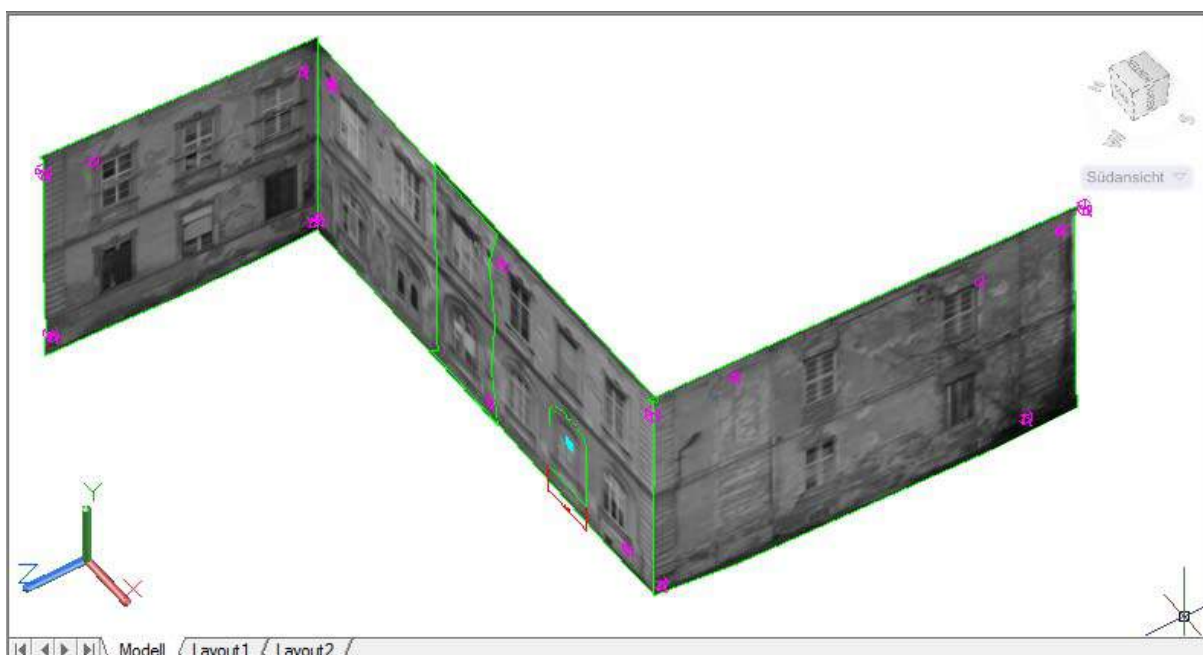
After having run the command you press the left mouse button, keep it pressed and move the mouse. If you found the right view you may let go the mouse button. You finish or escape the 3D orbit by pressing ECS or you press the right mouse button and select 'Finish' from the context menu.

You may also enable the 3D orbit by pressing **Ctrl-** and the **left mouse button** at the same time. Release the **Ctrl** key once the orbit is activated. **Note:** this works only if activated under Settings→AutoCAD (LT)).

Two more AutoCAD commands are useful in this context:

If you want to switch back to the plan view of the XY plane of the current UCS you run the command PLAN and use the option <Current>.

If you like to create a UCS from the current View you run the command UCS with the option <View>.

3D orbit can of course be started while another command is active (transparent mode).

View – 3D Orbit (with center)

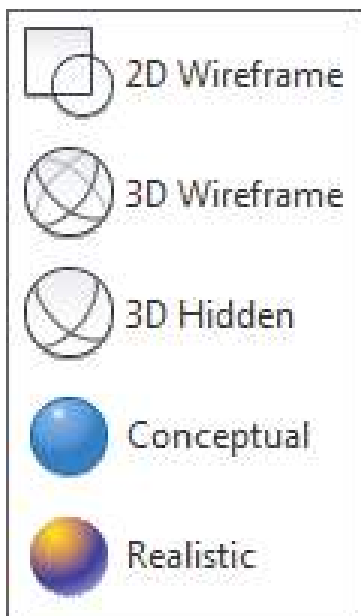|	Command name:	Menu:
	PP3DORBITCTR	As-Built Photo

This command is very useful when working with larger sceneries, since you may define the rotation center for the orbit.

View – Mode (visual style)

Command name:	Menu:
PPSETVISUALSTYLE	As-Built Photo

With this command you may set the visual style for your current viewport. It also works in AutoCAD LT an in camera navigation mode. The latter is necessary for plotting/printing, since plotting in perspective mode with the oriented image visible does only work if you set the visual style to "3D Hidden", "Conceptual" or "Realistic".

Following modes are available:

Rectification according to geometry - Correction of lens distortion

	Command Name:	Menu:
	KUBT_PC_CORRDISTGEOM	As-Built Photo

Our software allows you to eliminate distortions caused by photographic equipment that is not fully distortion free.

Photos that are taken with lenses which are not equipped for the correction of lens distortion are usually unsuitable for the use in surveying. Often you find such lenses in low quality cameras. If, however, the effects of distortion can be eliminated, the area in which these cameras can be used is much broadened.

Distortion of lenses can most commonly be recognized by the effect that originally straight lines are not straight in the picture. This effect is especially strong on the edges of the photo – some lenses distort a square to a cushion (edges are bent inward, picture 1a), others distort the square to a barrel (edges are bent outward, picture 1b). The degree of distortion of an image point depends on the distance to the principal point of a picture. The principal point of a picture is the point through which the optical axis of a camera runs. Except for a few specialized cameras, the principal point of is usually the centre of a picture.

1a) cushion shaped distortion   **1b) barrel shaped distortion**
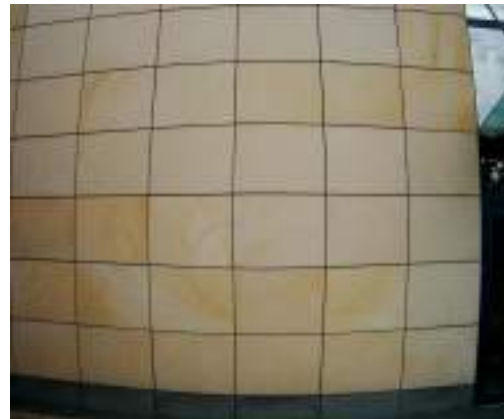
As-Built is able to delete also the radial-asymmetric distortion from an image. In this case, if necessary, more information have to be gathered but leads to a more precise result. In most cases it is sufficient enough to consider only the radial- symmetric distortion around the principal point of a picture.

The software offers multiple ways of distortion correction.

a) You can run correction of lens distortion in a separate process. A corrected image is produced, which you can use for rectification afterwards. The rectification parameters for a certain camera can be saved in a file and be reused at any given time.

b) You can determine the correction of lens distortion directly during the rectification process. This, however, only works with Rectification by control points - Rectification of photos (Projective Transformation)**.**

c) You can determine the correction of lens distortion directly during the image orientation process (→Oriented Images – Image orientation).

In the following method a) (correction of lens distortion in a separate process) is explained step by step. For method b) (correction of lens distortion directly in the rectification process) please refer to section Rectification by control points - Rectification of photos (Projective Transformation), for method c) to section Oriented Images – Image orientation.

How to proceed:

1)   Insert the distorted image in approximately natural size into an AutoCAD drawing. Therefore you can use the command '**Image - Load image**'

2)   Go to the As-Built Photo ribbon tab and choose '**Rectification according to geometry - Correction of lens distortion'.** You will then be lead through the process step by step. Your first step is to choose the distorted image.
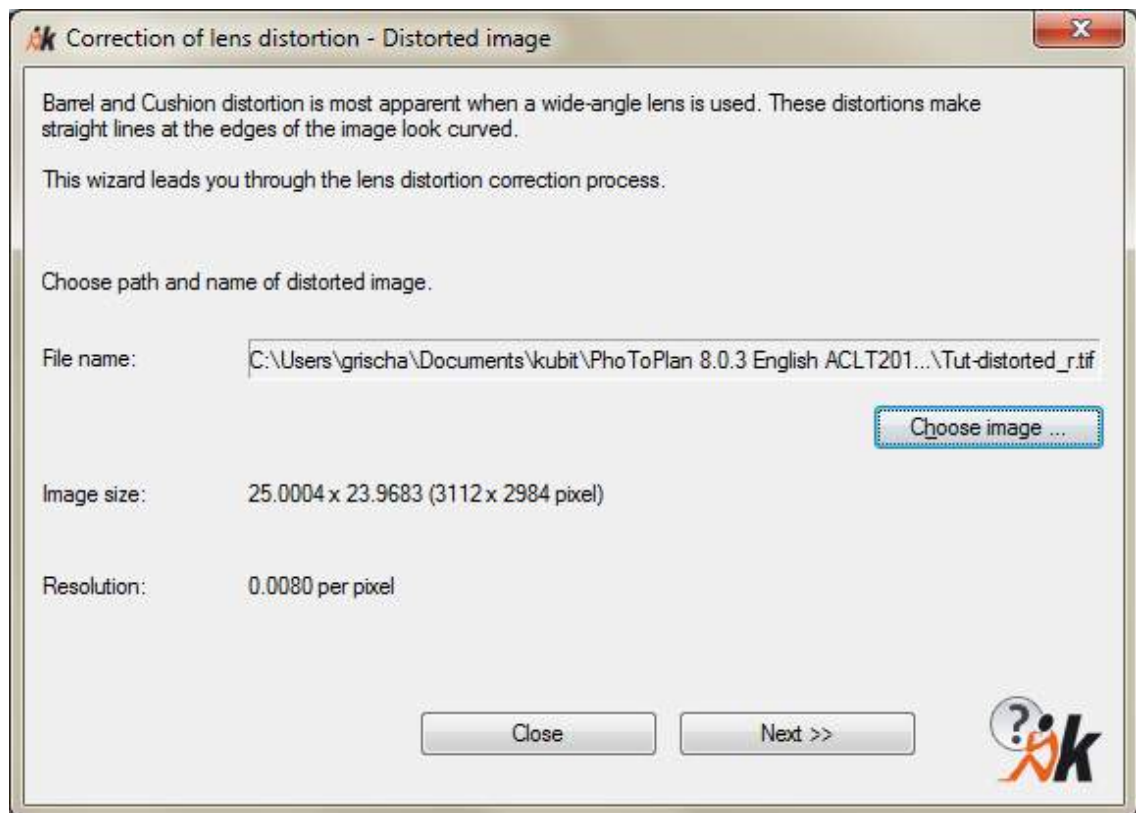
3)   If you already have determined and saved a set of distortion parameters for your camera, select 'Load from file' and proceed as in step 5). Otherwise select 'Derive from lines in current image'**.**
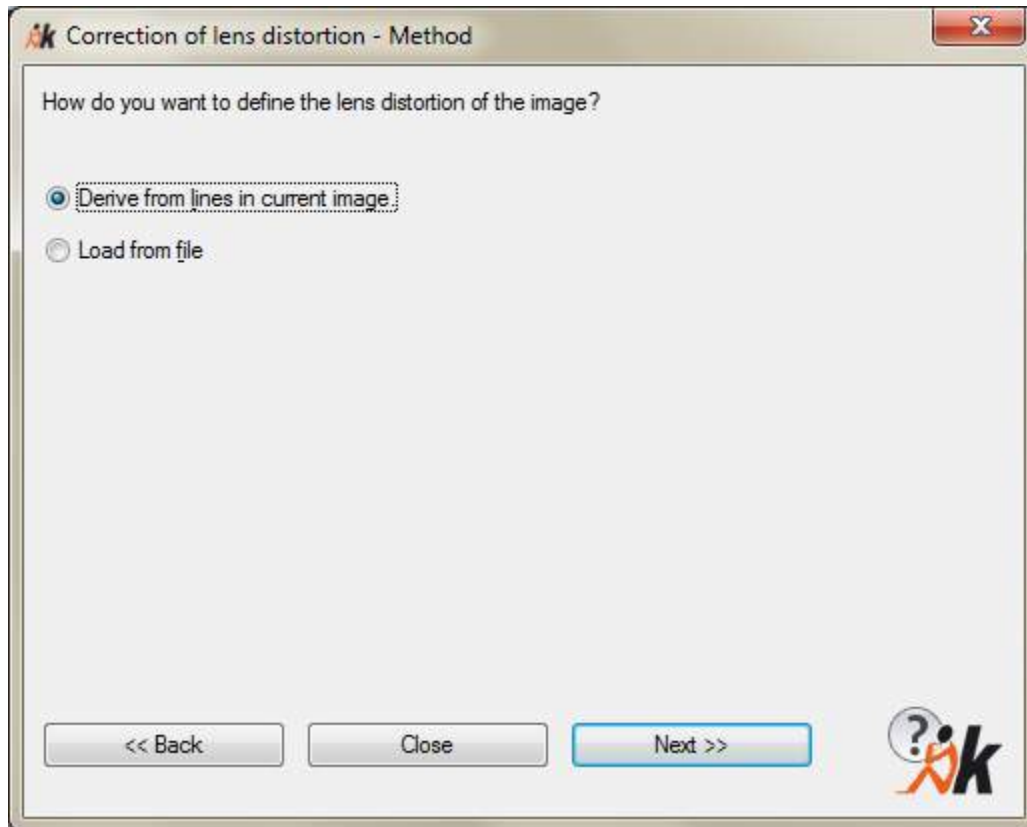
4.)   The next dialogue asks you to define linear structures (straight edges) in the
      image, which are needed for calculating the distortion parameters.
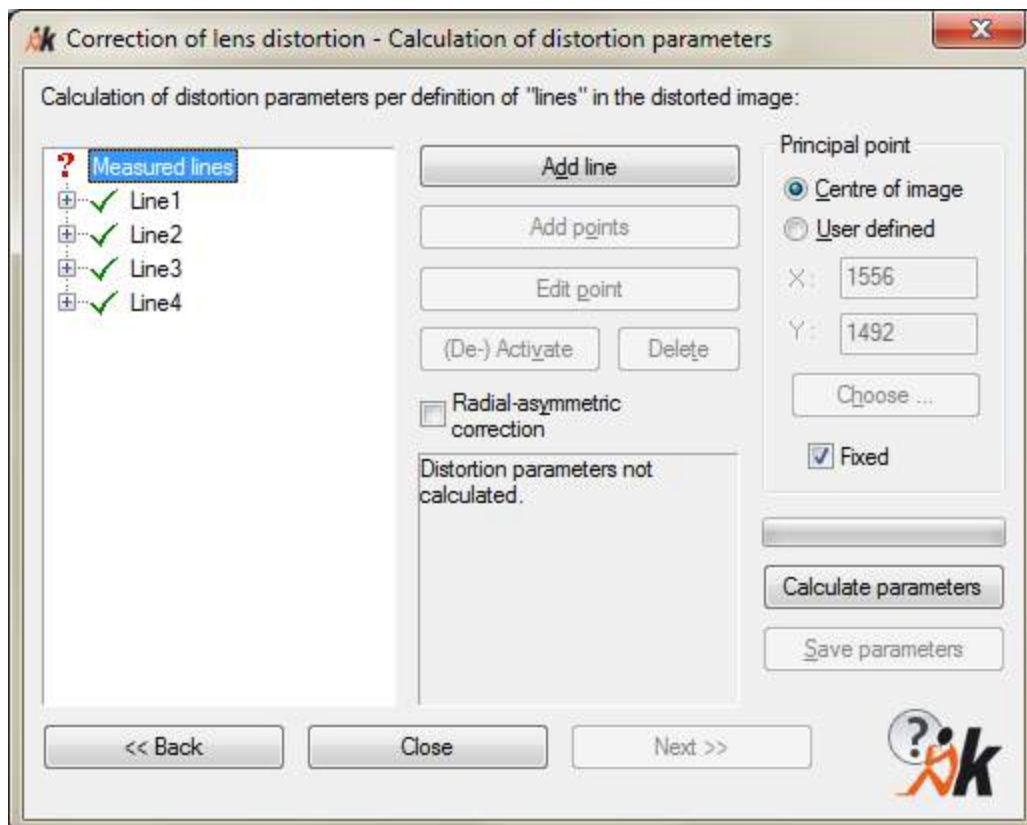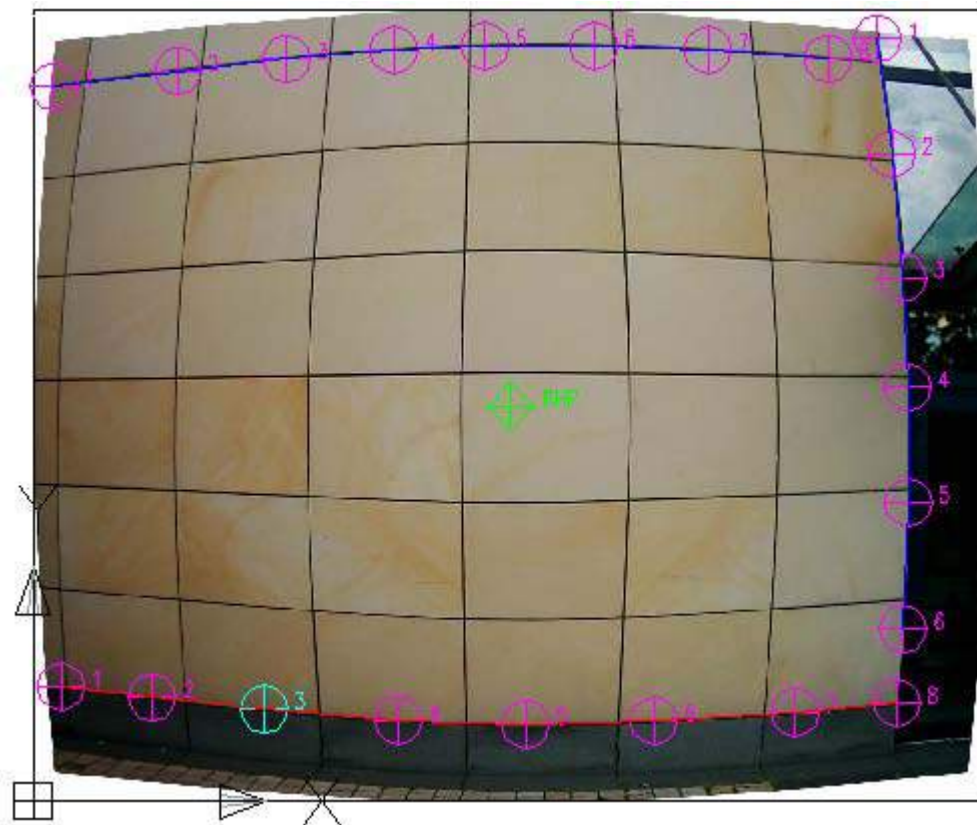

Define lines

First click 'Add line'. This will take you to the drawing and you will be asked to determine points within the image. After you have marked all points of a line, 'Finish' takes you back to the dialogue.

Using this method you should try to define as many lines as you can. Important: Not all edges in an image are suitable for distortion correction.

Be careful when defining lines. Consider following recommendations:

- Check that all edges are straight in reality. If there is a curvature on the original object, the result of the distortion correction will not represent a true image.

- Define enough points to describe the curvature of the line correctly.
- Lines that run radial to the principal point (green rhomb) i.e. diagonally through the picture are unfavourable since no useful distortion correction parameters can be determined by them.
- The longer a line is the better. Ideally, a line should run through the entire width or height of an image.

Notice: For defining lines within an image, we recommend the use of a scroll mouse. The mouse can be configured so that turning the wheel zooms the image in or out, whereas the image can be moved by pushing the wheel (button).

The picture below shows an ideal definition of lines. All depicted edges (here joints) are defined as lines with a sufficient number of points.
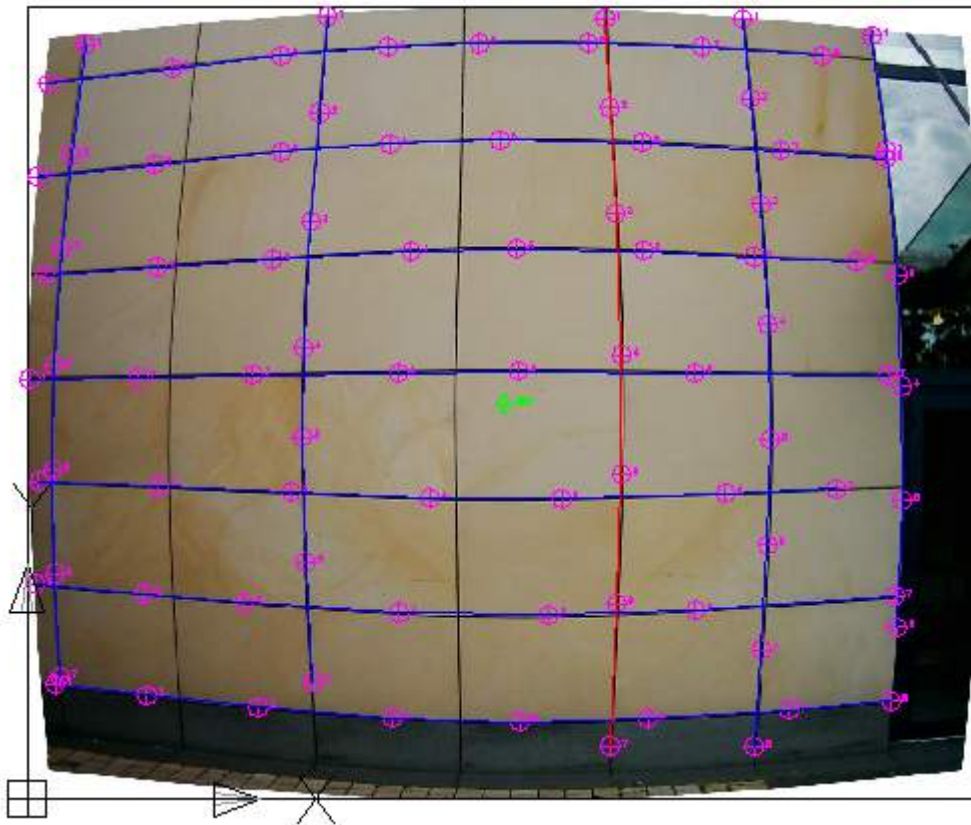
Principal Point:

In *unclipped* images of ordinary cameras the principal point should always be the centre of the image. If, however, the image was clipped or a special camera, in which the optical disc was not centred, was used the principal point does not coincide with the centre of the picture. In this case you have to approximately determine the principal point yourself (choose '**User defined**') and lose the fixing. The software will than try to calculate the principal point.

Calculate parameters:

After you have defined all lines, click '**Calculate parameters**'. The program will then present a set of distortion parameters. The correctness of the determination is expressed by individual errors of defined points in pixel.
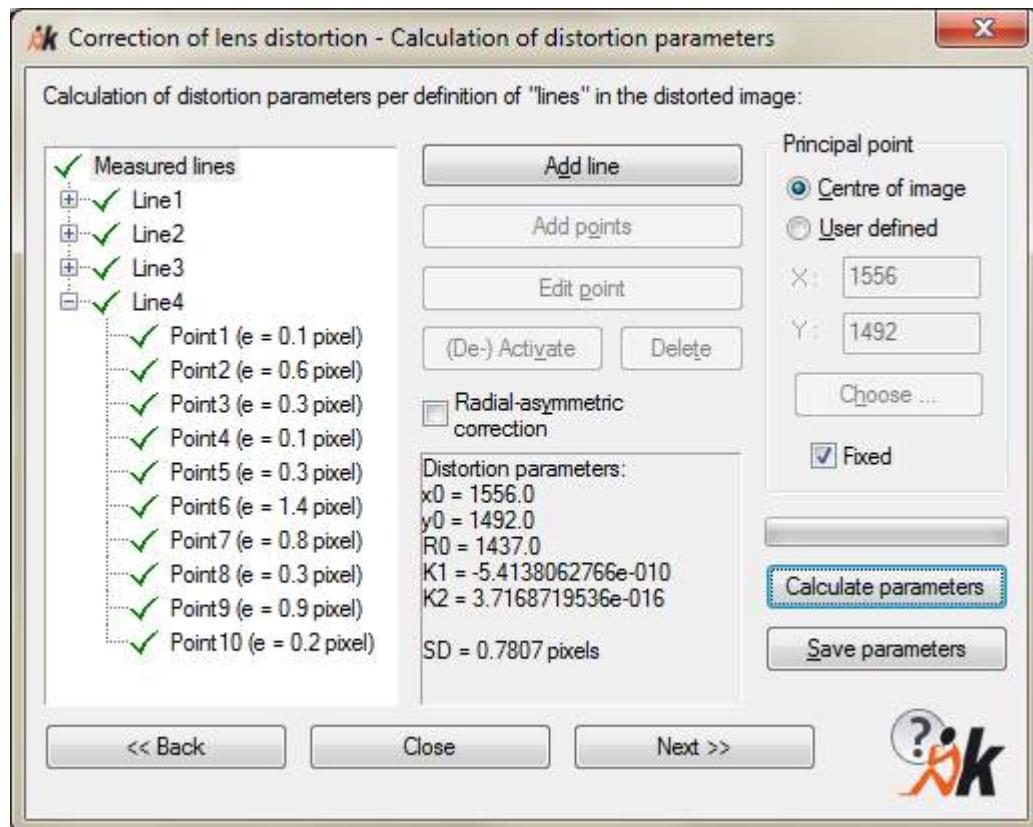
The individual error e hereby is the deviation of the corrected single point from the mean line through all corrected (line) points. The 'Mean deviation' is the mean value of all individual errors, which can be taken as a global quality criterion.

If you think that an individual error is too high you can edit this point. In order to obtain an optimal result, you may have to add additional lines or deactivate unfavourable lines/points. Mark the appropriate point or line in the list and use the buttons **'Edit', '(De-) Activate', 'Add line' and 'Delete'.** After the changes the calculation of parameters has to be repeated (button '**Calculate parameters**').

Save parameters:

You can save distortion parameters in a (*.vp2) file. Name the file e. g.: 'Camera name_Lens_Focal length_Image size'.

The distortion parameters can only be used for images of the same size (in pixel). If you use an image of the same camera configuration which has been clipped afterwards you have to determine the distortion parameters for this image size again.

5.) In the next step choose path and name of the undistorted image. Notice recommendations concerning file formats in chapter 'Rectification by control points - Rectification of photos (Projective Transformation)'. Detailed information on saving image data and on path options are to be found under →**Image - Load image**.
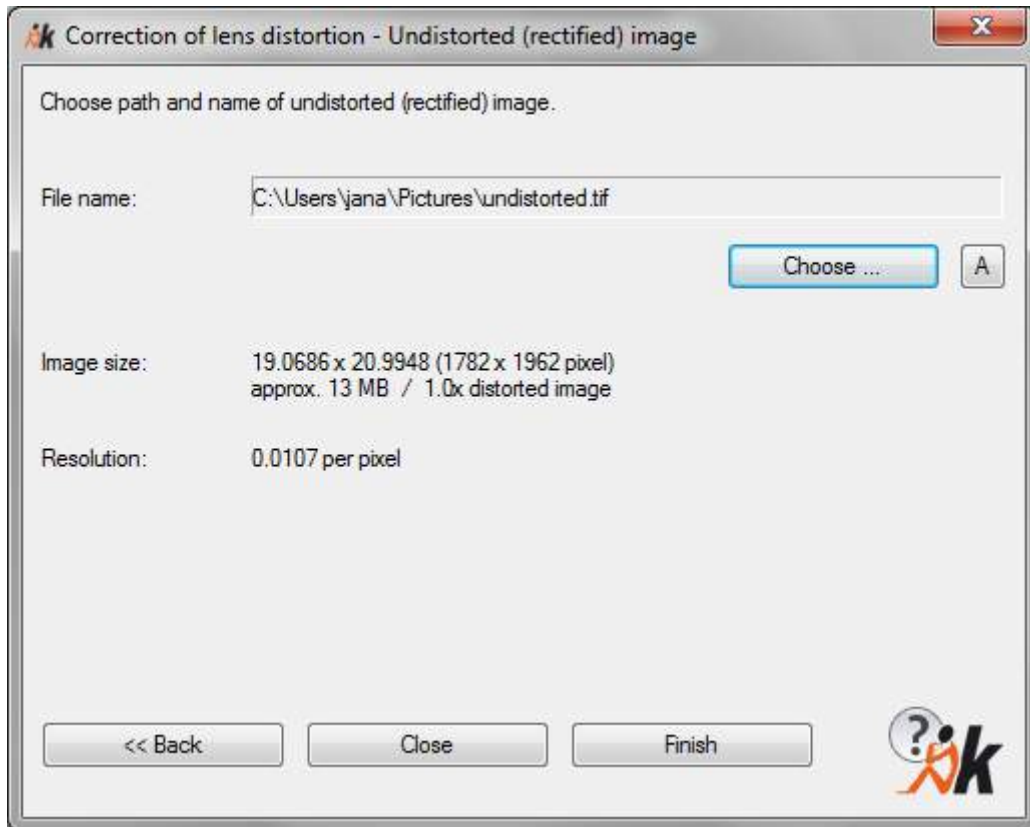
Finally, click '**Finish**' to calculate the undistorted image. It will be shown in your AutoCAD drawing right of your distorted image.

Previously curved lines appear as straight lines in the undistorted image. Edges that you have not defined through lines should also not resemble lines. If an unacceptable deviation occurs, the distortion correction has to be repeated under inclusion of these lines. Your current settings concerning the distortion correction process will be saved internally.

You can now use the undistorted image for Photo rectification according to geometry, which requires straight edges.

You can, of course, rectify an undistorted image with Rectification by control points - Rectification of photos (Projective Transformation) but the distortion correction process can be included in the rectification right away, which saves a great deal of time and work.

Recommendation:

We recommend using once determined distortion parameters on a number of images (e.g. all images of a project). That saves the hassle of having to determine the correction in every single image anew. Distortion parameters can be saved in a file. However, you have to use the exact same camera settings for all pictures. That means all pictures have to be taken with:

- the same camera and lens

- the same focal length (zoom level with zoom lenses)

- the same resolution (number of pixels) as well as

- the same image orientation (landscape format or panel format)

as the distortion is depending on these items.

The required image orientation can also be determined after the image has been taken with rotating it or pasting it rotated. **Caution**: The images must not be clipped before used in As-Built. Two separate files with parameters (*.VP2) are needed one for the landscape the other one for the portrait format, because the image size (height and width) as well as the parameters are saved in a certain order and therefore are not transferable between both formats.

This method especially is of advantage when the object to be rectified is not suitable for defining lines for distortion correction (e.g. stone walls, oblique historic timber-framed houses). Then you can take an additional picture, which is better suitable for distortion correction (e.g. a facade of a modern sky scraper with many horizontal and vertical edges). This picture can function as a calibration picture.

If you are using different cameras or if you are taking photos with the same camera but once in landscape and the other time in portrait format, you should build up a library of VP2 files that contains the distortion parameters for different lenses, focal lengths and image formats. Distortion is an optical phenomenon caused by the refraction of the light at the lens. It is therefore influenced by the quality of the lens, the focal length and the resolution.

You find a detailed description of the camera parameter file (VP2) in chapter 4.8.

Important Remarks:

Applying the **radial-asymmetric distortion correction** has to be done very carefully. On the one hand it leads to a better result in the corrected image but requires a complete grid of straight lines over the whole image. This can be found only in some kind of a test image.
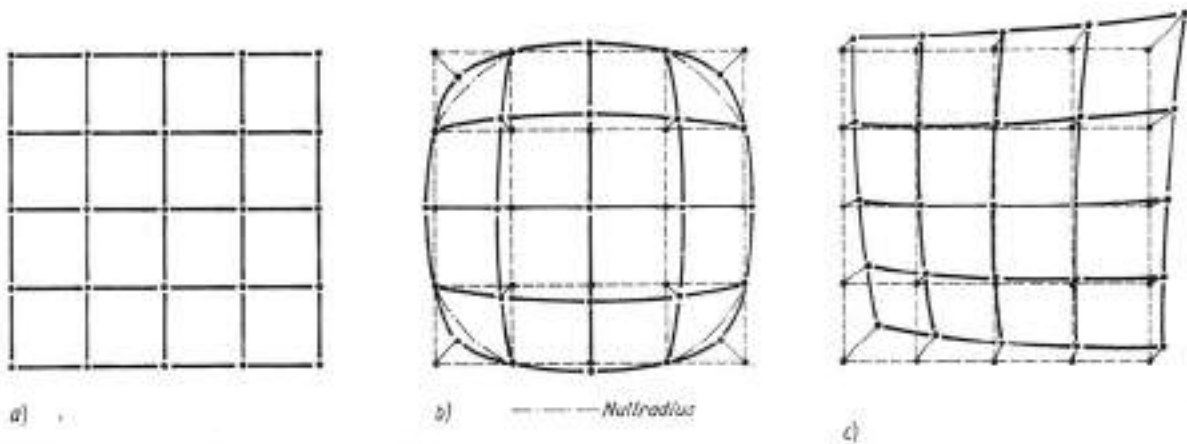
Abbildungsfehler — Verzeichnung des Objektivs
a) fehlerfreie Abbildung; b) symmetrische, radiale·Verzeichnung; c) asymmetrische Verzeichnung

Hint:

If you are saving the rectified image, it will automatically be placed on the layer which you have defined with the As-Built command →**Settings** under Layer "LayerUndistortedImages". If no layer is defined (default) the image will be placed on the current layer.

Rectification according to geometry - Attach rectification grid

	Command name:	Menu:
	KUBT_PC_RECTGRID	As-Built Photo

This command serves for inserting a rectification grid into a pixel image.

The rectification grid is a pre-condition for a rectification according to geometry. After inserting the grid it is adapted to the image in a way that its horizontal and vertical lines reflect the projective distortion in the image. With the help of the rectification grid the program will thus learn the degree of distortion.

After calling up the command you are at first asked for the distorted image:

> Select distorted image or <Cancel>:   *(click on the distorted image's periphery)*

Now a dialogue field appears.
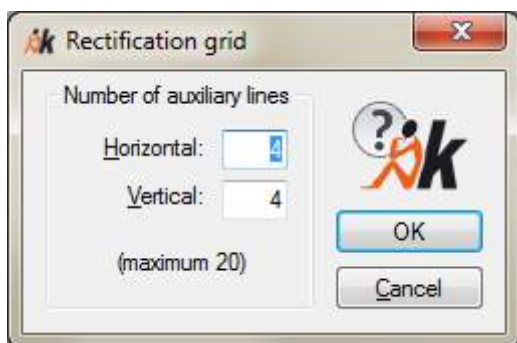
Here you may state how many auxiliary lines the grid should have in horizontal and vertical direction. Confirm your entry with **Return**. An even, rectangular grid in the color of the current layer will appear above the image.

The grid now has to be adapted. It is marked with a click on a grid line and the 'handles' typical for AutoCAD will appear in certain places. There are two different kinds of handles:

- On the four corner points the **main grid points** are situated, especially emphasized with a circle. Marking and pulling on the handles attached there with the mouse will alter the complete grid in its geometry.

- On each **auxiliary line** there are more than one handle between the points of intersection. With their help you may move the auxiliary lines parallel to each other while the grid's geometry remains unchanged.

Only one grid may be applied to each image. If you try to fit a grid above an image that is already provided with a grid a corresponding error message will appear.

Rectification according to geometry - Add horizontal auxiliary line

	Command name:	Menu:
	KUBT_PC_ADDHLINE	As-Built Photo

This command will add a horizontal auxiliary line to an existing rectification grid.

After calling up the command the following command line dialogue will appear:

Command: KUBT_PC_ADDHLINE

Select rectification grid: *(click on the rectification grid)*

Insert point for the new horizontal auxiliary line:

(click on the position of the new horizontal auxiliary line)

The number of auxiliary lines does not influence the rectification parameters. They only serve for a better visualization during the grid adaptation.

Rectification according to geometry - Add vertical auxiliary line

	Command name:	Menu:
	KUBT_PC_ADDVLINE	As-Built Photo

This command will add a vertical auxiliary line to an existing rectification grid.

After calling up the command the following command line dialogue will appear:

Command: KUBT_PC_ADDVLINE

Select rectification grid: *(click on the rectification grid)*
Insert point for the new vertical auxiliary line:
                                             (click on the position of the new vertical auxiliary line)

The number of auxiliary lines does not influence the rectification parameters. They only serve for a better visualization during the grid adaptation.

Rectification according to geometry - Delete auxiliary line

	Command name:	Menu:
	KUBT_PC_DELLINE	As-Built Photo

This command deletes an auxiliary line from an existing rectification grid.

After calling up the command the following message will appear in the command line:

Command: KUBT_PC_DELLINE

Select auxiliary line of rectification grid to be deleted: *(click on the auxiliary line to be deleted)*

You may delete vertical as well as horizontal auxiliary lines but not the lines on which the main grid points are situated.

Rectification according to geometry - Rectification of photos according to geometry (Projective transformation)

	Command name:	Menu:
	KUBT_PC_RECTIFYGEOM	As-Built Photo

With this command the photo rectification according to geometry is carried out.

An extensive dialogue window belongs to this command which is separated into various sections:
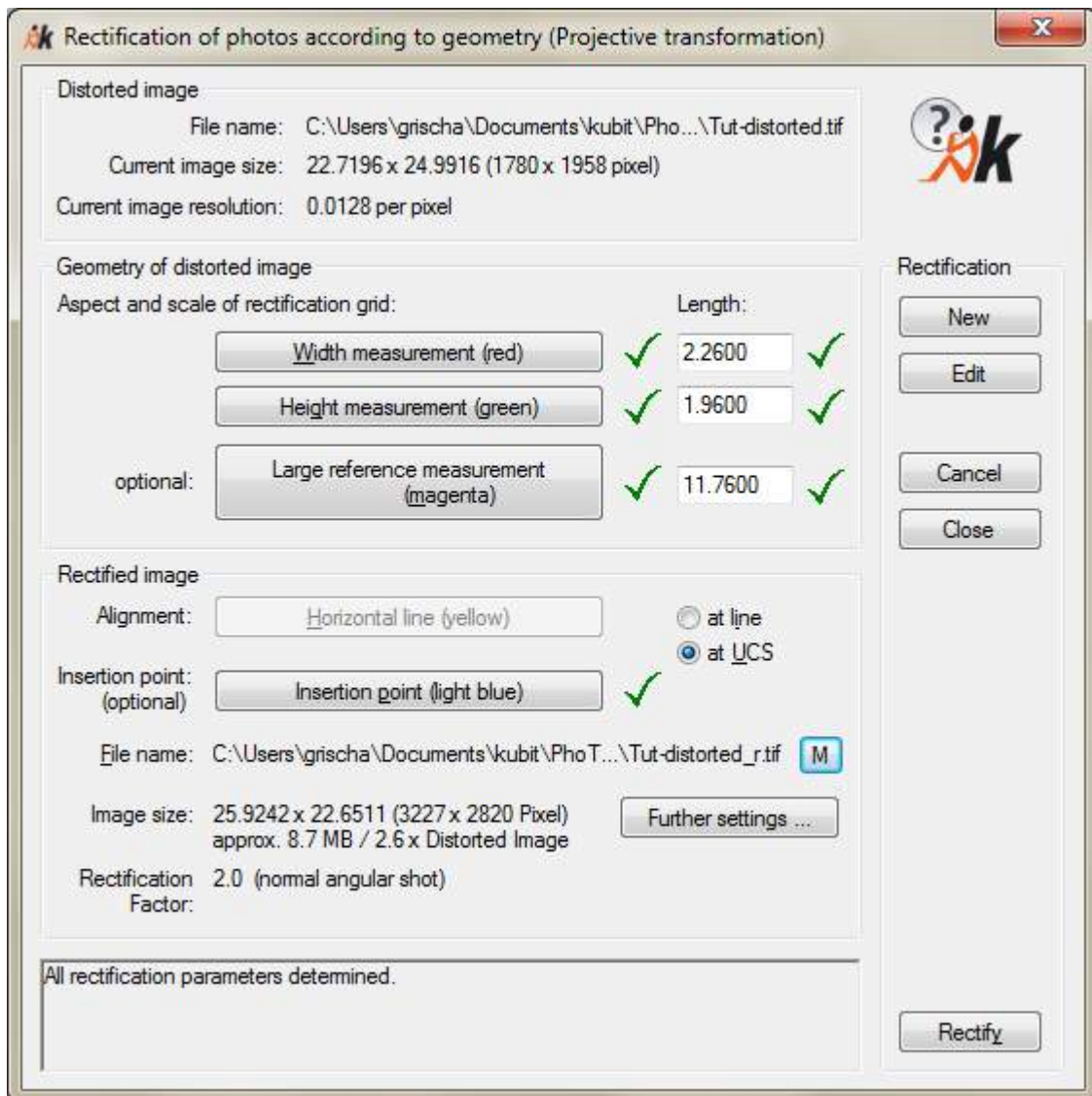
1. The Frame 'Rectification'

Here you may determine in general what you want to do next.

- With [**New**] you start a new rectification. With a click on this button you leave the dialogue for the moment and the following call will appear in the command line:

  Select distorted image or <Cancel>:   *(select pixel image in the drawing)*

  After that the dialog returns. All value fields are empty and behind them you will see red question marks. You may now start to assign the reference measures (see

3.: Geometry of the Distorted Image). A pre-condition for a rectification according to geometry is the existence of a rectification grid. If you select an image that does not yet have a grid a corresponding error message **'This image wasn't allocated to a valid rectification grid.'** will appear. If you select an image for which the grid was not yet adapted you will get a warning message: '**Rectification grid wasn't fitted to the distorted image.**'

- With [**Edit**] you call up a previous rectification and may alter it and/or carry it out anew. The following message will appear in the command line:

  Select rectified image which to be edited or <Cancel>:   *(click on image's periphery)*

  The reference measurement information that were already assigned in this rectification is displayed. At this point you may process the values and rectify the image anew. A rectification can only be processed if the corresponding distorted and rectified image still exist in the drawing.

- With [**Rectify**] you start the rectification process. The button is only activated if all requirements for a rectification are fulfilled: The rectification has to be determinable (that means all required values for the reference measures have to be stated) and all statements concerning the rectified image have to be complete.

- With [**Cancel**] you leave the dialogue. All alterations are discarded. With [**Close**] they are stored.

2. Information concerning the distorted Image

In the upper part of the dialogue you will find a few statements concerning the distorted image.

- Under '**current image size**' you will find two statements: the current size of your drawing and behind it in brackets the number of pixels in width and height.

- The **current image resolution** states – based on these values – the size of a pixel.

3. Geometry of the distorted Image

This frame takes up a central position. Here the measured values belonging to the reference measures are entered and the assignment of the reference measures in the image is carried out. In order to have a good overview the following symbols are used:

?   here a valid entry is missing

✓   here a valid entry already exists

You have to assign the three reference measures that you have measured on the object, in the image. These three buttons serve for that purpose:

When you click on them the dialogue will disappear for a while and the following prompts appear one after another in the command line:

First point for zoom region or <Cancel>: *(click near the first reference measure point)*

Second point for zoom region or <Cancel>: *(open a zoom region around the first point)*

First point for width measure: *(click on the first reference measure point)*

First point for zoom region or <Cancel>: *(click near the second reference measure point)*

Second point for zoom region or <Cancel>: *(open a zoom region around the second point)*

Second point for width measure: (*click on the second reference measure point)*

Draw the reference measurements into your distorted image in that way. The width and height measurement may only be aligned parallel to the grid lines. The direction of the large reference measurement may be selected randomly.

Hint: If you generally want to turn off the prompt for the zoom you may do it using the →**Settings** command (section "System").

Back in the dialogue a green hook will appear behind each button.

Behind it you will find a field labelled with '**length**' for each measurement. Enter the measured value belonging to each reference measurement here.

You may edit or repeat, respectively, the measured values and the assignment of the reference measurements as often as you want to.

4. Information concerning the rectified Image

In the frame 'rectified image' you have to make a few statements concerning the rectified image.

- **Alignment**

  You decide how the rectified image is to be aligned. If you accept the default 'at UCS' the image's lower edge is aligned to the X-axis of the current user coordinate system (UCS). If you select 'at line' then the button '**define horizontal line (yellow)**' will become active and you may state a line for aligning the image in the drawing. Command line run:

  First point for zoom region or <Cancel>:

  Second point for zoom region or <Cancel>:

  First point for yellow alignment line:

  First point for zoom region or <Cancel>:

  Second point for zoom region or <Cancel>:

  Second point for yellow alignment line:

- **Insertion point**

  With this you determine at which position the rectified image is to be inserted into the drawing. With a click on the button you select the point from the drawing. The command line run is similar to that of the reference measurement alignment. You have to state a reference point in the distorted image and assign an insert point to it. The definition of an insertion point for the rectified image is optional. If you do
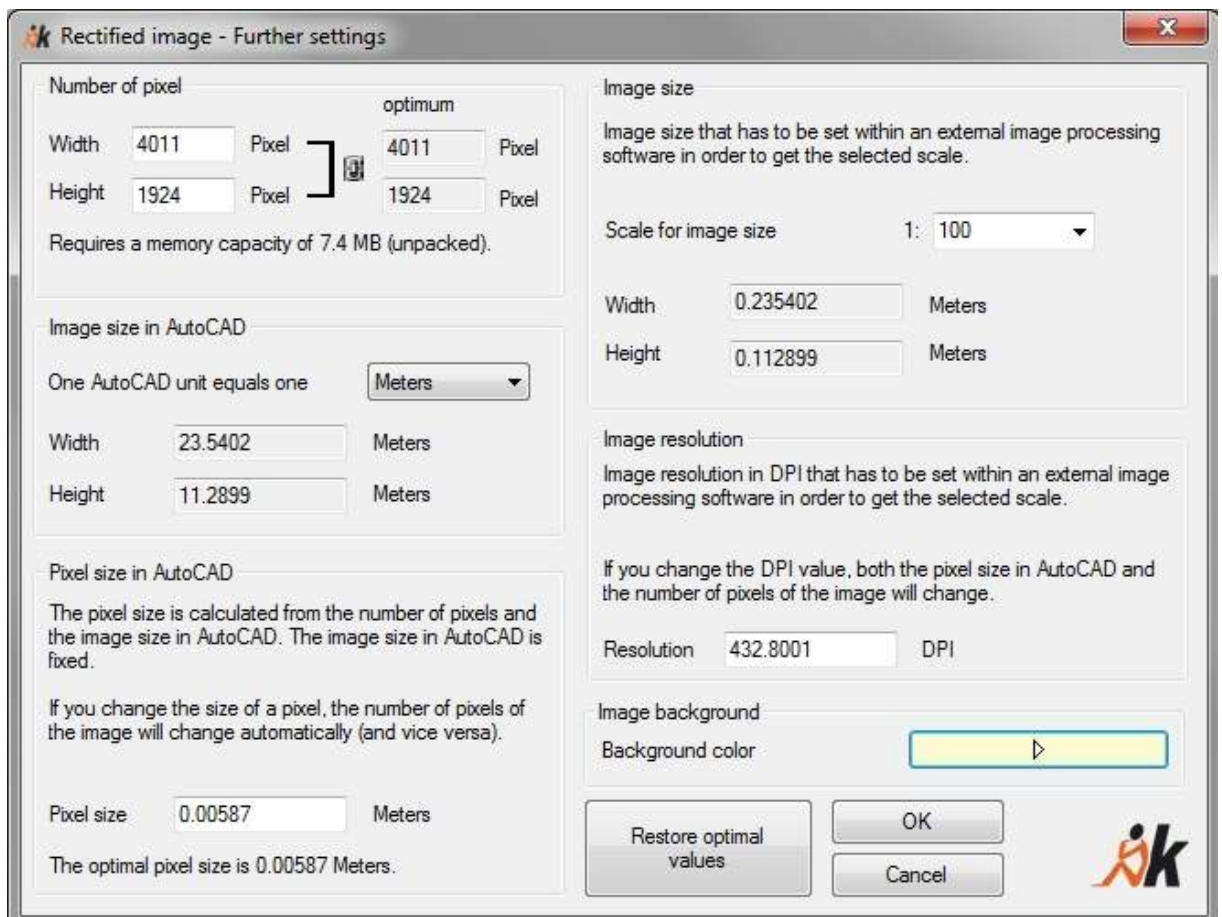
not define it, the rectified image is automatically placed right of the distorted image.

- **File names**

  Before you can start the rectification process, you have to enter a file name for the rectified image. Use the buttons [...] or [M] to enter name and path manually. BMP, TIFF, JPEG and PNG are at your disposal as file formats for the rectified image. With the button [A] you enable the automatic naming. You may determine where the rectified images shall be stored when using this mode using the →**Settings** command. Further more you may determine the image format (e.g. Tiff) and you may add a prefix or suffix to the file name.

- **Image size settings**

  With the button [**Further settings...**] you can adjust the properties of the rectified image. You will be shown the optimal values for the number of pixels, image size and pixel size/resolution. optimal means that the image to be created contains exactly so many pixels that a maximum of image information is available without wasting memory at the same time. For further details on the settings please refer to Rectification by control points - Rectification of photos (Projective Transformation) (page 7-37) of this command reference.

- **Image size**

  Here you see the information on an image in a compressed way:

  Image size   24.3253 x 23.3230 (3155 x 3025 Pixel)
                approx. 9.1 MB / 2.7 x Distorted Image

  Image size in AutoCAD

  Number of pixels

  Required disc space (uncompressed) and compared to the original image

- **Rectification factor**

  The Rectification factor indicates the relation between rectified and distorted image having an optimal resolution. The more the original images is distorted the larger this factor becomes. The information shall help to prevent extreme cases. In general the Rectification factor lies between values of 1 to 3. Only in cases of very large projective distortions larger values are to be expected.

5. The Status Bar

At the bottom of the dialogue you will find a status line that provides you with information concerning the current calculation status of the rectification. The following messages are possible:

- '**Rectification parameters not complete**' means that too few reference measurements were taken or activated. The button **Rectify** will be inactive in this case. What information is missing can be seen by the red question marks.

- '**Rectification determined**' means that all necessary information for calculating the rectification parameters are complete. The button **Rectify** is activated and you may start the rectification process with it.

- '**File name of rectified image not specified**' tells you that you still have to state a file name for the rectified image. The button **Rectify** will remain inactive.

- '**Error calculating boundary**' may have various reasons, generally it is an extremely distorted image that cannot be calculated anymore from As-Built. In these cases the image to be rectified has to be limited to the relevant sections with the command 'Clip Image'.

The rectified image has a rectangular matrix just like the distorted image. During the rectification process a more or less irregularly shaped image is formed. The peripheral areas that come into being, because no image data of the distorted exist, will be filled in with the currently set background colour of the AutoCAD drawing surface. You can make this visible by clicking the image boundary of the rectified image to draw a new boundary. New parts within the boundary will be filled with current background colour.

The Image Position File

For each rectified image a file 'FilenameRectifiedImage_FileExtension.PPB', in which the image position information is stored, will be set up in the same directory. If you have deleted the rectified image from your drawing by mistake you can reconstruct it exactly with the help of this file and the command 'Image - Load image'.

The Protocol File

In the same directory a file 'FilenameRectifiedImage_FileExtension.PRK' is also set up for each rectification. This protocol file in ASCII format contains all important information for each rectification such as name, size, resolution and scale of the distorted and rectified image as well as rectification parameters, values of the rectification parameters and UCS definition.


Hint: The rectified image will automatically be placed on the layer which you have defined with the command →**Settings** under Layer "LayerRectifiedImages". If no layer is defined (default) the image will be placed on the current layer.

Manual

	Command name:	Menu:
	PPHELP	As-Built Photo

This command opens the PDF file which contains the present manual and the belonging command reference. Thus, this helpful documentation is also available in digital format.

Tutorials

	Command name:	Menu:
	KUBT_PC_TUTORIAL1 or KUBT_PC_TUTORIAL1	As-Built Photo

The command "KUBT_PC_TUTORIAL1" automatically opens the drawing file TUTORIAL1.DWG whereas "KUBT_PC_TUTORIAL1" opens the drawing TUTORIAL2.DWG.

When running the command the first time the respective drawing is copied from the installation folder of As-Built to the folder \ DOCUMENTS and there into \FARO\AS-BUILT X.X.X EN ACXXXX\ TUTORIALS\PHOTO. Later always this copy is used for working on it.